

Abstracts

Contributed Papers (Poster and Oral)

Workshops

Colloquia

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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.

48 POSTER SESSION 1A (Abstr. 001–006) Culture & Management—Small Fruit/ Viticulture

001

Nitrogen Transformation in Low pH Soils for Cranberry

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Cranberry plants exclusively utilize ammonium forms of nitrogen. Nitrification of applied ammonium and subsequent leaching through sandy soils is a potential problem for growers. Peat, sand, and striped soils were collected in cranberry beds in central Wisconsin and soil pH was adjusted to 3.5, 4.5, or 5.5. Twenty-five grams of dry soil was placed in flasks and half the flasks were sterilized. Distilled water was added to half of the samples, and the other half received ¹⁵N-labeled ammonium. Flasks were incubated at 20°C for up to 70 days. Striped soils showed no nitrification at pH 3.5 or 4.5 during the 70 day incubation. At pH 5.5, nitrification began at 20 days and was almost complete at 70 days. Nitrification did not occur at any pH in sandy soils. This research suggests that ammonium fertilizer applied to cranberry is likely taken up before nitrification would occur.

002

Living Mulch for Strawberry Production Fields

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Annual ryegrass (*Lolium multiflorum*), which grows prolifically during the strawberry production season in the Gulf South, has the potential to serve as a living mulch if its growth is controlled. Sublethal dosages of Embark, a plant growth regulator, and the herbicides Poast and Rely were determined on ryegrass. Growth retardation was rated from 0 = none to 6 = dead. In 1993, all Poast dosages (1/8X – 1X, where X = 8 ml·L⁻¹) were lethal. Embark regulated ryegrass growth, but its study was discontinued because of the unlikelihood that it could be labeled for use on strawberries. Results of the 1994 study suggested that prime oil in the spray may cause an inordinate amount of vegetative browning. In 1995, three levels of oil (1/256X, 1/64X, and 1/32X, where X = 8 ml·L⁻¹) were

used with each of four levels of Poast (0, 1/32, 1/64, and 1/128X). Increased levels of oil generally caused increased browning at each level of Poast, but no browning occurred where oil only was applied in the spray. In contrast to results in 1995, oil at 1/32X with no Poast caused considerable browning (score = 3.25) in 1996. The most desirable control (score = 2.75) was accomplished by a spray containing 1/128X Poast and 1/64X oil. The most desirable control by Rely (score = 3.25) was accomplished by 1/64 and 1/32X sprays. Rely is not labeled for strawberries although it is labeled for other fruit crops. Chemical names used: 2-[1-(ethoxylmino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one (Poast); Paraffin Base Petroleum Oil + polyol Fatty acid Esters (Prime oil); N-[2,4dimethyl-5-[[[(trifluoromethyl)-sulfonylamino]phenyl] acetamide (Embark); ammonium-DL-homoalanin-4-yl-(methyl) phosphinate (Rely).

003

Root Distribution of 'Gulfcoast' Southern Highbush Blueberry

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A field study was conducted to evaluate individual and collective influences of three soil moisture-supplementing practices (irrigation, incorporated peatmoss, and mulching) on root system development in 'Gulfcoast' southern highbush blueberries. Root growth was least in plants not mulched and greatest in plants receiving all three supplements. Ranking of individual treatments on root dry weight production was mulch > incorporated peatmoss = irrigation. Mulching resulted in uniform root distribution from the plant crown outward and in root growth concentrated in the upper 15 cm of soil. Other practices (peatmoss > irrigation) tended to concentrate the root system near the crown area and resulted (peatmoss = irrigation) in greater root depth. Soil moisture appeared to be the major factor influencing root distribution.

004

Ice-nucleation-active (INA) Bacteria: A Detriment to Strawberry Flower Survival during Low-temperature Exposure

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Experiments were conducted to determine the temperatures at which different densities of INA bacteria incite ice crystallization on 'Totem' strawberry flowers and to determine if there is a relationship between densities of INA bacteria on strawberry flowers and floral injury. Primary flowers were inoculated with *Pseudomonas syringae* at 10⁶ cells/ml buffer, incubated at 25°C day/10°C night and 100% RH for 48 h, and exposed to -2.0°C. No ice nucleation occurred on these inoculated flowers and all of the flowers survived. However, when inoculated flowers were subjected to lower temperatures, ice nucleation occurred at -2.2°C and few of the flowers survived. In contrast, ice crystals formed on the surface of most non-inoculated flowers at -2.8°C and 21% of the flowers survived exposure to -3.5°C. When INA bacterial densities were ≈10⁵ colony forming units/g dry wt, floral injury occurred at a warmer temperature than to flowers that had lower bacterial densities.

005

Study of the Regular and High Application of Water with Drip Irrigation and Its Effect in the Floral Buds of 'Thompson Seedless' Grapes

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The region of Caborca is actually the largest grape-growing area in Mexico, with 14,000 ha. The main problem in this zone is the lack of water, and it is important to use this resource rationally. During 1990 and 1991, a drip irrigation experiment in 'Thompson Seedless' table grapes was conducted. The four treatments were 120%, 166%, 206%, and 250% of the evaporation from an evaporation pan type A. The crop coefficients (K_c) applied were 7.5%, 15%, 52.5%, and 80% from the beginning of budding until 1 week after harvest, and 7.5% after harvest (postharvest). The results indicated that the best treatments were 120% (105 cm of total water applied) and 166%, with no reduction in the floral buds (5.4 per cane for 120); however, 206% and 250% (202 cm of total water applied) got the lowest number of floral buds (0.90 per cane) for the following year, and, because of that, the lowest clusters per cane.

006

Dry Mass and Nitrogen Distribution in Papaya Seedlings in Response to Varied Fertilization of Divided Root Systems

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'Known You 1' papaya seedlings were grown in split-root containers and fertilizer was applied to one (1/2) or two (2/2) halves of the root system to determine the influence on transport of assimilates from canopy to roots and transport of nitrogen from fertilized roots to non-fertilized roots and canopy. Following 6 weeks of growth, the plants were bare-rooted and the root system halves and canopy were dried to constant mass at 70°C. Tissue was then analyzed for total nitrogen content. Fertilization increased root mass more than 250% and total plant mass 300% compared with control plants, which received no fertilization during the 6 weeks. Total root or plant mass did not differ between the 1/2 and 2/2 plants. Roots were evenly distributed between the two halves for 2/2 plants, but the fertilized half in the 1/2 plants accounted for 60% of the total root mass. Nitrogen content of roots and canopy were increased by fertilization. Nitrogen content of the non-fertilized roots of 1/2 plants was not different from that of the fertilized roots. These results indicate that fertilizing a portion of the papaya root system increased the sink activity of that portion and that the absorbed nitrogen from that portion is efficiently transported throughout the plant.

48 POSTER SESSION 1B (Abstr. 007–025)

Weed Control—Cross-commodity

007

Watermelon Weed Control: Current and Future Possibilities

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Watermelon is the major fresh-market vegetable grown in Oklahoma, but growers have few labeled herbicides from which to choose. Grower surveys in Oklahoma have identified weed control as the major production problem facing watermelon producers. In 1995 and 1996, various mechanical and chemical weed control strategies have been explored. 'Allsweet' watermelons were grown with various combinations of labeled and unlabeled herbicides, as well as mechanical control treatments. Treatments included bensulfide, clomazone, DCPA, ethalfluralin, glyphosate, halosulfuron, napropamide, naptalam, paraquat, pendimethalin, sethoxydim, and trifluralin. Certain chemicals were used in combination. Paraquat and glyphosate were used as wipe-on materials. Glyphosate and paraquat could not be applied until weeds were taller than the watermelon foliage, causing serious weed competition. In general, superior results were obtained from hand-weeded plots, trifluralin, and DCPA. Halosulfuron gave superior control of broadleaf weeds, but had a negligible effect on grasses. Napropamide gave good control of grasses and broadleaf weeds other than solanaceous weeds. No chemical, when used alone, gave satisfactory control throughout the growing season. Early cultivation, followed by chemical application at layby, appears to be one of the better treatments.

008

Effect of Light during Cultivation on Weed Emergence

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This experiment was conducted to determine whether light conditions during cultivation affect the number or species composition of emerging weeds. Plots were cultivated on 31 May 1996 under the following light conditions: 1) Ambient nighttime light (full moon) plus tractor headlights, 2) ambient nighttime light plus tractor headlights covered by transparent green film (green tractor lights), 3) ambient nighttime light with no tractor headlights, 4) ambient mid-day light. A fifth treatment was not cultivated at all, but was treated with glyphosate on 31 May to kill emerged plants. Results discussed below are based on weed densities determined 3 weeks after cultivation. Cultivated plots had more broadleaf weeds than uncultivated plots (119/m² vs. 40/m²). Annual grass populations were the same in cultivated and uncultivated plots (20/m²). Common lambsquarters (*Chenopodium album*) and carpetweed (*Mollugo verticillata*) were the most

common annual broadleaf weeds, representing more than 80% of the annual broadleaf population in cultivated plots. Light conditions during cultivation did not influence the total number of broadleaves, number of annual grasses, or total number of weeds emerging. Lambsquarters emerged in greater numbers after daytime or night cultivation using green tractor lights (48/m²) than after night cultivation using standard tractor headlights (32/m²). These results suggest no practical benefit to night cultivation for reducing overall weed density. A similar study in 1995 led to a similar conclusion. Although measurable effects of light conditions on weed emergence were observed in both years, the magnitude and consistency of the effects were not enough to suggest changes in cultivation practices without further research.

009

Solarization for Weed Control in a Short-season Climate

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A solarization site was established on the grounds of the Sawtooth Community Garden south of Ketchum, Idaho, in 1995. Feasibility of solarization for weed control was determined in a region of sunny, warm days and cool nights. Elevation of the site was 1829 m, with a growing season of 90 days. Treatments of double and single layers of clear and IRT plastic were applied 23 May 1995. These solarization treatments were compared to hand-hoeing, glyphosate sprays, and no control. Highest soil temperatures were reached under the double clear plastic, where daily peak temperatures ranged from 19 to 46°C. Plastic treatments were removed on 30 Aug. 1995. Weed growth and growth of peas, green beans, carrots, and beets were recorded during the summer of 1996. Weed growth on 14 June 1996 ranged from 0.3 to 0.8 weeds/m² in the solarization, hand-hoe, and glyphosate treatments and was 22.4 weeds/m² in the no control treatment. On 20 Aug., weeds/m² ranged from 1.4 to 2.0 in the solarization, hand-hoe, and glyphosate treatments and was 20.4 weeds/m² in the no control treatment. At both dates there was no significant differences between weed control treatments, and any weed control method was significantly better than no control. Weight per plant of beets and beans was no different across all treatments. Carrot and pea plants were smaller in the no control treatments, and some variable differences were noted between weed control treatments. Results indicate that solarization in short-season, cool climates will result in little to no advantage over hand-hoeing or herbicide control of weeds, and no subsequent differences in crop growth can be expected.

010

Pre-emergent Weed Control in Container-grown Herbaceous Perennials

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During the 1996 season, pre-emergent 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/ha; Oxyfluorfen + Pendimethalin (Scott's OH II), 0.54 kg a.i./ha; and Trifluralin (Treflan 5G), 0.72 and 1.44 kg a.i./ha. Herbicides were applied to *Campanula carpatica*, *Dianthus gratianopolitanus*, *Gaillardia* x 'Baby Cole', *Penstemon* x 'Husker's Red', and *Phlox subulata* 'Emerald Blue'. Phytotoxicity symptoms (visual defects and less height) were apparent with Oryzalin on *Penstemon* (at both rates) and on *Phlox* (0.72 kg a.i./ha). Weed control was significantly less with Trifluralin and Napropamide when compared to the other herbicides.

011

Evaluation of Herbicides for Phytotoxicity to Rose Plants and Efficacy

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Roses are likely the most popular garden plant in the United States, and cultivars are also used as landscape plant materials. Three herbicide trials with two main objectives were conducted with rose plants. The first objective was to evaluate injury to the roses when over-sprayed at various stages of growth. The second objective was to evaluate the efficacy of the herbicides. All herbicides were used at label rates and applied over the top of rose plants. In the first trial,

the pre-emergent herbicides pendimethalin, oryzalin, trifluralin, metolachlor, napropamide, and oxyfluorfen were applied to plots containing dormant roses with ≈1-cm shoots just pushing. Evaluations of shoot length taken over the next 6 weeks showed no differences in growth of rose plants, but weed populations were reduced. In the second trial, five post-emergent herbicides were applied to plots containing dormant roses. Herbicides evaluated included the grass herbicides fluazifop-p-butyl, sethoxydim, and clethodim. The nonselective herbicide glyphosate was included in the trial, as was a combination herbicide containing 2,4-D, mecoprop, and dicamba. There was no visible injury to rose plants until 6 weeks after treatment. At that time, roses treated with glyphosate had shorter shoots. Recovery from glyphosate appeared more rapidly than recovery from the combination herbicide. Weed control varied with each herbicide. The third trial evaluated the same five herbicides for control of bermudagrass in late spring. Injury to roses was noted immediately from the combination herbicide and glyphosate. All the grass herbicides and glyphosate were effective in controlling bermudagrass.

012

Postemergence Control of *Phyllanthus urinaria* by Prodiamine and Phytotoxicity to Ornamentals

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Postemergence control of *Phyllanthus urinaria* L. (chamberbitter) in nursery and landscape plantings has been primarily limited to hand-weeding. Prodiamine was evaluated for postemergence control of chamberbitter and phytotoxicity to containerized ornamentals. On 20 June 1995, prodiamine at 0, 1.68, 3.36, or 6.72 kg a.i./ha was applied over-the-top to immature chamberbitter growing in 3.8-L containers of established *Buddleia davidii* Franch. 'White Bouquet' *Cuphea hyssopifolia* HBK. 'Desert Snow', *Lantana camara* L. 'Irene', and *Lantana montevidensis* (Spreng.) Briq. 'Lavender Weeping'. Weed-free checks were included. Applications were made with a compressed air backpack sprayer. There were four replications per treatment placed in a randomized complete block design by species. Plants were established and maintained on a container bed under full sun and overhead irrigation. Growth of and phytotoxicity to the ornamentals species, and percent coverage and number of chamberbitter, were recorded periodically for 14 weeks after treatment (WAT). Chamberbitter shoots were harvested for dry weight analysis 14 WAT. Prodiamine provided some postemergence control of chamberbitter. However, *Cuphea* and both *Lantana* species exhibited leaf distortion and/or delayed flowering.

013

Tolerance of Fine Fescues to Clethodim

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Fine fescues are immune to two common graminicides, fluazifop-p-butyl and sethoxydim. This study was initiated to determine the tolerance of three fine fescues; chewings, hard, and creeping red, to clethodim alone or with a crop oil concentrate (COC) or non-ionic surfactant (NIS). Clethodim at 0.25 or 1.0 lb/a was applied on 23 Oct. 1995 and evaluated on 22 May and 9 July 1996. Clethodim at 0.25, 0.5, or 1.0 lb/a, was applied on 31 May and evaluated on 9 July 1996. Applied in the fall at 0.25 lb/a alone or with NIS, clethodim had little effect on chewings or creeping red fescue. Some injury to hard fescue was evident on 22 May, but it recovered by 9 July. The addition of COC resulted in moderate injury to all three species, with only partial recovery by 9 July. Severe injury of all species from clethodim applied at 1 lb/a was evident on 22 May. The amount of recovery that occurred by 9 July was dependent on the spray additive used. With none, all of the grasses recovered fairly well. With NIS, moderate injury to hard fescue persisted; and with COC, unacceptable injury to all species persisted. Similar results were obtained when the treatments were applied in the spring. The 0.5 lb/a rate caused an intermediate degree of injury. Though none of the clethodim treatments totally killed any of the fine fescues, unacceptable injury was caused by the 0.5 and 1.0 lb/a rates, regardless of additive, and by the 0.25 lb/a + COC treatment.

014

Effect of Formulation on Soil Movement of Hexazinone

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In order to assess the effect of hexazinone formulation on movement through the soil profile, soil samples were taken on 25 June 1995, 25 Aug. 1995, 22 Nov. 1995, and 24 May 1996 (1, 3, 6, and 12 months, respectively) at 0–5, 5–15, and

15–25 cm from plots treated 25 May 1995 with either hexazinone liquid formulation of Velpar L at 1.1 kg/ha, or as a granular in Pronone 10G, Pronone MG at 11.1 kg/ha, or Diammonium Phosphate (DAP) at 220 kg/ha impregnated with Velpar L at 1.1 kg/ha and an untreated control. The hexazinone liquid had the most leaching, the Velpar DAP formulation had the least leaching, and the Pronone formulation were intermediate. If hexazinone leaching into groundwater is a concern a particular site, then the Velpar/DAP fertilizer or Pronone formulations should be used over the liquid formulation. This project was done under a low rainfall year, 1995, and it should be reassessed with the new Velpar DF formulation and irrigation.

015

Tolerance of Selected Ornamentals for Phytoremediation of Atrazine, Simazine, and Metalaxyl Residues in Water

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Atrazine, simazine, and metalaxyl residues are often present in sprayer rinsates and in runoff water following application of the formulated products. As an initial step in the development of a constructed wetland for the phytoremediation of these pesticides in water, several plant species were evaluated for their tolerances to each. Plant species were chosen based on their aesthetics, tolerance to wetland conditions, and their potential to produce much vegetative growth. Species included: *Acorus gramineus*, *Canna hybrida* 'King Humbert', *Myriophyllum aquaticum*, and *Pontederia cordata*. Plants were exposed to various concentrations of each pesticide dissolved in 10% Hoagland's nutrient media for 7 days. Tests were conducted under metal halide lamps with a light intensity of 400 $\mu\text{mol}/\text{m}^2$ per s and a photoperiod of 16 h light : 8 h dark. Test endpoints measured included 7-day fresh mass production and chlorophyll fluorescence. A completely randomized statistical design with four replications of each concentration was utilized for each plant species. These tests indicate that all plant species were susceptible to atrazine and simazine in the 0.1 to 1 $\mu\text{g}/\text{ml}$ range. Effectuated plants displayed concentration-dependent degrees of chlorosis and necrosis. Plants were more tolerant to metalaxyl concentrations in water. However, leaf chlorosis and necrosis did occur at concentrations greater than 25 $\mu\text{g}/\text{ml}$. Future research will quantify the uptake and mineralization potential for these plants and pesticides.

016

Control of Canary Grass and Nutsedge Weeds with Microbially Derived Herbicides

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For the control of Reeds Canary grass (*Phalaris arundinaceae*) and yellow nutsedge (*Cyperus esculentus*) in blueberry fields, no satisfactory control measures are available. We tried microbially derived aerobic fermentation extracts of *Pseudomonas syringae* strain 3366 (P. S. 3366) as pre- and -post-emergence applications for the control of Reeds Canary grass and yellow nutsedge. In greenhouse studies using "conetainers," 2 mg of extract per g of soil applied as preemergence completely inhibited seed germination and aerial growth of Canary grass, but had no effect on nutsedge. In addition, the same level of concentration of P. S. 3366 (2 mg of extract/g of soil) under field conditions also showed 99% inhibition of germination and growth of Canary grass, but had no effect on germination of nutsedge. However, 4-fold increase in concentration of P. S. 3366 extract completely inhibited the sprouting of yellow nutsedge in greenhouse studies. These studies indicate microbially derived extract of P.S. 3366 can be used and has potential for the control of these weeds. Post-emergence foliar sprays of P. S. 3366 extract in blueberry fields failed to inhibit the aerial growth of Reeds canary grass and yellow nutsedge.

017

Suppression of Liverwort Growth in Containers by Cinnamic Aldehyde

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Extensive growth of liverwort (typically *Marchantia* sp.) on the surface of the growing medium in plant containers is a serious problem in many nursery and greenhouse operations. A spray application of cinnamic aldehyde at 0%, 0.25%, 0.5%, or 1% a.i. was applied to uninfested 4-inch-diameter containers, and to containers infested with *Marchantia polymorpha*. Application to uninfested

containers delayed liverwort establishment for an additional 1, 2, and 4 weeks at the 0.25%, 0.5%, and 1% applications rates, respectively, compared to the 0% control. Ten days after application, 0%, 70%, 95%, and 100% of liverwort thalli covering the growing medium surface of infested containers were killed by the 0%, 0.25%, 0.5%, or 1% application, respectively. However, only the 1% rate also killed the gemmae cups growing on the thalli surface. Regrowth of liverwort began 2, 3, and 5 weeks following application, respectively. Prevention of infestations is desirable, as dead liverworts are less attractive than live growth. No phytotoxicity symptoms were observed on *Rhododendron* growing in the treated containers.

018

Studies on the Allelopathic Effect of Corn Spurry (*Spergula arvensis* L.) on Cole Crops and English Pea

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These studies were initiated to investigate severe growth inhibition observed when some vegetable crops were infested with corn spurry (*Spergula arvensis* L.). Interference by a natural population of the weed reduced the shoot weights of English pea (*Pisum sativum* L.) and collard (*Brassica oleracea* L.) by 93% and 72%, respectively. In a greenhouse experiment where light competition by corn spurry was prevented, broccoli (*Brassica oleracea* L.) shoot weights were reduced by corn spurry, but pea weights were not different from the controls. Homogenized corn spurry shoot tissue incorporated into a greenhouse potting medium inhibited the growth of both species, and a concentration effect was observed. Sequential hexane, dichloromethane, methanol, and 50% aqueous methanol extracts of corn spurry root and shoot tissue were tested for inhibitory activity using millet seed germination and broccoli seedling growth bioassays. Dichloromethane, methanol, and aqueous methanol shoot extracts were inhibitory to broccoli; whereas all shoot extracts inhibited millet germination. Shoot extracts were more inhibitory than root extracts. Further fractionation of the inhibitors using a combination of reversed-phase sephadex LH-20 and silicic acid column chromatographic procedures showed that a major portion of the millet germination inhibition was due to sucrose esters (SE). Preliminary characterization of the esters showed that there were four different SE groups. The major groups contained either octanoic or dodecanoic acid along with butanoic and petanoic acids. All groups inhibited seed germination at concentrations as low as 20 ppm. This is the first report of the SE class of defense chemicals in plant species outside of the solanaceae family.

019

Tomato Production using Spring-sown Cover Crops' Mulch for Weed Control

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In the tropics, cover crops do not have to over-winter, but can be established in the same season as the vegetable crops. To emulate this situation, winter rye 'Wheeler' (*Secale cereale*) and field peas (*Pisum sativum*) in pure stands and bi-culture combinations in decreasing levels and varying ratios were established early in Spring 1996 and mown down 2 months later prior to transplanting tomato seedlings. Both cover crops grew to the flowering stage before being mown down. There were significant differences ($P=0.05$) between the treatments in weed control and tomato growth. The best tomato growth and yield was in the conventionally hand-weeded control and the worst in the un-weeded control, with almost no fruit yield. The cover crop treatments with comparable performance to the best treatment were the highest rates of pure field peas, 0.25 rye + 0.75 field peas, and 0.5 rye + 0.5 field peas. The pure rye treatments suppressed weeds best, but also suppressed tomato plant growth. Weeds were suppressed for the first month in most of the mulch covers, but 2 months after mowing down most of the mulch covers were overcome by weeds. Dicotyledonous weeds appeared first and grew faster than grass weeds. This work showed that there is potential for the use of cover crops for weed control in tropical vegetable production.

020

Management Alternatives for Purple and Yellow Nutsedge (*Cyperus rotundus* and *C. esculentus*)

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Yellow and purple nutsedge are problem perennials that resist common control

measures. High temperatures, irrigation, and relatively non-competitive crops combine to greatly increase the severity of nutsedge infestations in the Southwest. We compared the growth and susceptibility of purple and yellow nutsedge to chemical and cultural control measures at several locations in southern California. When not controlled, low initial populations of either species led to heavy infestations later in the season. Purple nutsedge was far more prolific in both tuber production and above-ground growth. Summer rotations that included crops with dense canopies severely decreased nutsedge shoot and tuber growth. Cool-season crops planted into heavy nutsedge infestations in the fall are generally unaffected because nutsedge infestations in the fall are generally unaffected because nutsedge soon enters dormancy and ceases growth. Solarization, or pasteurization of the upper soil layers, was effective in decreasing tuber formation. Tillage effectively spread local infestations over larger areas.

021

Influence of Smooth Pigweed (*Amaranthus hybridus*) and Common Purslane (*Portulaca oleracea*) Densities on Lettuce Yields under Different Phosphorus Fertility Regimes

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The effects of different population densities of smooth pigweed and common purslane were determined in field trials conducted in organic soils. 'South Bay' lettuce was planted in twin rows on 90-cm planting beds. Weed densities used were 0, 2, 4, 8, and 16 weeds per 6 m of row (5.4 m²). Phosphorus (P) was applied broadcast (1200 kg P/ha) and banded 2 inches below each lettuce row (600 kg P/ha). Lettuce fresh weights were collected 8 weeks after emergence. Data collected indicated that P regime and density had significant effects on lettuce yield and quality. For both weeds, yield decreased as density increased. In all cases, lettuce showed greater yields at a given density when grown with P banded than when P was applied broadcast. Critical density for smooth pigweed for P broadcast was between 2 and 4 plants per 5.4 m², whereas this critical density occurred between 8 and 16 plants per 5.4 m² when P was banded. Yield reductions of up to 24.4% and 20.1% occurred at the highest smooth pigweed density for broadcast and banded P, respectively. Two common purslane plants per 5.4 m² were enough to reduce lettuce yields. Banding P helped lettuce to produce significantly more within each common purslane density. Yield reductions of 47.8% and 44.3% occurred at the highest common purslane density for broadcast and banded P, respectively. Apparently, banding P gives an additional advantage to the crop against smooth pigweed and common purslane.

022

Effects of Phosphorus Fertility Regimes and Smooth Pigweed (*Amaranthus hybridus*) and Common Purslane (*Portulaca oleracea*) Removal Times on Lettuce Yields

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The effects of different smooth pigweed and common purslane removal times and two phosphorus (P) fertility regimes were studied under field conditions. Head lettuce (cv. South Bay) in organic soils low in P fertility. Smooth pigweed and common purslane were grown at a density of 16 plants per 6 m of row (5.4 m²) and five removal times (0, 2, 4, 6, and 8 weeks) after lettuce emergence. Phosphorus (P) was applied broadcast (1200 kg P/ha) and banded 2 inches below each lettuce row (600 kg P/ha). Lettuce fresh weights were collected 8 weeks after emergence. When smooth pigweed was removed after 4 weeks, significant reductions (-17%) were observed for P banding. However, these reductions occurred after 2 weeks if P was broadcast. No significant differences were observed if removal was imposed later for P broadcast, whereas lettuce yields gradually decreased as removal time was delayed. These findings indicate that P banding can counteract the negative impact of smooth pigweed on lettuce and may allow farmers to delay weed control (if necessary) for another 2 weeks without significant yield reductions. Common purslane interference did not cause significant lettuce yield reductions as compared to the weed-free control for 6 weeks when P was banded, whereas this was true for P broadcast up to 4 weeks. Phosphorus fertility regime significantly influenced the period of weed interference of common purslane with lettuce, reducing its impact when P was banded.

023

Influence of Nitrogen on the Interference of Purple and Yellow

Nutsedge (*Cyperus rotundus* and *Cyperus esculentus*) with Tomato (*Lycopersicon esculentum*)

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Field trials were conducted in Gainesville, Fla., to determine the influence of nitrogen fertilization on the interference effect of purple or yellow nutsedge on the yield of fresh tomato. Nitrogen (N) rates of 50, 100, 150, 200, 250, 300, and 350 kg·ha⁻¹ were applied broadcast to the soil. Before transplanting, 1-m-wide soil beds were covered with plastic and fumigated with methyl bromide to suppress the growth on undesired weeds. Nutsedge-free and purple or yellow nutsedge-infested tomato plots were separately established. 'Solar Set' tomatoes were transplanted in the middle of the soil beds, 50 cm apart in a single row. In nutsedge-infested plots, weed densities known to cause significant yield reduction in tomato (100 purple nutsedge plants/m² and 50 yellow nutsedge plants/m²) were uniformly established perforating the plastic and transplanting viable tubers in the perforations. Purple and yellow nutsedge tubers were transplanted the same day as tomatoes and were allowed to interfere during the whole crop season. Results indicate that N rates had a significant effect on tomato fruit yield in both nutsedge-free and nutsedge-infested treatments. The presence of either purple or yellow nutsedge significantly reduced the fruit yield of tomato at all N rates. As N rates increased, tomato fruit yield reduction caused by the interference of either nutsedge species also increased. When yellow nutsedge was allowed to interfere with tomato, fruit yield loss was as low as 18% at 50 kg N/ha and as high as 42% at 350 kg N/ha. In purple nutsedge-infested tomato, fruit yield reductions ranged from 10% at 50 kg N/ha to 27% at 350 kg N/ha. N effects on nutsedge-free and nutsedge-infested tomato yields were described by quadratic equations, with maximum tomato fruit yield values being reached between 200 and 250 kg N/ha in both nutsedge-free and nutsedge-infested treatments.

024

Effect of Purple Nutsedge (*Cyperus rotundus*) Population Densities on the Yield of Eggplant (*Solanum melongena*)

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Field experiments were conducted in Santo Domingo, Dominican Republic, to determine the effect of increasing population densities of purple nutsedge (*Cyperus rotundus*) on the yield of eggplant (*Solanum melongena*). Purple nutsedge populations were established by transplanting viable tubers on 1-m-wide soil beds previously fumigated to suppress volunteer weeds. Nutsedge densities were 0, 50, 100, 150, and 200 plants (tubers) per m². 'Jira' eggplants and purple nutsedge were transplanted the same day and were allowed to interfere season-long. Purple nutsedge initial population densities of up to 100 plants per m² did not significantly affect the fruit yield of 'Jira' eggplants. However, nutsedge densities between 100 and 200 plants per m² had a significant impact on eggplant yield, causing a linear decline in fruit yield as purple nutsedge density increased. Eggplant fruit yield loss was 22.3% at the density of 200 nutsedge plants per m².

025

Effect of Purple Nutsedge (*Cyperus rotundus*) Population Densities on the Growth of Transplants of Three Papaya (*Carica papaya*) Cultivars

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Nursery experiments were conducted in Santo Domingo, Dominican Republic, to determine the effect of increasing population densities of purple nutsedge (*Cyperus rotundus*) on the growth of papaya (*Carica papaya*) transplants. Seeds of 'Sunrise Solo', 'Red Lady', and 'Cartagena Ombigua' were separately sown in plastic 12 x 15-cm containers filled with a 1:1 mixture of sand and loamy soil. Viable purple nutsedge tubers were planted 5 cm apart from the papaya seeds. The purple nutsedge initial population densities were 0, 1, 2, 4, and 6 tubers per container. The crop and the weed were sown the same day and allowed to interfere during 6 weeks. Purple nutsedge density had a significant effect on the height, leaf area, and shoot dry weight of the three papaya cultivars. There was no significant difference in the response of the three papaya cultivars to purple nutsedge densities. In general, as purple nutsedge density increased, papaya growth decreased. Nutsedge interference caused papaya shoot dry weight losses of 15% at the density of one plant per container and 73% at six plants per container.

48 POSTER SESSION 1C (Abstr. 026–034) Undergraduate Education

026

Developing a Cyberserve Course

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Through a CyberServe Grant, a WWW Home Page and student/community listserv were established as core communication tools for a special study taught Spring 1997, Hort 4984, Horticulture and the Community: Professional Growth through Volunteering. It incorporated the Blacksburg Electronic Village to easily put student volunteers and the community programs they worked with in direct contact with each other, allowing an exchange of ideas that made them equal partners in their endeavors. It provided direct access to valuable information to understand the principles and philosophy behind programming efforts for both students and community sites where they volunteered. It also was a recruiting tool to involve other students and the Horticulture Club in service-learning projects because students in the class could post "help" notices to entice classmates to participate in defined projects. It provided students with knowledge and experience in the role of the Internet in enhancing the quality of life in their communities. Information installed on the site included reading materials on Horticultural Therapy, children's gardening, community gardening, science education through gardening, and volunteering in these areas; community site descriptions and slides, program activities, goals of program participants, and materials from the program (i.e., selected first-grade drawings of their garden); students participating in the class and information about them; goals, objectives, and management information on the course; and links to relevant information from around the world to put the activities of the students in an international framework.

027

Using Interactive Multimedia to Enhance Student Access to Information on Plant Anatomy and Cell Biology

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An interactive multimedia presentation was developed using authoring software (Authorware from Macromedia) to provide information on plant anatomy and cell biology. Our current course in growth and development of horticultural crops has limited time and lab facilities available for these subjects, yet a good foundation in this area is important to understanding growth and development. This software uses a variety of techniques, including color digital images, illustrations, cartoon animation, and video, to teach aspects of cell biology and different plant cell types. In addition, a review session allows students to interactively test their knowledge of the subject. The software was placed on a Dept. of Horticulture server that provided student access to a folder for course work. Students were able to access the software from anywhere on campus via the University network. Multiple students can use the software simultaneously. The approach of using a local server provided easy access and avoided some of the delays involved with viewing large (1 mb) images found when using the World Wide Web. It took students several weeks to complete the software's modules. Then, students completed an independent plant anatomy lab using the software for reference. Students were required to create a virtual notebook of labeled digital images captured from prepared microscope slides using a microscope attached with a digital camera and linked to a computer. Students found this approach to learning to be challenging, and initial feedback has been very positive.

028

Internships for Students: A College-wide Program with Active Faculty Involvement

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The College of Agriculture, Food and Environmental Science at the Univ. of Wisconsin–River Falls was established in 1968 and has evolved into a successful program, placing more than 200 students on internships annually. Much of the program's success has been attributed to the commitment and active involvement of faculty. Each discipline within the College of Agriculture has one or more faculty designated to participate in the program. These faculty are referred to as the Faculty Coordinators. The Faculty Coordinators assist students in identifying work

sites, collaborate with the student and employer to develop and approve learning objectives and a special internship project, read and evaluate student's on-going progress reports, make on-site visits with the interns and employers and evaluate the student's overall experience. The program is centrally administered through the Program Director, who reports to the Dean of the College. A Program Assistant provides clerical and office support for the Faculty Coordinators and Director. Six faculty members and the Director serve on the College's Internship Committee, which establishes and reviews the policies and procedures affecting the program. The program provides students with an opportunity to integrate classroom theory with practical experience, explore career opportunities, enhance and develop technical, interpersonal, and communication skills, and develop professional contacts.

029

Student Reactions to Technology in the Horticulture Classroom

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A new course, Topics in Home Horticulture, was developed at the Univ. of Missouri in Fall 1996. The course incorporated a mix of traditional lectures, hands-on laboratories, and technological teaching tools. Approximately 1/3 of the lectures were developed with computer presentation software; the remainder with slides or overhead transparencies. Class notes and some reading assignments were posted on the Internet. All students participated in a class e-mail discussion group. The course evaluation assessed students' use of and reactions to technological tools for the class. Students who used the Internet most frequently were more likely to agree that the class web pages enhanced learning. The greatest barrier to use of the Internet web pages was inconvenience of access. Students found the e-mail discussion group most helpful to get answers to questions outside class and to receive comments from peers. No strong preferences were expressed by students for type of lecture format. On a 5-point scale (1 = none to 5 = a lot), students' self-assessment of experience with the Internet as a result of the course increased 1.3 points, on average, while experience with e-mail increased 0.8 points. On the same scale, home horticulture knowledge gained was self-assessed to have increased by an average of 1.4 points.

030

Video and Photography Assignments from Field Trips Build Communication and Teamwork Skills

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Employers of undergraduates tell us there is a need to turn out students with greater communication and teamwork skills in addition to good horticultural and business training. Field trips are an important tool to expose students to the real world of horticulture. The course "Nursery Crop Production" has adopted a class project that enhances these skills and experiences. Teams of three students each are assigned a production nursery to visit and to bring back documentation to the class in the form of an edited video tape and a written report containing pictures. Their report is presented in class and each student receives a composite video tape and written report of all team efforts. Quality of the reports has been remarkable. Each part of the project (video, written report, and class presentation) is graded independently, with all team members receiving the same final grade. The department has purchased video cameras and editing equipment, which are essential to the success of this educational experience. Student evaluations indicate enthusiasm for this approach and the role of video in the class. Copies of finished projects are returned to each nursery for their information. A collection of these projects is being assembled to provide the Nursery and Landscape Crops Extension Specialist with additional information about the production nursery industry.

032

Mini-essays: Using Writing for Fun and Creativity

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Good written communication skills are essential for the success of our graduates. To promote good writing, students in Ornamental Plant Identification classes have been required to write mini-essays, one-page responses to real-world scenarios. Student's responses have been good and their writing has been very acceptable. The mini-essays were, however, just assignments to complete. In an attempt to get students truly involved and passionate about their writing, assignments were designed to illicit creative, fun responses. Students were asked to explain concepts to fourth graders. This brought responses that ranged from exercises

where kids were to stick out their tongues to imitate humming birds, to a short play demonstrating the importance of plant nomenclature. Another assignment asked students to complete a story about the famous detective, Hortus paradoxa. Student responses were incredibly creative, and some of the best writing I have ever seen. In addition, students had fun. It seems clear that, if students know that it is OK to be creative, they will greatly exceed your expectations. Just be prepared to have lots of fun while learning. Samples of the assignments, responses, and what is next will be presented.

033

New Horticulture Curriculum on Growing Media and Soil Amendment Available

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Horticultural schools are always looking for fresh material for their classes. The Canadian Sphagnum Peat Moss Association (CSPMA) has developed a lesson plan entitled *Growing Media and Soil Amendment* that is ideal for horticultural or greenhouse management courses. The teaching plan includes terms and definitions on all types of peatmoss and commonly used terms related to the resource. It discusses characteristics and qualities of world peat resources as well as comparisons of physical, chemical, and biological properties of organic materials used in growth media and as soil amendments. In addition to the research information on peat and other soil amendments, the teaching plan addresses the environmental issues surrounding the use of wetlands, including peatlands and the effects of peat harvesting on the environment. The plan introduces students and instructors to the reclamation and restoration efforts that have been developed and used to preserve the harvested bogs in Canada. The curriculum is divided into two sections: one for the students, which includes handouts and one for the instructor, with more in-depth background information.

034

A Laboratory Exercise to Demonstrate Meristem-tip Culture of Strawberry

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Many horticultural crops are infected with bacterial, fungal, or viral pathogens that reduce yield and/or quality. Recovery and maintenance of pathogen eradicated crops, such as strawberry (*Fragaria x ananassa* Duch.), have been possible following the isolation and culture of apical meristems or meristem-tips in vitro. A laboratory exercise has been developed to provide experience in the procedures required for the isolation, surface disinfection, and in vitro establishment of meristem-tip explants excised from strawberry stolons. Stolons are obtained from greenhouse-grown strawberries ('Sweet Charlie') maintained in hanging baskets under a 14-h photoperiod. Stolons are cut into single-node segments and terminal tips. The leaf blades are removed and the nodal sections are rinsed and then surface-disinfected by successive agitation in 70% ethanol and 1.05% sodium hypochlorite, followed by three rinses in sterile deionized water. In the transfer hoods, each student attempts to isolate meristem-tips and shoot tips of various sizes under high magnification provided by a stereomicroscope. Explants are inoculated onto Murashige and Skoog basal medium (Murashige and Skoog, 1962) supplemented with 30 g/liter sucrose, 80 mg/liter adenine sulfate, 1.0 mg/liter benzyladenine, 1.0 mg/liter indole-3-acetic acid, and 0.01 mg/liter gibberellic acid (GA₃) and solidified as 45° slants with 1.25 g/liter Phytagel and 3.0 g/liter TC agar. Growth responses are monitored weekly. After 6 weeks, students record the percentage of visibly contaminated cultures and number shoots produced per explant. The relationship between initial explant size and in vitro growth is also determined. Students index their cultures for the presence of cultivable bacteria and fungi using sterility test media.

48 POSTER SESSION 1D (Abstr. 035–044) Postharvest—Fruits/Nuts

035

Reducing Irradiation Damage to 'Arkin' Carambola

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Carambolas require quarantine treatment for security against the Caribbean fruit fly (*Anastrepha suspensa* Loew) (CFF) prior to shipment to certain domestic and export markets. Low-dose irradiation is effective for the control of CFF, but carambolas are susceptible to peel injury and quality deterioration at relatively low doses. Peel discoloration, stem-end breakdown, and fruit shriveling were reduced when carambolas were irradiated in polystyrene clam shell packs at 0.15 or 0.5 kGy compared with irradiation in conventional fiberboard packaging. Some pitting was observed at 5°C, but not at higher storage temperatures. Irradiation of carambolas in clam shell packaging increases the tolerance of fruit to peel and quality disorders, and improves the potential of irradiation as a quarantine treatment.

036

Postharvest Quality of Lychee Fruit: Role of Relative Humidity and Panicle

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Pericarp browning, weight loss, and the associated quality deterioration are the unsolved postharvest problems of lychee (*Litchi chinensis* Sonn.). Freshly harvested fruits (Brewster^{*}) were stored ± plastic wrap (99% and 84% relative humidity, RH, respectively) and ± panicle at 5°C for 18 days to simulate commercial handling scenarios. There were no significant losses in pericarp color (L*, hue angle, chroma value), total soluble solids, and total sugars from initial values for wrapped fruits. Wrapped lychees were 100% marketable, compared to 17% for unwrapped fruits. The former retained higher weight, moisture content and total titratable acidity (TTA, pulp), and lower pulp pH. *Colletotrichum* sp., *Cladosporium* sp., and *Alternaria* sp. caused decay in 56% of unwrapped fruits, whereas wrapped fruits were free of decay. Fruits with panicles had significantly higher weight loss (3%) than clipped fruits for both wrapped and unwrapped fruits. Pulp TTA tended to decrease and pH to increase more in fruits with panicle. Postharvest quality of lychee fruits was significantly extended by removing the panicle and maintaining nearly saturated RH during handling and storage.

037

Effectiveness of High-temperature Forced Air on Reducing Growth of Green Mold (*Penicillium digitatum* Sacc.) in Grapefruit

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Export and domestic marketing of grapefruit (*Citrus paradisi* Macf.) can be limited by phytosanitary barriers against fruit fly species and growth of decay organisms, especially green mold (*Penicillium digitatum* Sacc.), during the marketing process. The objective of this research was to identify whether the dose of high-temperature forced air that providing quarantine security against Mexican fruit fly could also beneficially control the growth of green mold during subsequent storage. 'Rio Red' grapefruit were harvested four times in 1995 and nine times in 1996 and challenge-inoculated with 10 L of a 1 x 10⁶ spores/ml spore solution (10,000 spores) of green mold before or after exposure to 46°C forced air for 300 min. Control fruit were challenge-inoculated but not exposed to the heat treatment. The growth of green mold was quantified by measuring lesion diameter after 3 days of storage at 23°C, 80% RH. Grapefruit inoculated prior to the heat treatment developed significantly smaller lesions than fruit inoculated after the heat treatment or fruit not exposed to a heat treatment. The average lesion diameter of fruit inoculated prior to the heat treatment was 2.5 and 0.9 cm, respectively, in 1995 and 1996. The average lesion diameter of fruit inoculated after the heat treatment was similar to non heat-treated, control fruit. Lesion diameter of control and post heat-challenged fruit were 6.4 and 6.1 cm in 1995 and 5.7 and 5.3 cm in 1996. Results suggest reduction in decay be attributed to alteration in the pathogenicity of green mold after exposure to the heat treatment rather than an altered resistance of the fruit to the pathogen.

038

Developing a Maturity Index for New Cherry Cultivars Growing in the San Joaquin Valley

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During the past 5 years, we have investigated the relationship between cherry

skin color stages (light red, 50% bright red, 100% bright, and dark red) measured at harvest and harvest/shipping quality for 'Brooks', 'Tulare', and 'King' cultivars. This relationship was studied with fruit grown in different geographic locations within the San Joaquin Valley (SJV). SSC increased, but titratable acidity levels did not change as cherries matured to the dark skin color. The perception of sweetness, sourness, and cherry flavor by a trained taste panel was related to the different cherry skin color stages. Dark red color developed on cherries picked at earlier color stages after simulated shipment. Pitting and stem browning were the main market life limitations. Pitting, stem browning, and decay were higher on cherries picked at the dark and 100% bright red colors than cherries picked at earlier stages.

039

Changes in Sugars and Volatiles of Ripening Erect Blackberry Fruit

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Erect-fruited blackberries are often described as having a wild blackberry flavor. Flavor can be greatly affected by sugar and volatile composition, neither of which is known for erect-fruited blackberries. This study was done to characterize changes in sugar and volatile composition in ripening blackberries. Blackberries of 'Navaho', 'Arapaho', 'Shawnee', and 'Choctaw' were harvested at red, mottled, shiny, and dull black ripeness stages. Sucrose was found in small amounts (4% to 15%) in all stages of ripeness in all cultivars. Total sugars increased from \approx 20–30 to 60–80 mg/g dry weight as fruit ripened from red to dull black. Fructose and glucose maintained a constant 1:1 ratio with ripeness stage and cultivar. Three of the four cultivars had a linear increase in total sugars with ripening; total sugars increased 4% to 40% as fruit ripened from shiny to dull black. Twenty to 25 volatile peaks were found by headspace gas chromatography in ripening blackberries. Six volatiles, tentatively identified as α -pinene, eugenol, limonene, p-cymene, α -terpinol, and gernaylacetone, appeared in all cultivars, but only in ripe (shiny and dull black) fruit. Few volatile peaks were observed in red (unripe) fruit. Data indicate that blackberries continue to increase in sugars in the latter stages of ripeness and that volatiles unique to ripe blackberries are produced during this period.

040

Postharvest Performance of 'Elegant Lady' Peach Grown with Different Nitrogen Sources

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Fruit quality, storage potential, and consumer acceptance were evaluated for 'Elegant Lady' peach fruit from non-conventional and conventional fertilizer management systems. Conventional treatments were fertilized with synthetic sources of nitrogen (ammonium nitrate), while the non-conventional plots received organic sources of nitrogen such as vetch cover, biosolids compost, grass compost, chicken manure, or steer manure. Fertilization treatments were applied at high (300 N unit per acre) and low rates (100 N unit/acre) 2 years before the first postharvest evaluation. Evaluations were carried out for three seasons. There were no significant differences in fruit firmness (N) measured at different fruit positions, soluble solids concentration (%), pH, titratable acidity (% malic acid), water loss susceptibility (%), rate of softening, red color (%), or inking incidence. The incidence of flesh browning, mealiness, and flesh bleeding was only related to storage time and not to the fertilizer source. Therefore, the storage potential was not affected by the nitrogen fertilizer source. In our in-store consumer preference test during the 1995 season, 950 consumers did not perceive any taste differences between fruit from the different nitrogen fertilizer sources. Despite this, consumers still would prefer to buy fruit produced using an organic source of nitrogen rather than synthetic sources.

041

Antioxidant Potential and Strawberry Preservation

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Plant antioxidants have gained considerable interest because of their im-

portance for the preservation of produce and also because of their therapeutic properties. There is increasing evidence that these compounds protect plant tissues from stress and that they delay senescence. Seven strawberry cultivars were analyzed to investigate the possible relationship between their antioxidant potential and fruit shelf-life. The antioxidant defense systems studied were free radical scavenging enzymes (SOD, catalase, glutathione reductase, GSH, ascorbate peroxidase, ascorbate free radical reductase), ascorbic acid, and ellagic acid. Enzyme assays were performed using spectrophotometric kinetic measurements. Ascorbic acid and ellagic acid were determined by HPLC. The antioxidant potential of the tissues had an incidence on fruit quality and shelf-life. The impact of these antioxidative parameters will be discussed with respect to breeding criteria for reduced perishability of strawberries.

042

Determination of Maximum Maturity for Stone Fruit

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Maximum maturity indices for different packinghouse conditions based on cultivar critical bruising thresholds and bruising potentials were developed for stone fruit cultivars. The critical bruising thresholds, based on fruit firmness, and the bruising probabilities varied among stone fruit cultivars. In general, plums tolerated more physical abuse than yellow-flesh peach, nectarine, and white-flesh peach cultivars. Impact location on the fruit was an important factor in the determination of critical bruising thresholds. Potential sources of bruising damage during fruit packing were located using an accelerometer (IS-100). A survey of different packinghouses revealed that bruising potentials varied from 21 to 206 G. Bruising potential was reduced by adding padding material to the packinglines, minimizing height differences at transfer points, synchronizing timing between components, and reducing the operating speed. Bruising probabilities for the most-susceptible California-grown cultivars at different velocities and Gs have been developed. Development of a practical sampling protocol to determine fruit firmness during maturation was studied.

043

Effects of Heat Treatment on Postharvest Quality of Mango Fruits

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Mango fruits (*Mangifera indica* L.) were harvested at the preclimacteric stage. Fruits were immersed in 38, 42, 46, 50, and 54°C heated water for 30, 60, and 45 min prior to storage at 5°C for 2, 4, or 6 weeks in carton boxes. After storage, they were kept at 20°C. Fruits were evaluated for pulp color, total soluble solids, titratable acidity, β -carotene content, reducing sugars and visible symptoms of chilling injury. Heated water had no significant effect on pulp color parameters (lightness, hue, and chroma). Soluble solids concentration, β -carotene content and reducing sugars were higher in heated than in nonheated fruit after ripening. The chilling index was three-fold lower in treated than nontreated fruit. During storage and after removal at 20°C, hot-water-treated fruits ripened faster than nontreated fruits. Results of this study indicate that mango tolerance to chilling temperatures may increase after prestorage heat treatments.

044

Consumer Acceptance and Quality Characteristics of Disease-resistant Cultivars

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Increased consumer awareness of pesticide usage in fruit production and demand for reduced pesticide residue on produce are major incentives to investigate the integration of disease-resistant apple cultivars into commercial fruit production. Appearance, flavor, and texture are key attributes in determining consumer acceptance of these new cultivars. The objectives of this study were to examine the physical, chemical, and sensory characteristics of five DRCs, 'Liberty', 'McShay', 'NY 75414-1', 'NY 74828-12', and 'NY 65707-19', at harvest and following commercial storage. Consumer panels were asked to indicate their opinion of appearance, flavor, and overall attributes using a 9-point hedonic scale. Firmness, sweetness, and tartness were measured using a 5-point "just right" scale. Sugars, Hunter color, pH, titratable acidity, texture, Brix, and browning were determined. Statistical analysis of the parametric and nonparametric data were performed

using SAS. Significant differences ($P < 0.05$) were seen in titratable acidity, Brix, Hunter color, and texture. 'Liberty' and 'NY 65707-19' received significantly ($P < 0.05$) higher liking scores for overall appearance. Firmness, sweetness, and tartness liking scores decreased over storage. However, 'Liberty' and 'NY 75414-1' maintained acceptable scores for these attributes. 'NY 74828-12' was found significantly lower in degree of browning. Based upon the performance of these cultivars, 'NY 75414-1' and 'Liberty' have the greatest potential for fresh-market consumer acceptability and 'NY 74828-12' may serve as a good processing cultivar due to reduced browning.

48 POSTER SESSION 1E (Abstr. 045–050) Insects & Pests—Cross-commodity

045

Nematicide Trials on Paprika Pepper

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Nematodes (*Meloidogyne* sp.) are a potential problem when paprika peppers (*Capsicum annuum* L.) are grown in fields historically planted to peanuts (*Arachis hypogaea* L.). Nine nematicide treatments were evaluated over 3 years in field experiments on paprika pepper. Materials tested included the chitin nematicide ClandoSan and six chemicals: fosthiazate, carbofuran, aldicarb, oxamyl, fenamiphos, and dichloropropene. Stands at harvest were increased relative to the control by ClandoSan in 2 of 3 years. Other horticultural effects (plant dry mass and fruit yield) were minimal for all nine nematicide treatments. No one nematicide treatment consistently reduced nematode counts at harvest relative to the control. Nematode counts at harvest were greater in plots treated with ClandoSan than in plots treated with any other material in 2 of 3 years. Nematicide treatments were not cost effective under the conditions of these studies.

046

Effects of Girdling by the Threecornered Alfalfa Hopper on Host Plant Growth and Physiology

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The threecornered alfalfa hopper, *Spissistillus festinus* (Say), is a major pest to production of a wide variety of crops. Herbivory by this insect is often highly detrimental because of girdling of petioles and shoots. Although girdling by this hopper has been recorded on a variety of hosts, the physiological effects of girdling have been examined primarily on one host (*Glycine max*). We examined the physiological effects of girdling by four densities of hoppers on *Arachis hypogaea* (L.) cv. Florarunner. Densities of 0, 2, 4, and 6 hoppers per plant were maintained for a 1-week period on peanuts grown in cages in a greenhouse. Effects of hopper herbivory on growth (shoot elongation and increases in plant dry weight) and whole-plant chemistry (carbon, nitrogen, and amino acid analysis) were determined at the end of the 1-week feeding experiments, and again at 2-week intervals until maturation of plants. Differences in plant growth or chemistry were not apparent at the conclusion of the feeding experiment. However, plants subjected to the highest rates of herbivory showed pronounced deleterious effects 2 to 6 weeks after girdling had occurred. Mean shoot growth was decreased by nearly 40% and plant dry weight was reduced by roughly 20%. Foliar nitrogen concentrations were also significantly reduced; peanuts subjected to high rates of herbivory contained 30% less foliar protein than control plants. This delayed response to girdling appeared to be in part attributed to increased rates of shoot and petiole breakage well after girdling occurs. Girdles became more brittle as shoots matured and hardened with maturity. Effects of girdling may be particularly detrimental to yield, as effects are most pronounced as plants are entering the reproductive stage.

047

Enhanced Resistance to West Indian Sweetpotato Weevil (*Euscepes Postfasciatus*) in Transgenic 'Jewel' Sweetpotato with Cowpea Trypsin Inhibitor and Snowdrop Lectin

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Euscepes postfasciatus is one of the most important sweetpotato pests in the South Pacific, Caribbean basin, and some countries of Central and South America. Development of host resistance will greatly improve the effects of integrated pest management (IPM) for this pest. Ten transgenic clones of 'Jewel' sweetpotato with cowpea trypsin inhibitors and snowdrop lectin, developed by Axis Agri. Genetics, Ltd., were assayed for weevil resistance using a no-choice bioassay. A replicated experiment was conducted in the greenhouse. Five storage roots from each clone were infested with five pairs of adults. Non-transformed 'Jewel' was used as a check. Resistance was assessed 60 days after infestation by estimating the percentage of internal damage and the weevil population in the storage roots. A five-grade damage index was recorded. The experiment was repeated twice. Significant enhancement of resistance was found in the transgenic clones. Clone CTI-13 with cowpea trypsin inhibitor and clone PCG-7 with both cowpea trypsin inhibitor and snowdrop lectin demonstrated moderate resistance to *E. postfasciatus*, whereas the non-transformed 'Jewel' was susceptible. This result shows that resistance to *Euscepes postfasciatus* can be achieved through genetic transformation.

048

Alternative Methods to Control Western Flower Thrips (*Frankliniella occidentalis*) in Greenhouse Crops

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Research focused on alternative methods to control Western flower thrips (*Frankliniella occidentalis* Pergande), encompassing chemicals from varying classes, parasitic nematodes, microbial insecticides, and physical/mechanical deterrents. Chemical spray applications were applied weekly for 4 to 6 weeks. Experiment 1 made comparisons between fenoxycarb (Precision), bifenthrin (Talstar), and entomopathogenic nematodes (Biosafe). Experiment 2 compared abamectin (Avid), spinosyn A and D (Spinosad), azadirachtin (neem extract: Margosan-O), and diatomaceous earth (a physical control aimed at deterring pupation). Experiment 3 compared Spinosad, fipronil, and two microbial insecticides (Naturalis-O and Mycotrol). The number of thrips counted in flowers after treatments had been applied indicated that the strict chemical treatments (Avid, Spinosad, fipronil) provided quick knockdown and overall longer-term population control. Microbial insecticides, diatomaceous earth, and nematodes maintained populations at a lower level than the control, but were not as effective as strict chemical controls. Margosan-O, Precision, and Talstar controlled populations at medium levels. For periods when populations may cycle upward, more potent chemicals could be used (Spinosad, fipronil, and Avid) while still avoiding problems associated with more toxic chemicals.

049

Effectiveness of Different Applications of Imidacloprid for the Control of Sweetpotato Whitefly and Muskmelon Yield

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Sweetpotato whitefly (*Bemisia tabaci* Gennadius) is one of the serious pests on cucurbits and causes injury by sucking sap and by the transmission of virus. In Western Mexico, melon and other vegetable crops have been subjected to losses as a result of whitefly feeding and whitefly-transmitted virus infection. Traditional control is based in the Metamidophos and Endosulfan applications (more than 10 times). Recently, Imidacloprid has been reported as new alternative to whitefly control. Thus, this study was conducted to determine the effect of Imidacloprid under different applications methods on sweetpotato whitefly populations and cantaloupe yield. Ten treatments were evaluated: 1) seed + basal stem, 2) seed + soil at 8 cm, 3) seed + soil (near to seed), 4) seed + soil (seedlings emergence), 5) seed only, 6) basal stem, 7) soil (plant emerged), 8) foliage, 9) Metamidophos and Endosulfan (regional application), and 10) control, without application. These were arranged in a randomized complete-block design with four replications. Each replication had four beds 7.5 m long. Number of whitefly adults was determined weekly on 24 plants selected at random for each treatment (two leaves/plant). At 22, 39, 57, and 73 days after showing, the whitefly nymphs/cm² were also counted. Imidacloprid applied to foliage five times showed the best whitefly control during the entire crop season, reducing injury and increasing melon yield at 1346.7 cartons/ha, while Metamidophos and Endosulfan showed an intermediate effect

(1073.6 cartons/ha).

050

Effects of Ovipositional Preference on Distribution of the Xylophagous Leafhopper, *Homalodisca coagulata* (Say)

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Homalodisca coagulata (Say) is a xylem-feeding leafhopper that is the principal vector of many economically important diseases resulting from infection by *Xylella fastidiosa* (i.e., plum leaf scald, phony peach disease). We have previously established that high abundances and high consumption rates of *H. coagulata* occur on host species with high amide concentrations in the xylem fluid. Several lines of research suggest that selection of "marginal hosts" (those that typically have low abundances of leafhoppers) may be influenced by ovipositional, as well as feeding, preferences. In northern Florida, *Euonymus japonica* consistently has the highest densities of eggs and young nymphs, but is only a marginal host for adults. Adults caged on this host feed little and have a short longevity. In contrast, young insects (second instar) caged on the host have high survivorship rates and assimilate dietary nutrients with high efficiency. *H. coagulata* are abundant on *Prunus* germplasm in northern Florida during the month of June, but only occasionally visit *Prunus* after this period. In a study of 10 *Prunus* scion/rootstock combinations, we established that abundances of *H. coagulata* on *Prunus* during the peak period were correlated to leafhopper consumption rates. During summer, when *Prunus* serves as a marginal host, leafhopper abundances are tightly coupled to fecundity rates. Understanding of ovipositional preference may be central to our understanding of *Xylella* acquisition. These preliminary experiments suggest that leafhoppers may sample xylem fluid during ovipositional selection, as they preferentially select ovipositional sites that have proper nutrient profiles for development of young nymphs ("mother knows best"). Although consumption rates are low for marginal hosts, repeated probing for ovipositional preference may contribute to the spread of diseases caused by *X. fastidiosa*.

48 POSTER SESSION 1F (Abstr. 051–067) Growth Regulators—Cross-commodity

051

Influence of Several Container Media Components on Paclobutrazol Efficacy

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A broccoli seedling bioassay was used to compare the activity of paclobutrazol applied at six concentrations to 20 media component samples mixed 1:1 (v:v) with vermiculite. Results indicated that 4-, 5-, and 10-fold higher media paclobutrazol concentrations were required in old composted pine bark, fresh pine bark, and composted pine bark samples, respectively, to achieve the same activity observed in sphagnum peatmoss. Paclobutrazol bioassay activity in coir was similar to the activity observed in peat, while activity in vermiculite and perlite was greater than in peat. In a second trial, paclobutrazol activity was reduced more in the fine (<2 mm) fraction of fresh and composted bark samples than in medium (2–4 mm) or coarse (>4 mm) fractions. In a third trial, petunias grown in a 60% composted pine bark:0% peat mix required a ≈14-times higher drench paclobutrazol concentration to achieve the same size control as petunia grown in a 0% composted bark:60% peat mix. It was concluded that media components differed greatly in their influence on paclobutrazol activity and that the bioassay procedure might serve as a useful tool for predicting media–paclobutrazol interactions.

052

Use of Paclobutrazol to Control Height of Impatiens Grown in Media Containing Compost

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Ornamental horticulture industries have the opportunity to utilize compost products as components in growing media, but heterogeneity among compost products can cause unpredictability in the activity of some growth regulators when applied as a drenches to the growing medium. These experiments evaluated the effect

of 0%, 30%, 60%, or 100% compost (by volume) in the medium on the efficacy of paclobutrazol applied as a drench on *Impatiens wallerana* Hook. In experiment 1, paclobutrazol was applied at active ingredient (a.i.) drench rates of 0, 0.016, 0.032, 0.06, or 0.125 mg/pot 16 days after transplanting impatiens 'Accent Red'. In experiment 2, paclobutrazol was applied at a.i. drench rates of 0, 0.25, 0.50, 1.0, or 2.0 mg/pot 14 days after transplanting impatiens 'Dazzler Punch'. In both experiments, final height and size were reduced by paclobutrazol treatments compared to untreated plants. In experiment 1, shoot dry mass of treated plants was on the average of 0.92 g less than untreated plants, while shoot dry mass, in experiment 2, did not show a significant difference between treated and untreated plants. In both experiments, final height, size and shoot dry mass were significantly different among the media, with the greatest growth in 100% compost.

053

Effect of Hydrogen Cyanamide on Bloom Date, Quality, and Yield of 'Kerman' Pistachios on Three Different Rootstocks

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Hydrogen cyanamide (H_2CN_2) has been shown to effectively substitute for lack of chill in a number of species. A 2% H_2CN_2 solution was applied 24 Feb. 1996 to 24 female *Pistacia vera* cv. Kerman trees, 6 each on *P. atlantica*, *P. integerrima*, and *P. atlantica* x *P. integerrima*, hybrid after a season of inadequate chill (<600 hours < 0.5°C). The trees on *Atlantica* rootstocks were unaffected by the H_2CN_2 application. Trees on the other two rootstocks produced significantly higher yields after treatment with H_2CN_2 . The primary effect of the H_2CN_2 appears to have been to significantly decrease the percentage of blank (empty) nuts.

054

Long-term Effects of Triazol Growth Regulators on Stem Elongation of *Rhododendron* and *Kalmia*

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The persistence of effects of paclobutrazol or uniconazole on stem elongation was determined for several years after large-leaf *Rhododendron* and *Kalmia latifolia* were treated with a single-spray application of these triazol growth-regulator chemicals. Potted plants were treated in the second year from propagation, and transplanted into the field in the following spring. The elongation of stems was measured in the year of application and in the following 2 to 4 years. Treatments with a wide range of doses were applied in 1991, 1992, or 1995. For all except the most-dilute applications, stem elongation was retarded in the year following application. At the highest doses, stem growth was inhibited 2 years following application. The results could be explained by a model of growth regulator action that assumed stem elongation was inversely related to amount of growth regulator applied. The dose response coefficient for paclobutrazol was less than that for uniconazole. The dose that inhibited stem elongation one-half as much as a saturating dose was about 0.5 and 0.05 mg/plant, for paclobutrazol and uniconazole, respectively. The dose response coefficient decreased exponentially with time after application, with an exponential time constant of about 2/year. The model predicted a dose of growth regulator that inhibited 0.9 of stem elongation immediately after application would continue to inhibit 0.5 of stem elongation in the following year.

055

Growth and Development Responses of Flowering Cabbage and Kale Cultivars to Four Growth Retardants

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During the fall of 1993 and 1994, four commonly used growth retardants (B-nine, Cycocel, A-rest, and Bonzi) were compared for their effect on the growth and development of three ornamental flowering cabbage cultivars (white, red, and pink) and two ornamental flowering kale cultivars (frizzy red and red peacock). Two weeks after transplanting, seedlings of each cultivar were sprayed with aqueous solutions of the four growth retardants. Treatments for each cultivar were arranged in a randomized complete block design with 6 replications. Plant height, plant width, and dry weight were the parameters used to measure growth and development. Treatments for each cultivar were rated for head formation and color development. Results showed that all the growth retardants except for Cycocel significantly affected growth and development without any effect on head formation and color development. Bonzi caused the greatest growth suppression.

056

Chrysanthemum Cultivars Differ in Response to Photoperiod when Grown under Far-red Absorbing Filters

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Two chrysanthemum [*Dendranthema x grandiflorum* (Ramat) Kitamura] cultivars, Bright Golden Anne and Spears, were grown in unfiltered sunlight (control) or under filters that removed far-red (FR) light under long- or short-day photoperiods for a total of four treatments. Eight plants from each cultivar were exposed to each treatment. Tips of lateral branches were harvested every 3 days and preserved in formalin, acetic acid, 70% ethyl alcohol (5:5:90 by volume), then observed and photographed under a dissecting microscope. In 'Spears', all short-day treatments developed floral primordia at the same time and rate and the development was normal. Under long days and under FR-absorbing filters, floral primordia initiated and developed normally, but was delayed several days compared to short days. Plants under long days and control filters also developed normal primordia, but at a slower rate than any of the other treatments. In 'Bright Golden Anne', only short-day treatments developed normal floral primordia. Development was the same regardless of filter. Under long days, plants under FR-absorbing filters eventually initiated floral primordia, but development was abnormal. No floral primordia developed under long-day and control filter conditions. In all cases, 'Spears' primordia development was much more rapid than 'Bright Golden Anne'.

057

Improving Fuchsia Cutting Performance by Grafting

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Increased sales have demonstrated a demand for certain popular cultivars of fuchsia. One of the difficulties in meeting the demand for some of these cultivars has been a low production of cuttings. Grafting was investigated as a means to improve cutting production and performance. Tip cuttings of the poor producer 'Little Beauty' were grafted as scions to unrooted cuttings from the more-vigorous cultivars 'Beacon' and 'Dollar Princess', both known to have very well-developed root systems. 'Black Prince', another poor producer with a weak root system, was likewise grafted to unrooted cuttings of the cultivar 'Gartenmeister', another cultivar with a vigorous root system. The grafted cuttings were placed in a white poly tent on the greenhouse bench for 7 to 10 days for the graft union to heal and then placed under mist with bottom heat until roots formed. Controls were cuttings from ungrafted plants of the poor producers and autografts of the poor producers. Cuttings grown from grafted plants of 'Little Beauty' on 'Beacon' or 'Dollar Princess' were ~40% larger than cuttings from autografted or nongrafted plants. In the case of 'Black Prince' grafted to 'Gartenmeister', the resulting cuttings were 100% larger than cuttings grown from autografted or nongrafted plants. The root systems of cuttings from grafted plants developed better than those cuttings from controls.

058

Effect of Nitrogen, Gibberellic Acid, Triadimefon, and Kinetin on the Seedling Growth of Sapodilla (*Achras sapota*) and Tamarind (*Tamarindus indica*)

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Container experiments were conducted in the Dominican Republic to determine the effects of nitrogen, gibberellic acid, triadimefon, and kinetin on the seedling growth of sapodilla (*Achras sapota*) and tamarind (*Tamarindus indica*). Plants were started from seeds on cylindrical plastic containers (20 x 20 cm) filled with an artificial 1:1 mixture of sand and loamy soil, allowing the growth of only one plant per container. Nitrogen rates (0.5, 0.75, and 1.0 g N per plant, applied as ammonium sulfate) were factorially combined with the rates (0, 25, 50, 75, and 100 ppm each) of the regulators. When the plants had three true leaves, nitrogen was applied to the growing mixture, whereas the growth regulators were applied foliarly. Plants were allowed to grow during 60 days after treatment. There were no nitrogen and regulator interactions. Kinetin treatments did not significantly influence shoot dry weight and height in either species. Both species responded with linearly increased height, internode length, and dry weight to increasing GA₃ concentrations. Increasing rates of the growth retardant triadimefon significantly reduced the internode length and total height of sapodilla and tamarind seedlings. These results suggest that gibberellin and triadimefon could be effectively used as a

means to stimulate or retard, respectively, the growth of sapodilla and tamarind.

059

Influence of Folcysteine and Nitrogen on Lettuce (*Lactuca sativa*) Yield

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Greenhouse experiments were conducted in the Dominican Republic to determine the effect nitrogen (N) and the biostimulant folcysteine on the yield of 'Black Seeded Simpson' lettuce. Plants were individually grown in plastic containers filled with loamy soil and treated with combinations of N and folcysteine. N rates (35, 70, 105, 140, 175, and 210 kg/ha) were applied at planting, while folcysteine (0, 100, 200, 300, and 400 ppm) was applied as a foliar spray when the plants had five true leaves. Plants were harvested 50 days after planting. The results show that there was an interaction of the effects of N and folcysteine on lettuce yield. The highest yields were obtained with combinations of 300–400 ppm of folcysteine and 140–210 kg N.

060

Influence of Methanol, Ethanol, and Nitrogen on the Yield of Lettuce (*Lactuca sativa*)

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Greenhouse experiments were conducted in the Dominican Republic to determine the effect of methanol and nitrogen (N) on the yield of 'Black Seeded Simpson' lettuce. Plants were individually grown in plastic containers filled with loamy soil and treated with combinations of methanol, folcysteine. N rates (70, 105, 140, and 175 kg/ha) were applied at planting, and aqueous solutions of either ethanol or methanol (0%, 5%, 10%, 15%, and 20%) were applied as a foliar spray when the plants had five true leaves. Plants were harvested 50 days after planting. There were no significant effects of ethanol or methanol on lettuce yield. Lettuce yield was significantly influenced by N rates, with yield increasing as N rates were higher.

061

Characterization of Shade-avoidance in Chrysanthemum and Genetic Transformation with Phytochrome-A from Oat

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Shade-avoidance in plants can result in tall, spindly, and unmarketable plants. Because plant spacing and shade can signal shade avoidance, we grew chrysanthemum (*Chrysanthemum grandiflora* Ramat, cv. Nob Hill) under two planting densities to characterize the normal plant response to crowding. Plants grew 72 ± 4 cm and developed 17 ± 3 floral branches under 55-cm spacing, while plants grown in close proximity (15-cm centers) grew 78 ± 3 cm and developed 7 ± 1 floral branches under a 12-hour photoperiod. Because phytochrome-A overexpression is known to create dwarf plants, we were interested in transforming 'Nob Hill' to alter its phenotype. Sterile leaf and stem cuttings of 'Nob Hill' were transformed to express phytochrome-A (Phy-A) from oat (provided by R. Vierstra) using *Agrobacterium tumefaciens*. The method of Ledger et al. [Plant Cell Reports 10:195 (1991)] was improved when we used internodal segments as described by Yepes et al. [Plant Cell Reports 14:694 (1995)] for a 58% regeneration efficiency. Transformants were screened by selective media and confirmed by southern blots using monoclonal antibodies provided by R. Vierstra. Transgenic and control plants were grown in a greenhouse at 20°C day and 18°C night temperatures with a 14-hour photoperiod. At 4 weeks old, transgenic plants (11 ± 2 cm) were shorter than control plants (15 ± 3 cm). The use of this new transgenic chrysanthemum for high-density mum production is discussed.

062

Abstract Withdrawn

063

Use of Growth Regulators Improves Germination of 'Jalapeno M' Chile at Supraoptimal Temperatures

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Thermoinhibition has been observed in chile (*Capsicum annuum* L.) transplants grown in greenhouses in southern climates. Hormones have been used successfully as a treatment for thermoinhibition in other vegetable crops. This experiment examined the effects of Ethrel and Release as treatments to improve germination in chile seeds germinated at a supraoptimal temperature. Seeds of 'Jalapeno M' were soaked in solutions of Ethrel at 1.75, 3.0, 7.0, or 10.5 mM concentration or Release at 0.50, 1.0, 2.0, or 3.0 mM concentration, or 16 different combinations of the two growth regulators. The seeds were soaked in the treatment solutions for 40 hours at 25°C. A H₂O-soaked and a non-soaked control were also included. Afterwards, the seeds were rinsed, dried, then germinated in 25°C or 40°C incubators. At 25°C, all treatments reached 98% germination or better after 10 days, indicating that none of the treatments were detrimental to germination. At 40°C, germination percentages among treatments ranged from 0% for the nonsoaked control to 90% for a Release–Ethrel combination. Generally, the combination treatments resulted in germination percentages higher than either Ethrel or Release used alone. Results of these tests in petri dishes indicate the possibility of growth regulators being used to overcome thermoinhibition in chile. A greenhouse study is underway.

064

Auxins Increase Post-transplant Growth of Vinca

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Auxins are commonly used to induce root formation during in-vitro culture of higher plants. Because transplanting is often accompanied by root damage and loss of small roots, auxins also could be beneficial in minimizing transplant shock. *Vinca* (*Cataranthus rosea*) seeds were germinated in a peat-lite growing mix and transplanted into pots (55 mL) filled with a diatomaceous earth (Isolite) 10 days after planting. Pots were then placed in a tray containing 62.5 mL of auxin solution per pot. Two different auxins [indole-acetic acid (IAA) and naphthylacetic acid (NAA)] were applied at rates ranging from 0.01 to 100 mg/L. Post-transplant growth was slow, possibly because of Fe²⁺-deficiencies. Both IAA (1–10 mg/L) and NAA (0.01–10 mg/L) significantly increased post-transplant root and shoot growth. As expected, NAA was effective at much lower concentrations than IAA. At 63 days after transplant, shoot dry mass of plants treated with 0.1 mg NAA/L was four times that of control plants, while 10 mg IAA/L increased shoot dry mass three-fold. High rates of both IAA (100 mg/L) and NAA (10–100 mg/L) were less effective. The highest NAA rate (100 mg/L) was phytotoxic, resulting in very poor growth and death of many plants. These results suggest that auxins may be a valuable tool in reducing transplant shock and improving plant establishment.

065

Effect of Humic Acid Substrate Drenches on Growth and Development of Seedlings

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Cucumis sativus (cucumber), *Pelargonium x hortorum* (geranium), *Tagetes patula* (marigold), and *Cucurbita pepo* (squash) seed were sown into plug cells (5 ml volume) filled with a germination substrate containing peat, vermiculite, and perlite. After the seed were sown, the substrate was saturated with solution containing 0 (deionized water) 2500, or 5000 mg/L humic acid (HA). Additional treatments included seed which were sown into the substrate and saturated with nutrient solutions corresponding to the nutrient concentration of each humic acid solution. Seed were placed in a growth chamber and maintained at 22°C and under a 12-h photoperiod with a PPF of 275 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. After 10 d for cucumber and squash and 14 d for marigold and geranium, plants were harvested and root and shoot fresh mass recorded. Shoot fresh mass was not significantly affected by treatment for any of the species tested. Except for squash, root fresh mass was significantly increased by humic acid treatments. For cucumber, root fresh mass ranged from 0.24 g in deionized water to 0.34 g in 2500 and 5000 mg/L HA. Geranium root fresh mass ranged from 0.03 g in deionized water and 5000 mg/L HA to 0.05 g in 2500 mg/L HA. Marigold root fresh mass ranged from 0.02 g in deionized water to 0.03 g in 2500 and 5000 mg/L HA. Root fresh mass for nutrient controls were similar to those for deionized water.

066

Efficacy of Paclobutrazol Drenches on Growth of Potted Sunflowers Grown in 16.5-cm Pots

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Drench applications of plant growth retardant paclobutrazol were applied at 2, 4, 8, 16, or 32 mg a.i./pot, plus an untreated control to pot sunflowers (*Helianthus annuus* cv. 'Pacino') to determine its effect as a chemical height control. All paclobutrazol concentrations applied significantly reduced plant height by $\approx 27\%$ when compared to the untreated control, but excessively short plants were observed at 16 and 32 mg a.i./pot. Plant diameter was also significantly decreased by $\approx 16\%$ at 2 and 4 mg a.i./pot of paclobutrazol, when compared to the untreated control. Flower diameter decreased by $\approx 4\%$ at 2 and 4 mg a.i./pot of paclobutrazol, but only concentrations ≥ 4 mg a.i./pot were significantly different from the untreated control. Paclobutrazol concentrations had no effect on days from potting to flowering. Drench concentrations of 2 and 4 mg a.i./pot of paclobutrazol produced optimum height control in relation to 16.5-cm-diameter pot size used.

067

Pot Sunflower Growth and Flowering Responses to Foliar Applications of Daminozide, Paclobutrazol, and Uniconazole

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Plant growth retardant (PGR) foliar spray treatments (mg·liter⁻¹) of daminozide at 1000 to 16,000; paclobutrazol from 5 to 80; and uniconazole from 2 to 32 were applied to 'Pacino' pot sunflowers (*Helianthus annuus*) to compare their effectiveness at chemical height control. When the first inflorescence opened, the number of days from seeding until flowering, total plant height measured from the pot rim to the top of the inflorescence, inflorescence diameter, and plant diameter were recorded. Total plant height, plant diameter, inflorescence diameter, and days until flowering were significant for the PGR treatment interaction. Marketable-sized plants grown in the 1.2-liter pots were produced with uniconazole concentrations between 16 and 32 mg·liter⁻¹ or with daminozide concentrations between 4000 and 8000 mg·liter⁻¹. Paclobutrazol foliar sprays up to 80 mg·liter⁻¹ had little effect and higher concentrations or medium drench treatments should be considered.

51 POSTER SESSION 2A (Abstr. 068–084) Breeding & Genetics—Fruits/Nuts, Small Fruit/Viticulture

068

Strawberry Fruit Composition during the Harvest Season

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Fruit composition can be affected by genetic and environmental factors during development and ripening. Red-ripe strawberries were harvested at regular intervals during the harvest season to determine how early or later ripening fruit may vary in composition. The cultivars 'Cavendish', 'Honoeye', and 'Kent' were harvested twice weekly over a 3-week period and FW, %DW, and sugar, acid, and anthocyanin pigment content was measured. The study was repeated for 2 years. Fresh fruit weight declined over the harvest period, while the %DW increased in all cultivars. Although the content of sucrose and glucose (mg/g DW) did not vary among the harvest dates, their content was different among the cultivars. Citric and malic acid content (mg/g DW) was lower in the later harvests, although their content was similar among the cultivars. Total anthocyanin content increased and then declined during the harvest season. Pelargonidin 3-glucoside, the major strawberry anthocyanin, was highest in 'Honoeye', while cyanidin 3-glucoside content was similar among the three cultivars.

069

Interspecific Hybrids Originated from Crossing Asian Wild Strawberries (*Fragaria nilgerrensis* and *F. iinumae*) to *F. xananassa*

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The use of wild species as breeding materials was tried for expanding hereditary variation in strawberry. Some interspecific hybrids setting large fruits

with peculiar aroma have been bred by pollination of *F. vesca* to *F. xananassa*. Although Asian wild diploid strawberries such as *F. nilgerrensis* or *F. iinumae* have not been exploited as a breeding material until the present, the crossing test between cultivated strawberries (8x) and the Asian wild strawberries (2x) were attempted. The interspecific hybrids originated from pollination of *F. nilgerrensis* or *F. iinumae* to *F. xananassa* cv. 'Toyonoka' were all sterile pentaploids. By in vitro colchicine treatment of these sterile hybrids for chromosome doubling, many fruiting interspecific hybrids were produced. In particular, some superior hybrids were obtained from 'Toyonoka' x *F. nilgerrensis*. From the results of RAPD analysis, the interspecific hybrids had the fragments specific for both parents. While their morphological characters were close to 'Toyonoka', they had some characters from *F. nilgerrensis*, such as numerous hair on their petioles and peduncles. Their fruits have good characters that are same level of cultivated strawberry about size, Brix, acidity, and vitamin C content. The flesh is soft and skin color is pale pink. The aroma components are resemble *F. nilgerrensis*, and enrich ethyl acetate. The fragrance of interspecific hybrid like peach is characteristic.

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Some Interesting Traits of European and Asian *Fragaria* Species

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Several interesting attributes have been observed while working with European and Asian species of *Fragaria*. *F. nilgerrensis* has shown immunity to aphids and leaf diseases. *F. iinumae* produces runners that frequently have unusual tap roots. *F. moschata* demonstrated excellent winter hardiness in a water-logged field during an unusually long cold winter (1995–96) in southern Ontario, excellent leaf disease resistance, and high susceptibility to *Botrytis*. When grown in the greenhouse, *F. moschata* fruit taste like a concord grape. *F. pentaphylla* (Guelph P-1 and P-2) displayed unusually bright red-colored fruit that were uniformly wedged, firm, but lacking flavor. *F. pentaphylla* P-1 is extremely vigorous and immune to leaf diseases. *F. nubicola* and *F. daltoniana* are the smallest and least-vigorous plants in the Univ. of Guelph's collection, yet they appear to confer hybrid vigor to their progeny when crossed to other species. *F. daltoniana*'s leaf has a waxy cuticle and dark green color similar to *F. chiloensis*. *F. viridis* has a spicy, cinnamon-like flavor. When *F. viridis* is crossed to most other diploids, powdery mildew and leaf diseases are prevalent. *F. orientalis* crosses easily to synthetic tetraploids, has a flavor similar to *F. viridis* and *F. nubicola*, but is extremely susceptible to viruses. Aroma is quite variable in *F. vesca* with the most desirable originating from Russian accessions.

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Tissue Specificity of 'Chandler' Strawberry Peroxidase Isozymes

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Peroxidase activity in extracts from freeze-dried tissue of *Fragaria x ananassa* Duch. cv. Chandler was highest in tissue-cultured (TC) plants, followed by field-grown (FG) and lowest in greenhouse (GH) plants. Among tissue types, activity was highest in petioles, with leaves second highest. Fruit, root, and crown tissue all exhibited low or no activity. When subjected to isoelectric focusing (IEF), petiole tissue extracts exhibited more isozymes than extracts from other organs regardless of staining substrate. Using 4-chloro-1-naphthol and H₂O₂ as substrates, anionic and cationic isozymes were observed in TC petiole extract with nine isozyme bands ranging in pI from 3.9 to 9.5. In TC leaf extract an isozyme at pI 7.4 was observed that was not present in other organ extracts when H₂O₂ and benzidine, p-phenylenediamine or 3-amino-9-ethylcarbazole were used as substrates. Specific isozymes and number of isozymes varied according to plant organ and developmental stage. Mature leaves and over-ripe fruit appeared to exhibit more activity and a larger number of isozymes than developing tissues of those plant organs.

072

Small Fruit Germplasm Collection in Northeast China

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The wealth of small fruit genetic resources present in China is recognized;

however, very little collection and subsequent incorporation of this germplasm have taken place. From July to Aug. 1996, we collected small fruit germplasm with Chinese colleagues in northeast China. The collection area was primarily in Heilongjiang and Jilin provinces; from the Russian border (53°N) to the North Korean border and south to 42°N. Collections were made in the Changbai Shan, Xio Hinggan Ling, and Da Hinggan Ling mountain ranges. The primary genera of interest included *Rubus*, *Ribes*, *Vaccinium*, and *Fragaria*. In addition, species within *Corylus*, *Actinidia*, *Lonicera*, *Sambucus*, and *Schizandra* were collected along with ornamental trees, herbaceous perennials, and shrubs when available. Seed was shared with our Chinese colleagues. Collections have been deposited within the USDA-ARS National Plant Germplasm System. The most-promising collections included: an extremely large fruited *Rubus crataegifolius* population, many populations of *Vaccinium uliginosum* and *V. vitis-idaea* from a broad geographic range, large samples of *F. orientalis*, and a number of populations of the edible *Lonicera caerulea*. The collected species, collection sites, and observations will be presented.

073

Ploidy Levels of Hardy *Actinidia* Accessions in the U.S. Determined by Flow Cytometry

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The hardy *Actinidia* species represent a source of genetic diversity for improving *A. deliciosa* (kiwifruit) as well as for creating new economically important cultivars through intra- and interspecific crosses. Attempts at breeding in *Actinidia* have been complicated by the existence of intraspecific as well as interspecific variation in ploidy. The haploid chromosome number in *Actinidia* is 29 and diploid (2n=2x=58), tetraploid (2n=4x=116), and hexaploid (2n=6x=174) levels have been identified. Because of the problems encountered when crossing parents differing in ploidy level, it is desirable to know the ploidy levels of plants to be used in breeding. We determined the ploidy levels of 61 *Actinidia* accessions currently available in the U.S., including primarily accessions of relatively winter-hardy species. The 61 accessions, representing eight species and three interspecific hybrids, were screened for ploidy using flow cytometry. Mitotic root tip cells from one plant from each putative ploidy level were examined microscopically to confirm the ploidy level derived from flow cytometry. There were 17 diploids, 40 tetraploids, and 4 hexaploids. Intraspecific variation was not found among accessions of the species *arguta*, *callosa*, *deliciosa*, *kolomikta*, *melanandra*, *polygama*, or *purpurea*. All *kolomikta* and *polygama* accessions were diploid. All *arguta*, *callosa*, *melanandra*, and *purpurea* accessions were tetraploid. *Actinidia deliciosa* was hexaploid. One *chinensis* accession was tetraploid. Two accessions (NGPR 0021.14 and 0021.3), acquired as *chinensis*, were hexaploid and may, in fact, be *A. deliciosa* based on their morphology. 'Issai' (*arguta* x *polygama*) was hexaploid and 'Ken's Red' and 'Red Princess' (both *melanandra* x *arguta*) were tetraploid.

074

Biochemical and Molecular Characterization of 18 *Agrobacterium vitis* Isolates

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Agrobacterium vitis is the causal organism of crown gall in grapevine. Infection is particularly severe in areas that experience winter damage to vines. Improving resistance to *A. vitis* will require a detailed knowledge about this organism. In this study, 18 grapevine isolates of *A. vitis* were collected from different locations near Lubbock, Texas. Isolates were subjected to a phenotypic characterization using 12 biochemical tests, including production of alkali from L-tartrate, production of 3-ketolactose, utilization of citrate, and others. Previously characterized isolates of *A. vitis* and *A. tumefaciens* obtained from the American Type Culture Collection served as positive and negative controls in these assays. Isolates were also evaluated for host range, tumor morphology, and opine utilization, and were compared at the molecular level by restriction fragment length polymorphism analysis of the oncogenic regions of the T-DNA plasmid. Although all isolates were able to metabolize tartrate and grow on Roy-Sasser media, there was much variability based on other tests. Twelve of 18 isolates were able to utilize octopine as a sole carbon source. All isolates tested thus far have been pathogenic on tomato and tests on grapevines are underway.

075

Evaluation of Apple Scab Resistance of *Malus sieversii* Populations from Central Asia

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Resistance to apple scab (*Venturia inaequalis*) in apple cultivar breeding has been derived mainly from the *V_i* gene from *Malus floribunda* 821, which introgresses horticulturally unfavorable characters. *M. sieversii*, now thought to be the primary progenitor of *M. x domestica*, grows wild in many diverse habitats in Central Asia and can have fruit quality comparable to commercial cultivars. Since 1989, four major collections of *M. sieversii* have been made in Central Asia, where scab is endemic. Some seed collections have been made from trees with superior fruit, that were not infected with scab. Over a 6-year period, 3000 seedlings from 220 wild *M. sieversii* trees representing 10 diverse ecosystems in Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan have been inoculated with conidia of five races and two wild types of *V. inaequalis*. Suspensions (270,000 conidia/ml) were applied to 4- to 8-leaved seedlings, which were incubated for 48 h at 19°C with constant leaf wetness. Symptoms for three resistant reactions were assessed 2 to 4 weeks after inoculation: A = chlorosis with crinkling (*V_i* type reaction); B = stellate necrotic lesions (*V_i* type reaction), and N = large necrotic areas (uncharacterized resistant reaction). Results indicated that nearly 20% of the seedlings showed one or more of the resistant reactions. The range of resistance within seedling populations from each of the 220 single-tree sources ranged from 0% to 75%. Significant differences existed among seedlings from each of the ecosystems. Most resistance reactions appeared to be similar to those observed for *V_i* from "Russian seedling." Resistant selections with superior horticultural traits may constitute a genepool for increased efficiency of breeding scab-resistant cvs. This genepool may also be useful to address the breakdown of resistance to *V. inaequalis* race 6.

076

Adaptation of ELISA Test for the Diagnostication of Apple Chlorotic Leaf Spot Virus (CLSV) in Apple Trees

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The purpose of this study was to adapt an ELISA test for diagnosing of "Apple Chlorotic Leaf Spot Virus" (CLSV) in apple trees. This work was carried out at Centro de Pesquisa Agropecuária de Clima Temperado-CPACT/EMBRAPA, Pelotas-RS, Brazil, during the 1996 spring season. The application of ADGEN Diagnostic Systems protocol does not give some positive results from diseased apple trees. The procedure modified by FLEGG & CLARK (1979) gives an unsatisfactory result for color reaction in the positive samples. It means it is necessary to adapt this methodology. When the antigen was obtained from leaves grown from the base to the intermediate position in the stem and grounded with extracting buffer—0.02 M, pH 7.4 (1 g tissue : 3 ml extracting buffer) and polyclonal antisera and antibody alkaline phosphatase conjugate was diluted in coating buffer—0.05 M, pH 9.6 (1 µg antisera or antibody : 500 µl coating buffer) the reaction become more intensive and the test was able to diagnosticate the presence of the pathogen in infected leaves of apple trees.

077

Simple Sequence Repeat (SSR) Variation in a Collection of *Malus* Species and Hybrids

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A diverse collection of 133 *Malus* species and hybrids from the USDA Plant Genetic Resources Unit's core subset collection was screened with five simple sequence repeat (SSR) primer pairs in order to determine genetic identities and overall levels of genetic variation. The number of amplification products (alleles) per locus (primer pair) in this collection ranged from 6 to 39, with some genotypes showing complex banding patterns of up to four products per locus, suggesting that duplication events may have occurred within the genome. Five primer sets unequivocally differentiated all but 10 pairs of genotypes in the collection, with seven of these 10 being pairs of the same species. Within three of the species holdings surveyed, *M. honanensis*, *M. sargentii*, and *M. sikkimensis*, no genetic

variation was revealed with the SSR markers. The discrimination power for the combined loci in this collection was nearly one, which indicates that the likelihood of two genetically different accessions sharing the same alleles at all the loci included in this study would be nearly impossible. Coupled with results from a previous survey of *M. x domestica* accessions, this finding suggests that with five SSR primer pairs, the majority of the *Malus* holdings could be assigned a unique fingerprint identity. The average direct count heterozygosity over all loci was 0.620, ranging in value from 0.293 to 0.871 over individual loci. These heterozygosity counts will be compared with a survey of naturally occurring *M. sieversii* to determine whether current repository holdings are representative of the overall levels of diversity occurring in *Malus*. Information generated with this study, coupled with passport and horticultural data will inform curatorial decisions regarding deaccessioning of duplicate holdings and plans for future germplasm collections.

078

Cryopreservation of Embryonic Axes and Axillary Buds of 'Pineapple' Sweet Orange [*Citrus sinensis* (L.) Osb.] Encapsulated in Alginate Gel

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Economically, citrus is the second most-important fruit crop grown worldwide; thus germplasm conservation of commercial cultivars, as well as of wild relatives, is essential. Presently, citrus germplasm has been conserved mainly in field genebanks. This approach is helpful; however, it is costly, exposes germplasm to climatic and biological hazards, and is not a long-term conservation system. Cryopreservation (conservation in liquid nitrogen, at -150°C to -196°C) is a technique that can ensure long-term storage of plant material. Attempts to cryopreserve citrus are restricted to a few reports, but the results obtained are encouraging. The basic purpose of this study is to define cryopreservation protocols for embryo axes and axillary buds of 'Pineapple' sweet orange using the encapsulation-dehydration method. Embryo axes encapsulated in Na-alginate beads, precultured with high levels of sucrose and dehydrated over silica gel before freezing in liquid nitrogen had 60% survival. No survival was obtained for buds treated the same way, however buds isolated from plants acclimated at 0°C over a 30-day period survived exposure to -20°C when slow cooled at 2°C/hour. Additional experiments will combine cold acclimation, slow cooling and pre-treatment with sugars and other chemical compounds as an attempt to enhance cold hardiness of axillary buds and obtain survival after freezing in liquid nitrogen. Different approaches will be used to increase embryo axes survival rates.

079

Purification and Characterization of a Polygalacturonase-inhibiting Protein from Grapefruit Flavedo

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Polygalacturonase-inhibiting proteins (PGIPs) are believed to be one component of plants inherent defense mechanisms against fungal pathogens. We have purified a PGIP from mature grapefruit (*Citrus paradisi* cv. Marsh) flavedo using ammonium sulfate precipitation, preparative isoelectric focusing and ion exchange chromatography. Two peaks of PGIP activity were separated by isoelectric focusing, one at pH 6-7 and one at pH 9-10. The basic protein was more abundant than the neutral protein and was selected for further purification. The basic protein binds to S Sepharose at pH 6.1 and has an apparent *M_r* of ≈43,000 based on SDS-PAGE analysis. The protein is glycosylated as revealed by binding to ConA sepharose and is serologically similar to PGIPs from bean hypocotyl and pear fruit. Two dimensional PAGE analysis revealed the presence of two bands of similar *M_r* but with slightly different pI's (≈9.0-9.5). The N-terminal amino acid sequence of grapefruit PGIP shows high homology with PGIPs from fruit of other species and with a cDNA clone of PGIP that was isolated from a *Citrus sinensis* cv. Hamlin expression library. Grapefruit PGIP inhibits polygalacturonases from *Aspergillus niger*, and the citrus pathogen *Penicillium italicum*. We are interested in the role of PGIP in resistance of citrus fruit to postharvest decay fungi.

080

Healthy, Precocious, and Fertile Hybrids Obtained from *Microcitrus* spp. (*Citrus ichangensis*)

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Microcitrus is one of five genera that are partially sexually cross-compatible with the genus *Citrus*. The genus *Microcitrus* contains seven species with characteristics that may be valuable for breeding citrus scions and rootstocks, including zygotic embryony, short juvenile period, short fruit maturation time, and resistance to nematodes and *Phytophthora*. However, relatively few F_1 hybrids between *Microcitrus* and *Citrus* have been reported, and most of these have been pollen- and ovule-sterile. Some of these intergeneric hybrids have also been highly susceptible to cold damage. To create a genetic bridge for recombination of useful traits from *Microcitrus* into *Citrus*, two selections of *Citrus ichangensis* (an exceptionally cold hardy species with zygotic embryony and short juvenile period) were hybridized with *Microcitrus warburgiana* and two selections of *Microcitrus inodora*. Seed were collected from these crosses and germinated in a warm greenhouse. A total of 94 *M. inodora* x *C. ichangensis* hybrids and 34 *M. warburgiana* x *C. ichangensis* hybrids were obtained and transplanted to 4-gallon pots in a screenhouse. At 33 months after planting the seed, 42% of the *M. inodora* x *C. ichangensis* hybrids and 67% of the *M. warburgiana* x *C. ichangensis* hybrids had flowered. Pollen germination tests on agar plates indicated that several hybrids produced large quantities of viable pollen. Numerous crosses were completed using some of these F_1 hybrids as pollen and seed parents. Several F_1 hybrids were confirmed to be highly fertile by recovery of healthy F_2 and backcross hybrids with *Microcitrus* sp., *Citrus* sp., *Poncirus trifoliata*, and other *Microcitrus* (*C. ichangensis*) selections.

081

Evaluation of the Genetic Diversity *Castanea pumila* var. *ozarkensis* through Isozyme Analysis and DNA Amplification Fingerprinting

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The genetic diversity within and between four geographic populations of the Ozark chinkapin was evaluated and partitioned in order to gain an understanding of the overall genetic diversity and structure of this species, which will be instrumental for its preservation and germplasm enhancement. Nuts of chinkapin trees along the natural range of the species in the Sylamore Ranger District of the Ozark National Forest in Arkansas were collected and evaluated with isozyme and RAPD markers scattered across the genome. Allozyme differences were detected among the geographic populations. Allele frequencies will be determined and subjected to genetic diversity statistics. A conservation plan will be recommended.

082

Use of 2n Giant Pollen to Produce Nonaploid Japanese Persimmon

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Distribution of pollen diameter of Japanese persimmon cv. Zenjimaruru ($2n = 6x$, $x = 15$) was determined using pollen grains hydrated with CPW solution supplemented with 0.9 M mannitol. Mean diameter of giant pollen grains (65 μ m) was 1.3 times longer than that of normal pollen grains (50 μ m). The occurrence of giant pollen was estimated to be about 5% of the pollen population. The hydrated giant pollen grains could be sorted out from normal pollen grains by filtering through a layer of nylon mesh (62 μ m). Flow cytometric analysis of nuclear DNA content confirmed that giant pollen was unreduced $2n$ pollen. $2n$ giant pollen grains were pollinated to cv. Jiro ($2n = 6x$) callie and plantlets could be obtained from immature embryos excised from seeds 70 days after pollination.

083

Isozyme Analyses of *Musa* Clones Maintained at in Vitro Conditions

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Fifteen clones of banana and plantain of different ploidies, belonging to the Colombian Collection of Musaceae (CCM), maintained at in vitro conditions were characterized. Twenty-three isozyme systems were analyzed using young leaves of micropropagated clones. Eleven systems presented electrophoretic activity:

diaphorase (DIA), esterase (EST), glutamate dehydrogenase (GDH), malate dehydrogenase (MDH), malic enzyme (ME), peroxidase (PRX), phosphoglucosomerase (PGI), phosphoglucuronate dehydrogenase (PGDH), phosphoglucosomutase (PGM), ribulose biphosphate carboxylase (RUB), and shikimate dehydrogenase (SKDH). DIA and RUB isozymes are reported the first time for the genus *Musa*, and ME, GDH, PGDH, and PGI are not reported previously in acrilamide support. A total of 24 loci were identified that encoded at least 50 alleles. The enzymes with greater genetic variability were EST and DIA, with 14 and 10 alleles, respectively—these represent 48% of the polymorphism detected in this study. The systems PGM, SKDH, PGDH, and ME allowed to differentiate clones of *M. acuminata* (bananas AA and AAA) from hybrid clones derived of *M. acuminata* x *M. balbisiana* (plantains AAB and ABB). Otherwise, it was found that materials maintained under in vitro conditions for more than 10 subcultures presented evidence of variation at the protein level. The isozymes that allowed us to observe these changes were: DIA, EST, ME, PGDH, PGM, and SKDH.

084

Nature of Resistance of Pecan Cultivars to Black Pecan Aphids

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Foliar feeding by the black pecan aphid [*Melanocallis caryaefoliae* (Davis)] can cause tremendous economic losses. Evaluations of black aphids on pecan genotypes indicates that both antixenosis and antibiosis-like resistance mechanisms exists. Tests for antixenosis indicated that aphids possess clear preferences for certain genotypes over others and that this preference can be dependent on a water-soluble chemical component of the leaf surface. Aphids also exhibited a "conditioning preference," in which they preferentially feed on genotypes from which they originated. Antibiosis tests indicated that pecan genotypes influence the reproductive success of aphids already possessing a feeding adaptation to those same pecan genotypes; therefore, an evaluation of 30 cultivars for antibiosis indicated that populations developed only 20% as fast on 'Choctaw' and 'Alley' as on 'Desirable' and 'Success'. No cultivar was observed to essentially prevent aphid reproduction.

51 POSTER SESSION 2B (Abstr. 085–089) Cell & Tissue Culture—Fruits/Nuts

085

Influence of Ontological Age on Adventitious Bud and Shoot Formation of Pawpaw [*Asimina triloba* (L.) Dunal] Nodal Explants

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Clonal propagation of pawpaw is currently limited to budding and grafting. A tissue-culture system to rapidly produce clonal material would be valuable for both production and preservation of germplasm. Forced scion wood, shoots from root cuttings, and seedlings were explant sources for ontologically mature, intermediate, and juvenile ages, respectively. Preliminary data indicated that nodal explants had more rapid adventitious shoot formation than shoot tip explants. Disinfestation protocols were developed for each explant source. Nodal explants were cultured on MS medium supplemented with 10 μ M BA and 0.1 μ M TDZ. Within 3 weeks, 60% of the seedling explants had expanded axillary buds, while no bud expansion was observed for explants of either the intermediate or mature sources. By 6 weeks, seedling axillary shoots had elongated and were suitable for subculture. By 8 weeks, multiple adventitious buds and shoots had formed on all seedling explants. At this same time, axillary shoots began to elongate on intermediate source explants, but mature source explants appeared to be recalcitrant. Explant exudation caused medium darkening, but, by reducing the transfer interval from 4 to 2 weeks, discoloration was minimized. Mature source explants were maintained in culture and after \approx 7 months, axillary bud expansion occurred in a small percentage of these explants.

Production of Interspecific Hybrids of Persimmon by Protoplast Fusion

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Interspecific hybrids between *Diospyros glandulosa* ($2n = 2x = 30$) and *D. kaki* cv. Jiro ($2n = 6x = 90$) were produced by electrofusion of protoplasts. Protoplasts were isolated from calli derived from leaf primordia, fused electrically, and cultured by agarose-bead culture using modified KM8p medium. Relative nuclear DNA contents of calli derived from fusion-treated protoplasts were determined by flow cytometry. One-hundred-forty-nine of 166 calli obtained had the nuclear DNA content of the sum of those of *D. glandulosa* and *D. kaki* cv. Jiro. RAPD analysis showed that the 149 callus lines yielded specific bands for both *D. glandulosa* and *D. kaki* cv. Jiro and they appeared to be interspecific somatic hybrid calli. Shoots were regenerated from 63 of the 149 interspecific hybrid calli. PCR-RFLP of chloroplast DNA analysis, flow cytometric determination of nuclear DNA content, and RAPD analysis revealed that the 63 interspecific hybrid shoot lines contained nuclear genome from both the parents but only chloroplast genome from *D. glandulosa*. Microscopic observation of root tip cells confirmed that somatic chromosome numbers of the interspecific hybrids were $2n = 8x = 120$.

Factors Influencing Shoot Regeneration and β -Glucuronidase Expression from 'Royal Gala' Apple Internodes

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Factors influencing regeneration and β -glucuronidase expression from apple (*Malus x domestica* Borkh.) stem internodes were studied as part of a program to develop transgenic 'Royal Gala' apple with improved disease resistance. The early stages of the transformation process were monitored by counting the number of β -glucuronidase (GUS) expressing zones immediately after co-cultivation of explants with *Agrobacterium tumefaciens* supervirulent strain EHA105 (p35SGUS_INT) and by counting the number of GUS-expressing calli developing on explants 2 weeks after co-cultivation. Etiolated shoots were produced from in vitro shoots cultured for 2 weeks in the light followed by 2 weeks in the dark and were compared with shoots cultured for 4 weeks in the light (green shoots). First internodes from etiolated shoots produced three, 10 and 100 times the number of shoots regenerated from second, third, and fourth internodal explants, respectively, and produced seven times the number of shoots compared with similar explants from green shoots. 100% of first internodes from etiolated shoots exhibited GUS-expressing zones and yielded twice as many GUS-expressing zones when compared with leaf explants from green shoots, which exhibited GUS-expressing zones in only 60% of the explants. An average of nine GUS-expressing calli per explant were produced on first internodes from etiolated shoots 2 weeks after co-cultivation.

Callogenesis and Organogenesis as Affected by NAA and Picloram Concentrations under an Aluminum Medium in *Malus prunifolia*

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The apple crop in Brazil is established in acid soils with low pH. This condition leads to high aluminum levels in the soil. The aim of this work was to evaluate the callogenesis and organogenesis of apple rootstock somatic material under aluminum and different auxins concentrations. Internodes of apple rootstock cv. Marubakaido were inoculated in a MS medium containing aluminum ($10 \text{ mg} \cdot \text{L}^{-1}$), BAP ($5.0 \text{ mg} \cdot \text{L}^{-1}$), MS vitamins, myo-inositol ($100 \text{ mg} \cdot \text{L}^{-1}$), sucrose ($30 \text{ g} \cdot \text{L}^{-1}$), and agar ($6.0 \text{ g} \cdot \text{L}^{-1}$). Picloram and NAA were tested at (0, 0.5, 1.0, 1.5, and 2.0 μM). Internodes were inoculated in test tubes and the whole material remained in dark for 3 weeks and then to 16-h photoperiod, $25 \pm 2^\circ\text{C}$ and 2000 lux. NAA-treated explants performed better than picloram ones. Callus intensity was maximized at 0.5 μM NAA. Although the higher percentage of callus formed (91%) occurred for NAA at 1.0 μM and 82% for picloram at the same concentration. NAA-treated explants responded for 62% of regenerated callus, while picloram presented only 6%. NAA also increased the mean number of shoots (3.54) and buds (11.52) as

compared to picloram, which presented 1.40 and 2.78, respectively.

Screening of Mycorrhizal Arbuscular Fungi for Nursery Production of Banana Vitroplants

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In western Mexico, banana is traditionally multiplied by vegetative reproduction in the orchard; recently, micropropagation of this species has increased considerably. Banana has been shown to give a positive response to AM fungal inoculation. However, the selection of efficient AM fungi species, currently propagated in vitro, has not been documented. The selection of the most-effective arbuscular mycorrhizal (AM) fungi for growth enhancement of banana vitroplants is the first step toward development of an AM inoculation system. This work reports the effect of nursery inoculation of *Glomus aggregatum*, *G. clarum*, *G. etunicatum*, *G. intraradices*, *G. monosporum*, *G. mosseae*, and *Gigaspora margarita* on the banana vitroplants growth. Pots (4 kg) containing a mixture of soil and coconut fiber (1:1) sterilized with methyl bromide were used. Treatments were arranged under a fully randomized experimental design with eight replications. The plants were harvested 120 days after inoculation and plant height, number of leaves, leaf area, fresh weight of roots, mycorrhizal colonization, and intensity of infection were measured. *Glomus etunicatum*, *G. monosporum*, *G. mosseae*, and *G. aggregatum* were shown to be the most-effective endophytes. Plant height was increased, as well as the production of banana roots in response to mycorrhizal inoculation with these fungi. On the other hand, *G. intraradices* and *G. clarum* showed low levels of colonization. The data clearly show the most efficient AM fungi for future inoculation studies in nursery banana production.

51 POSTER SESSION 2C (Abstr. 090–100) Growth & Development—Woody Ornamentals/Turf/Tree Fruit

Unique Plant Material for Studying Woody-plant Nitrogen Metabolism

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Temperate woody perennials produce proteins in the stem for seasonal nitrogen (N) storage. In *Populus* species, this seasonal N storage occurs primarily as a 32-kDa Bark Storage Protein (BSP), which can accumulate to 50% of total bark proteins during the winter. Plants of the *Populus tremula x Populus alba* (clone 717) were transformed with the BSP cDNA in antisense orientation (fused to a constitutive promoter), and regenerated lines were screened. Several independent antisense-BSP (A-BSP) lines were selected, which, after 4 weeks of SD photoperiod, showed 70% to 90% reduction in total BSP accumulation compared to the wild-type (WT). A series of experiments were conducted to compare LD growth of one A-BSP line to that of the WT. A-BSP plants showed reduced growth at both 5 and 50 mM ammonium nitrate fertilization. However, the higher N rate eventually resulted in toxicity in WT, but not in A-BSP plants. A-BSP plants grown hydroponically (0.5x Hoagland's) showed altered partitioning with reduced stem length and increased leaf area (Leaf:stem dry-weight ratios were 14.8 and 20.9 for ABSP and WT, respectively). Partitioning to the roots was not different between A-BSP and WT. Proposed functions of BSP in seasonal and LD nitrogen metabolism will be discussed.

Effect of Foliar Application of Nitrogen and Sulfur during Flower Bud Formation on Alternate-bearing of Apple Trees

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Different concentrations of urea and ammonium sulfate were sprayed to 15-

year-old 'Golden Delicious' and 'Redspur Delicious' "on" selected apples trees, after 8, 9, and 10 weeks of full bloom. Leaf samples were taken 1 week before and after sprays for protein analysis with Near Infrared Reflectance (NIR). Percentage of flowering and fruit length-to-diameter ratio (L/D) were measured in both cultivars. Number of fruit only in 'Redspur Delicious' during "on" and "off" years were recorded. Spray of nitrogen and sulfur chemicals increased the leaf protein contents up to a certain extent. Leaf protein content was not significantly affected by spray concentration, time of application, or cultivars. Foliar application of these chemicals at different periods reduced flower density, but did not have a significant effect on fruit L/D ratio. Foliar sprays increased the number of fruits in 'Redspur Delicious' in the "on" year, but did not affect different treatments during the "off" year. The sprays after 8, 9, and 10 weeks of full bloom intensified alternate bearing in the following "off" year.

092

Flower and Fruit Load Influence Blueberry Plant Development and CO₂ Exchange Rate

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Two southern highbush blueberry cultivars, 'Sharpblue' and 'Misty', were used to investigate the influence of varying flower bud density and fruit load on vegetative development, whole-plant canopy CO₂ exchange rate (CER), and leaf CER. Plants were grown in pots and flower buds were removed so that initial flower bud density (flower bud number/total cane length) on a whole-plant basis ranged from 0.05–0.35 flower buds/cm. Vegetative budbreak number, leaf area, and leaf area: fruit ratio decreased with increasing flower bud density. In 'Sharpblue', whole-plant canopy CER measured at fruit ripening decreased with increasing flower and fruit load and decreasing leaf area:fruit ratio, while leaf CER increased with increasing fruit load and decreasing leaf area:fruit ratio. In 'Misty', whole-plant canopy CER measured 4 weeks after full bloom decreased with increasing flower and fruit load, but whole-plant canopy and leaf CER at fruit ripening were similar among the different fruit loads. Average fruit fresh and dry weights increased and the fruit development period decreased with increased leaf area:fruit ratio in both cultivars. These data suggest that carbohydrate source limitations from reduced leaf area development and whole-plant canopy CER lead to decreased fruit fresh and dry weights and delayed ripening in some southern highbush blueberry cultivars.

093

Growth Dynamics of 'Packham's Triumph' Pear Fruits

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The objective of this work was to predict 'Packham's Triumph' (*Pyrus communis* L.) fruit growth as a function of time using an empirical mathematical model. A mature crop was studied at the Experimental Farm of the Comahue National Univ., Rio Negro, Argentina, during the 1992–93, 1993–94, and 1994–95 growing seasons. Trees were selected at random and fruits were collected at weekly intervals. The range of sampling dates was 27 and 178 days after full bloom (DFB). Fresh fruit mass (FM) was measured using an electronic scale (n = 1169). Fruit number/trunk cross-sectional area was also determined; cultural practices were performed according to the local standard program. Equations were developed with SYSTAT procedure. Results showed that the following logistic model provided the most satisfactory fit to the pooled data, as compared to the power and linear models: $FM (g) = 316.081 / (1 + e^{5.030 - 0.039 DFB})$ $R^2 = 0.84$ $P < 0.001$. The accuracy of predictions was tested on an independent crop in the 1995–96 growing season. According to the values of the statistical F test, no significant differences (Pr0.05) were detected between the mean squared deviations of the observed and the estimated values, suggesting that, overall, the model works well. It can provide growers with a means of determining adequate fruit mass at harvest, considering that unless a certain minimum size is obtained, the fruit will be given a lower grade and price.

094

Sugar Metabolism and Relative Enzyme Activities during Fruit Development and Ripening of Papaya

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This study examined the relationship between the activity of fruit enzymes involved in metabolizing sucrose and sugar accumulation during fruit develop-

ment, to clarify the role of these key enzymes in sugar accumulation in papaya fruit. Papaya fruit (*Carica papaya* L. cv. Sunset) were harvested from 14 to 140 days after anthesis (DAA). Fruit dry matter percent, total soluble solids (TSS), and sugar composition and the activity of enzymes: sucrose phosphate synthetase (SPS), sucrose synthetase (SS), and acid invertase were measured. 'Sunset' papaya matured 140 days after anthesis during the Hawaii summer season and in about 180 days in cool season on the same plant. Fruit flesh dry matter percent, TSS, and total sugar did not significantly increase until 30 days before harvest. Sucrose synthetase was very high 2 weeks post-anthesis, then decreased to less than one-third in 42 to 56 DAA, then remained relatively low during the rest of fruit development. Seven to 14 days before fruit maturation, SS increased about 30% at the same time as sucrose accumulation in the fruit. Acid invertase activity was very low in the young fruit and increased more than 10-fold 42 to 14 days before maturation. SPS activity remained very low throughout the fruit development and was about 40% higher in mature-green fruit. The potential roles of invertase and sucrose synthetase in sugar accumulation will be discussed.

095

Reproductive Development in Evergreen vs. Deciduous Blueberry Production System

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Two cultivars of southern highbush blueberry (*Vaccinium corymbosum* interspecific hybrid) were grown in containers under the traditional deciduous production system, or the dormancy-avoiding evergreen production system. In the dormancy-avoiding system, plants are maintained evergreen and do not enter dormancy in the winter. This alleviates the chilling requirement, thus extending the potential growing area of blueberries into subtropical regions. Plants in the evergreen production system were maintained in active growth through weekly or biweekly N fertilization (≈ 21 – 23 g N/ plant per year). Keeping foliage through the year lengthens the duration of the photosynthetic season of the plant and is hypothesized to improve the carbohydrate (CHO) status of the evergreen plants. This, in turn, may decrease source limitations to reproductive development and potentially increase fruit number and/or size. In both cultivars, the evergreen production system advanced the time of anthesis by 3 to 4 weeks compared to the deciduous production system. Plants in the evergreen system initiated 10% to 25% more flower buds than plants in the deciduous system, depending on cultivar. Average leaf area, leaf fresh weight, total above-ground fresh weight, bud density, and cane length were greater in the evergreen plants than deciduous. The evergreen production system increased plant fresh weight and flower bud number compared to the deciduous system, and may ultimately increase yield.

096

'Himrod' Grape Responses to Rowcover Microclimate

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Rowcovers were placed over 'Himrod' grapes during the 1992 and 1993 growing seasons to test the feasibility of manipulating the microclimate temperature sufficiently to bring the covered grapes into full bloom and harvest earlier. The rowcovers were removed from the grapes after fruit set each year. In 1992, the covered grapes bloomed 18 May, 6 days earlier than the open blocks. In 1993, full bloom in the covered grapes occurred on 29 May, 9 days earlier than the controls. However, the advanced bloom of the covered grapes did not result in the expected earlier maturity when compared to the uncovered grapes. Covered grapes did attain a soluble solids maturity index of 18 two to three days earlier than uncovered grapes.

097

Arbuscular Mycorrhizal (AM) Fungal Isolates Differentially Altered Morphology of Young 'Volkamer' Lemon Plants under Well-watered Conditions

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Four AM fungal isolates (*Glomus* sp.) were screened for effects on growth of 'Volkamer' lemon (*Citrus volkameriana* Ten. and Pasq.) under well-watered conditions. Plants were inoculated with an isolate of AM fungi, or non-inoculated. Non-mycorrhizal plants received more phosphorus (P) fertilizer than mycorrhizal

plants because mycorrhizae enhance P uptake. Mycorrhizal and non-mycorrhizal plants were grown in 8-liter containers for 3 months in a glasshouse. Plants were then harvested, and root length colonized by mycorrhizal fungi, leaf P concentration, and plant growth were determined. Root length colonized by AM fungi differed among isolates; control plants were non-mycorrhizal. Leaf P concentration was in the optimal range for all plants; however, plants colonized by *Glomus mosseae* isolate 51C had higher leaf P concentration than non-mycorrhizal plants. Plants colonized by *Glomus* AZ112 had higher leaf P concentration than all other plants. All plants had similar canopy leaf area, shoot length, and shoot dry mass. Plants colonized with AM fungi, except *Glomus mosseae* isolate 51C, had longer root length and greater root dry mass than non-mycorrhizal plants. All mycorrhizal plants had lower shoot:root dry mass and leaf area:root length ratios than non-mycorrhizal plants. Our results showed that under optimal P nutrition and well-watered conditions, AM fungal isolates differentially altered the morphology of citrus plants by stimulating root growth.

098

Gas Exchange and Growth of Selected Transplanted and Non-transplanted Landscape Tree Species

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Gas exchange and growth of transplanted and non-transplanted *Acer platanoides* 'Schwedleri' and *Tilia cordata* 'Greenspire' trees were investigated. This study was conducted on trees planted in 1991 in a field nursery near Logan, Utah. In Spring 1995, three trees of each species were moved with a tree spade to a new location within the nursery and three non-transplanted trees were selected as controls. To simulate landscape conditions, all trees were watered at the time of planting and once per week during the growing season. Pre-dawn water potential, dawn-to-dusk stomatal conductance, mid-day photosynthesis, and growth data were collected over a 2-year period. Transplanted trees of each species were under more water stress (indicated by more negative pre-dawn water potential) than non-transplanted trees. However, pre-dawn water potential of transplanted *A. platanoides* recovered to near non-transplanted levels, while transplanted *T. cordata* did not. Dawn-to-dusk studies in 1995 and 1996 showed that stomatal conductance was lower throughout the day in transplanted trees. Once again, transplanted *A. platanoides* recovered to near non-transplanted levels, while transplanted *T. cordata* did not. A similar trend for mid-day photosynthesis was found for both species in 1995 and 1996. Transplanted trees of each species had less stem area increase, shoot elongation, and total leaf area than non-transplanted trees for each year. These data indicate that transplanted *A. platanoides* can recover to near non-transplant pre-dawn water potential and gas exchange levels earlier, and therefore establish faster, than transplanted *T. cordata*. However, after 2 years neither transplanted tree species were able to fully recover to non-transplanted growth rates.

099

Do Rhizobia Infect Roots of American Yellowwood and Japanese Pagodatree?

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Knowing whether leguminous trees have the potential to nodulate after infection by rhizobial bacteria is important for managing nitrogen (N) applications during tree production and for culture in the landscape. Although 98% of studied species in the Papilionoideae nodulate, the nodulation status of two tree species in this subfamily is uncertain. *Cladrastis kentukea* (Dum.-Cours.) Rudd (American yellowwood) did not form nodules during inoculation studies in 1939 and 1992. Nodules were observed on mature *Sophora japonica* L. (Japanese pagodatree) in Japan and Hawaii in the 1940s, but compatible rhizobia reportedly isolated in Japan are no longer held in bacterial collections. Our objective was to verify further that American yellowwood does not nodulate and to confirm reports that Japanese pagodatree does nodulate. Rhizobia that infect many plant hosts, soil samples and rhizobial isolates from other *Sophora* spp., and soil samples from mature American yellowwood and Japanese pagodatree were used to inoculate 5-day-old seedlings of American yellowwood, Japanese pagodatree, and control species. Soil from indigenous and introduced trees in the continental United States, Hawaii, Japan, and China was used. Inoculated and uninoculated plants were grown for 7 weeks in sterile Leonard jars or clay pots containing perlite and irrigated with sterile, N-free Hoagland's solution. No inoculation treatment elicited

nodulation of American yellowwood or Japanese pagodatree. Our results provide additional evidence that American yellowwood lacks that capacity to nodulate and cast further doubt on nodulation of Japanese pagodatree.

100

Growth of Turfgrasses under Different Levels of Shading

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Turfgrass is grown under a wide range of environmental conditions, especially light conditions. In residential and commercial applications, selecting the appropriate turfgrass depends, in part, upon its performance under differing light conditions. This study was conducted to determine the growth habits of four turfgrasses under different shade treatments. 'Common Bermuda', 'Tif dwarf Bermuda', 'Seashore Paspalum', and 'Z-3' were grown outdoors in pots. 'Z-3' is an attractive new variety of turfgrass for residential lawns. Benches were covered with shade cloth to provide different shade conditions (0%, 30%, and 50% shading). Clippings were taken every 2 weeks and dried to determine growth. Turfgrass growth under the three shade treatments were significantly different. In the 0% and 30% shade treatments, 'Common Bermuda' and 'Seashore Paspalum' had similar growth with their dry weights being greater than that of 'Tif dwarf Bermuda' and 'Z-3'. Under 50% shade, 'Seashore Paspalum' grew significantly greater than the other turfgrasses. 'Common Bermuda' grew significantly less under 50% shade than under 0% and 30% shade. 'Common Bermuda' does well on golf courses because of its fast growth and attractiveness. With its vigorous growth and shade tolerance, 'Seashore Paspalum' can be used for residential lawns. 'Z-3' turfgrass, a relatively new variety for residential lawns, shows slow growth but is desirable because of its tolerance to different shade conditions.

51 POSTER SESSION 2D (Abstr. 101–108) Nutrition—Cross-commodity

101

Growth Response of Marigolds (*Tagetes erecta* 'Hybrid Gold') in Mulched Landscape Plantings

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The effects of a mulch material on nutrient availability remain questionable. As organic materials decompose, the increased activity of microorganisms immobilizes nutrients (particularly nitrogen) to preform this process. The decomposition of mulch material and the activity of microorganisms may then compete for nutrients applied to ornamental species in the landscape. To examine this question, four widely available mulch materials (pine bark, cypress pulp, pine straw, and cottonseed hulls) and three fertilizer application methods (granule, liquid, and time release), which were applied either above or below the mulch, were established. Beds with and without mulch cover and no fertilization were established as controls. Marigolds, *Tagetes erecta* 'Hybrid Gold', were planted within the beds. Growth response was found to be greatest in beds with cottonseed hulls. Cottonseed hulls are reported to have a high nitrogen content of their own that may influence less immobilization of nitrogen for decomposition. Beds using pinebark showed significant reduction in plant growth. Fertilization application method also demonstrated significant differences in plant response. The use of a granule fertilizer produced the greatest growth response although initial plant loss was observed in beds using this method. The fast release nature of granule fertilizer and potential toxicity were the suspected reason for this observation. Growth data indicated plant performance was unaffected by fertilizer placement.

102

Macro- and Micronutrient Levels Associated with Nitrogen and Sulfur Applications to 'Freedom Red' Poinsettia

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In order to understand the effects of reduced nitrogen and sulfur on overall poinsettia plant growth and development, experiments were run to determine the relationship, if any, between nitrogen and sulfur applied and other macro- and

micronutrients. Cuttings of 'Freedom Red' (*Euphorbia pulcherrima* Willd. ex Klotzsch) were grown vegetatively in a peat:perlite:vermiculite mix during the fall and spring. Three levels of sulfur (0, 12.5, 25 ppm) were applied in combination with four levels of nitrogen (50, 100, 200, 275 ppm). The experimental design was a randomized complete block. Leaf samples were analyzed using LECO for nitrogen and ICP-ES for sulfur. X-ray fluorescence was used to determine trends in the nutrient concentration of other macronutrients and micronutrients. Nutrient analyses indicated that all nutrients were present in sufficient quantities. Leaf concentrations of nitrogen, sulfur, potassium, and copper were distinctly higher in spring and fall, while phosphorus, calcium, magnesium, and iron concentrations were higher in fall. The typically subtle effects of sulfur were most obvious in magnesium and calcium leaf concentrations. Phosphorus and calcium concentrations increased at lower levels of applied nitrogen. Concentrations of boron, copper, and manganese also increased strikingly at lower levels of applied nitrogen. Apparently when levels of nitrogen less than 200 ppm are applied, micronutrient uptake increases, suggesting the potential of either luxury consumption or possible toxic effects if too little nitrogen is supplied.

103

Iron Chelate Photodegradation in Fertilizer Solution Affects Foliar Iron and Manganese

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We have shown previously that Fe-chelates incorporated into soluble fertilizers are vulnerable to photodegradation, and that such solutions can cause modifications in root reductase activity. The objective of this research was to determine the effects of Fe-chelate photodegradation under commercial production conditions. Marigolds were grown in a greenhouse and transplanted stepwise from #200 plug trays to 804 packs to 11.4-cm (4.5-inch) pots. Plants were harvested at the end of each stage, and treatments consisted of either irradiated (complete loss of soluble Fe) or non-irradiated fertilizer solutions ranging from 100-400 mg/L N (0.5-2 mg/L Fe). In the plug and pack stages, foliar Fe was significantly lower and Mn significantly higher in plants treated with the irradiated than non-irradiated fertilizer solutions, averaging $97 \mu\text{g}\cdot\text{g}^{-1}$ and $115 \mu\text{g}\cdot\text{g}^{-1}$ Fe, and $217 \mu\text{g}\cdot\text{g}^{-1}$ and $176 \mu\text{g}\cdot\text{g}^{-1}$ Mn, respectively. Fe(III)-DTPA reductase activity of roots of plugs treated with the irradiated fertilizer solution was 1.4-times greater than for roots treated with the non-irradiated fertilizer solution. Leaf dry weight in the plug and pack stages was not affected by treatment, and averaged 0.1 g and 1.2 g per plant, respectively.

104

Effect of Calcium Nutrition on Disease Development and Latent Infection of Bacterial Wilt in Grafted Tomato Seedlings

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To control bacterial wilt of tomato, grafting with resistant rootstocks widely prevails in Japan, but the disease has recently occurred even on grafted plants. Concerning this breakdown of resistance, the experiments were conducted to investigate the effect of Ca nutrition on disease development and latent infection of bacterial wilt in grafted tomato seedlings. Three levels of Ca (0.4, 4.4, or 20.4 mM) in a nutrient solution were applied to grafted seedlings (scion: 'Momotarou', resistant rootstock: 'Hawaii 7998') grown in a phytotron. One week after the Ca treatment, seedlings were inoculated with a 10^8 cfu/ml suspension of *Ralstonia solanacearum* by a stem puncture at the basal stem of the rootstock. The disease incidence was recorded for 21 days. In a second experiment, xylem exudates were collected from decapitated scions of the Ca-treated seedlings 5 days after inoculation. Populations of the pathogen in the exudates were counted by plating on a selective medium. Colonies isolated were reinoculated to susceptible seedlings to check the virulence. The high Ca treatment increased leaf and stem Ca contents, and significantly reduced the disease incidence. While Ca concentrations in the xylem exudates increased with the high Ca treatment, the populations of the pathogen in the exudates were high ($>10^9$ cfu/ml) even at the high Ca treatment. All the colonies isolated were virulent. These results showed that grafted tomato seedlings treated with a high Ca concentration were highly resistant to bacterial wilt, but latently infected.

105

Onion Yield, Quality, and Storage Responses to Phosphorus

and Potassium on a High-phosphorus, Low-pH Muck Soil: Maybe K, but Hold the P

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The influences of preplant, broadcast P and K fertilizer on long-day yellow onion yield, quality, and storage characteristics were evaluated in 1995 and 1996 on a low-pH muck soil in north-central Ohio. Recommendations based on pre-season soil tests indicated the crops would benefit from supplemental K, but not P, in 1995 and also in 1996. In both seasons, broadcast P rates were 0, 67, and 138 $\text{kg}\cdot\text{ha}^{-1}$ P_2O_5 ; K rates were 0, 168 and 336 $\text{kg}\cdot\text{ha}^{-1}$ of K_2O . The 3 x 3 factorial of P and K treatments was replicated four times. Phosphorus rate did not significantly influence yield or quality in either 1995 or 1996. Total yield, percent marketable yield, and the concentration of K in the bulbs increased linearly with K in 1995, even though the highest K application rate exceeded the rate recommended by soil testing by more than $100 \text{ kg}\cdot\text{ha}^{-1}$. Mean bulb size did not differ significantly among K rates. Potassium rate did not affect yield or quality in 1996, a drier year than 1995. After 5 months of commercial storage, onions from all nine treatments harvested in 1995 had similar amounts of rotten or sprouted bulbs, and weight loss. These results support the idea that P applications can be reduced or eliminated on high-P muck soils without reducing yield or quality. Onion response to applied K requires additional study before firm recommendations can be made.

106

Soil Quality Factors Affecting Garlic Production

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Recent demand for high-quality garlic (*Allium sativum* L.) has prompted an interest in growing garlic as an alternative crop in the Upper Midwest. The overall objective of this study was to determine the effects of various amendments on garlic growth and selected soil quality indices in two contrasting soils. Garlic (Rocambo type) was planted in the fall of 1995 on a Kandota sandy loam (5% organic matter) and a Spartan loamy sand (1.5% organic matter). Three treatments replicated three times were tested: 1) a nonamended control, 2) manure compost, and 3) fertilizer application based on a soil test. Scapes were removed on half the plants in each plot and allowed to grow until harvest on the other half. Soil microbial biomass nitrogen (N) and carbon (C) were determined before planting and about 4 weeks after emergence. Within each site, the effect of soil amendments on garlic yield depended on scape removal. Garlic yield in nonamended soil was lowest when scapes were not removed. The effect of scape removal tended to diminish when compost or fertilizer was applied. Overall yields were 35% higher in the sandy loam soil compared to the loamy sand soil. Drought stress occurred during bulbing at both locations. Higher yields in the sandy loam soil were likely due to its higher water-holding capacity. Soil amendments did not consistently affect microbial biomass N and C; however, the sandy loam soil had 2 to 6 times higher biomass N and 3 to 4 times higher biomass C than the loamy sand soil and reflected the higher organic matter content of the sandy loam.

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Lettuce Response and Nitrate-N Leaching to Water and Nitrogen on Sand

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The low desert region of Arizona is the major area of lettuce (*Lactuca sativa* L.) production during the winter. Most lettuce is grown on alluvial valley loam and clay loam soils. There is interest in moving some vegetable production onto sandy soils on the upper terraces (mesa) to partially relieve the intensive production pressure currently being placed on land in the valleys. Water and N management is a major concern in coarse-textured soils. Studies were conducted to evaluate the response of crisphead lettuce to sprinkler-applied water and N fertilizer on a coarse-textured soil ($>95\%$ sand). The experiments were irrigated using a modified lateral irrigation system that applied five levels of water and five levels of N in specified combinations. Nitrate-N concentrations were determined in samples collected in ceramic suction cups placed below the crop rooting zone. Leaching fraction was estimated by frequent neutron probe soil moisture measurements. Lettuce yield increased with water and N but rates required for maximum economic yield exceeded rates typically required on finer-textured valley soils. These data show the potential for large N leaching losses on this coarse-textured soil.

Desert Lettuce Responds to N Rate but Not N Source

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Approximately 30,000 ha of iceberg lettuce (*Lactuca sativa* L.) are produced in the low desert region of the southwestern United States during the fall–winter–spring period each year. During this period, soil temperatures in lettuce beds range from 10 to 30°C. During the cooler part of the growing season, growers typically use nitrate-N sources because they believe they are generally more available for plant uptake. However, limited experimental evidence exists to support this practice. Three field studies were conducted during the 1994–1995 growing season to evaluate the response of iceberg lettuce to N rate and N source. The N sources urea, ammonium sulfate, ammonium nitrate, and calcium nitrate were applied at rates ranging from 0 to 300 kg N/ha. Although lettuce growth, N accumulation, and marketable yield significantly increased by N rate, there were generally no differences due to N source.

51 POSTER SESSION 2E (Abstr. 109–114) Water Utilization & Management—Cross-commodity

109

Effects of Irrigation Nonuniformity on Nitrogen and Water Use Efficiencies in Shallow-rooted Vegetable Cropping Systems

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This research tests the hypothesis that decreasing lateral spacing from 45 to 35 feet in solid-set sprinkler systems increases the uniformity of irrigation water distribution and improves water and N fertilizer use efficiencies. Three different spacings between sprinkler laterals (35', 40', and 45') were set up in three blocks in a 60-acre commercial carrot field in Western Kern County in California's San Joaquin Valley. Determinations of irrigation water distribution uniformity, yields, crop water use, plant growth, and nitrate leaching were made. Mean sprinkler distribution uniformities (DU) were found to be 80.6%, 78.1%, and 86% for the 35-, 40-, and 45-ft spacings, respectively. Total carrot yield and quality did not differ significantly among the three spacings, corroborating the finding that irrigation uniformities were similar among the treatments. Although the three lateral spacings evaluated in this initial experiment did not result in major differences in irrigation uniformity, total yields, or quality, the findings of this initial stage of our research are significant. They point to the need for new assessments of currently used protocols for evaluating sprinkler irrigation management of water and nitrogen fertilizer if they can be confirmed by repeated trials in coming years.

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Use of Citric Industry Waste on Saline Soil

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Amelioration and/or reclamation of saline and non-saline soils is based on the application of high quantities of agrochemical products or high volumes of water, which causes an injury in soil or downward displacement of nutrients to the lower layers in soils. Research was conducted to evaluate the effect of application of citric industry waste on saline and non-saline soil. The waste has an electrical conductivity (EC) of 2.7 dS/m and pH of 3–4.2, 35% is organic material that is readily decomposed. This experiment was carried out on field conditions using applications of three different volumes, T1 = 3200, T2 = 6400, and T3 = 9600 m³·ha⁻¹·m⁻¹ and a control, no-waste, (T0), using just irrigation water (EC = 2.5 dS·m⁻¹). The same treatments were added to non-saline soil. Effect of citric industry waste application in both saline and non-saline soils was similar. In all the treatments, EC was decreased with respect to T0 and soil before application (BA), the largest decrease was found in T3. pH decreased in the top soil layer much more than in the bottom layers. Ions were decreased in all soil profile. Organic matter (OM) was increased in the profile in treatment T1 with respect to

treatment T0, as well as in the top soil layers in T2 and T3, but no changes were detected in the remainder of the layers in treatments T2 and T3. We can suggest that the waste studied can be used in the amelioration of saline and non-saline soils.

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Controlling Root and Weed Growth in a Nursery Crop Sandbed Subirrigation System

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Roots growing out of container drainholes, and weeds growing on the sandbed surface, are the two major problems associated with the use of sandbed subirrigation systems for nursery crop production. Adjusting the water level within the sandbed, application of herbicides to the sandbed surface, placing weed barriers on the sandbed surface, and placing copper hydroxide-treated weed barriers on the sandbed surface were tested to control rooting-out and weed growth. Copper-treated barriers provided the best control of rooting-out and weed growth without reducing the shoot growth of heather, forsythia, or weigela. Several herbicides provided good control of rooting-out and weed growth without reducing the shoot growth of daphne.

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Effects of Flood Irrigation Frequencies on Yield and Quality of 'Lisbon' Lemons in Southwestern Arizona

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A 3-year study (1993–96) was recently completed evaluating the response of 'Lisbon' lemons to various flood irrigation intervals. The irrigation intervals were based on soil moisture depletion (SMD), as calculated from frequent neutron probe soil moisture measurements at various depths. Individual treatments were irrigated when total SMD was 25%, 40%, 55%, and 70% respectively. Results obtained indicate that fruit growth was significantly reduced at the 70% SMD regime. In the first (ring) picks the most frequent (25% SMD) and the frequent (75% SMD) had reduced yields. Combined data from the three years indicated that early yields were maximized at the 40% SMD regime. Differences in fruit quality (peel thickness, percentage juice, solid/acid ratio, etc.) were not generally statistically significant at the 0.05 probability level.

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Evaluation of the Response to Water in Olive

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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, at Caborca, evaporation is greater than rainfall. Because of this, an experiment was conducted in 1992 in which the main objective was to determine the optimum water requirements for olives (table olives). The results indicated that the greatest yield (42.72 kg/tree) was with 35% of the available moisture (AM) in the soil and the lowest yield (24.27 kg/tree) was with 10% of the available moisture in the soil. The total water applied with the 35% of the AM was 197 cm (1.97 m).

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Seasonal Water Use of a Kiwifruit Vine: Measurements and a Model

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We recorded canopy development and stomatal function of a kiwifruit vine for the purpose of calculating the seasonal water use by the crop. Canopy development was described using an empirical "S-shaped" curve fitted to weekly measurements of the vine's leaf area. Stomatal conductance was described using a semi-empirical model based on the incident radiation, and the ambient vapor pressure deficit of the air. These two descriptors, leaf area and stomatal conductance, were combined with meteorological data to calculate vine transpiration via the Penman–Monteith model. Transpiration rates calculated at 30-min intervals were in good agreement with the instantaneous rates of sap flow measured by heat-pulse sensors located in the vine stem. The measured and calculated transpiration remained in concert

throughout the experiment, thereby confirming the Penman-Monteith model as a robust and suitable model to describe the seasonal water use by kiwifruit vines. The model validation enables confident predictions of crop water use and thus aids irrigation allocation for kiwifruit crops.

51 POSTER SESSION 2F (Abstr. 115–121) Propagation—Woody Ornamentals/ Landscape/Turf

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The Effect of Substrate pH on the Rooting of Rhododendron with Subirrigation

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Subirrigation is a viable alternative to mist for the cutting propagation of many woody and herbaceous plants. However, poor success has been reported with rhododendron cuttings. This study evaluated the rooting of two *Rhododendron* cultivars in a subirrigation system maintained at two different levels of substrate pH. Stem cuttings of *Rhododendron* 'PJM' and *R. 'Catawbiense album'* were wounded, treated with Dip 'n Grow (1:10 dilution), and rooted in subirrigated perlite subirrigated with tap water (pH 7.5), or tap water adjusted to pH 4.5 with weak sulfuric acid (1N H₂SO₄). Percent rooting and root ball displacement were recorded after 7 weeks. The pH of the subirrigation system dramatically affected root initiation and development. At pH 4.5 'PJM' cuttings rooted 100% with an average displacement of 7.6 ml; cuttings of 'Catawbiense album' rooted 88% with an average displacement of 12.1 ml. At pH 7.5, 'PJM' cuttings rooted 52.5%, with an average displacement of 0.8 ml, while 'Catawbiense album' rooted 73% with an average displacement of 2.5 ml. A root ball displacement of ≥ 3 ml was judged to be commercially acceptable for rooted cuttings of 'PJM' rhododendron, ≥ 4.5 ml for 'Catawbiense album'. At pH 7.5 only 15% of the 'Catawbiense album' cuttings and none of the 'PJM' cuttings produced commercially acceptable rooted cuttings. At pH 4.5, 83% of the 'Catawbiense album' cuttings and 93% of the 'PJM' cuttings were commercially acceptable. Subirrigation is a suitable method of irrigating rhododendron cuttings during rooting if a low substrate pH is maintained.

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Understanding the Role of Cytokinins in Tissue Proliferation of *Rhododendron* 'Montego'

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Tissue proliferation (TP) is characterized primarily by the formation of galls or tumors at the crown of container-grown rhododendrons propagated in vitro. However, TP of *Rhododendron* 'Montego' is observed initially in in vitro shoot cultures and it is characterized by the formation of multiple shoots with small leaves and nodal tumors. The formation of shoots in 'Montego' TP (TP+) shoot cultures occurs without the presence of exogenous cytokinin in the medium, unlike normal 'Montego' (TP-) shoot cultures, which require cytokinin for shoot growth. Structural studies have shown that tumors are composed of many adventitious buds and parenchyma cells, suggesting that TP is a result of abnormal cytokinin regulation that is controlling tumor and shoot formation. Two approaches are being used to determine if differences in cytokinin concentration and/or metabolism exist between TP+ and TP- shoot cultures. In the first approach, shoot cultures are grown in vitro for 1 week in the presence of tritiated isopentenyladenine (iP). Cytokinin uptake and metabolism are analyzed using HPLC and other analytical methods. Experiments suggest that extensive degradation and N-glucoside conjugation occur in TP+ and TP- shoots, resulting in the removal of most of the exogenous iP. In the second approach, the levels of endogenous cytokinins such as iP, isopentenyladenosine, zeatin, and zeatin riboside, are being measured in TP+ tumors and shoots and in TP- shoots by an ELISA method.

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Effects of Vesicular–Arbuscular Mycorrhizal Fungi on Rooting and Growth of Two Woody Ornamentals

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A commercial inoculum of *Glomus intraradices* Schenk and Smith, a vesicular–arbuscular mycorrhizal fungus, has been used with the objective of studying its effects on rooting and on subsequent growth of two woody ornamental plants (*Juniperus Sabina* 'Blue Danube' and *Cornus sericea* 'Coloradensis'). This inoculum, called *Mycorise*[™], is produced by Premier Peat Co. (Rivière-du-Loup, Québec, Canada) and it contains one propagule/g of *Glomus intraradices*. The cuttings's rooting media was mixed in order to contain 0%, 10%, 20%, 40%, or 80% of inoculum. Hardwood cuttings have been inserted in 65-ml cells and put under a mist until good rooting. For both species used, presence of inoculum in rooting media has not given significant effects during the rooting stage of cuttings, but has given some during the following stage of growth in 6-L containers. The growth of young mycorrhizal plants of *Juniperus* was up to 50% greater than the control after the first season of growth. The young plants of *Cornus* have only showed a tendency to have a higher growth. Moreover, several mineral elements (N, P, Ca, Mn, Zn) were present at higher concentrations on mycorrhizal plants. For roots colonization by the fungus and growth results, the inoculum proportion of the rooting media the most appropriate for *Juniperus Sabina* 'Blue Danube', a slow-rooting species, was 40%, and the most appropriate for *Cornus sericea* 'Coloradensis', a quick-rooting species, was 20%.

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IBA and Environment Affect Rooting of Cotoneaster Cuttings

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Softwood cuttings of *Cotoneaster multiflorus* Bunge were collected on 11 June 1996 from a large specimen shrub located at Manhattan, Kan. Uniform cuttings 12 to 15 cm long were dipped in 0, 5000, 10,000, 15,000, or 20,000 ppm IBA solution for 10 sec and Hormodin[™] #2. Cuttings were stuck in a rooting mix consisting of 30% Canadian sphagnum peat and 70% perlite (v/v). The experiment was conducted in a greenhouse either equipped with a fog generator (Humidifan, turbo XE 1000) or the conventional intermittent mist system. The fog generator and the mist system were operated for 12 hr/day. On 12 Aug. 1996, the experiment was terminated and cuttings were evaluated for percent rooting. Cuttings treated with 5000 ppm IBA rooted 100% either under mist or with the fog system. Twelve percent of the cuttings under mist rooted when treated with no IBA or Hormodin[™] #2, as compared to 50% and 40% under fog, respectively. The rooting quality under the fog system was better than the mist. Rooted cuttings were potted in 15-cm plastic containers filled with Metro Mix[™] 702 and were grown under standard greenhouse environment for several weeks prior to planting outdoors.

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Rooting of Maple Cuttings as Influenced by IBA Treatment

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Softwood cuttings of *Acer saccharum* 'Commemoration', a Caddo maple selection (90-7185), and *Acer truncatum* were collected on 12 July 1996 from specimen trees at the Wichita Hort. Res. Center. Ten uniform cuttings of 14- to 19-cm-long containing four to five leaves were dipped for 10 sec in 0, 5000, 10,000, 15,000, or 20,000 ppm IBA solution and Hormodin[™] #2. Cuttings were rooted in a mix of 30% Canadian sphagnum peat and 70% perlite (v/v) and placed in a greenhouse located at Kansas State Univ. The greenhouse was equipped with a fog generator (Humidifan, turbo XE 1000) that was operated for 12 hr/day from 12 July to 5 Oct. 1996. After 12 weeks, cuttings were evaluated for rooting quality and percent using a visual rating scale of 1–5. 'Commemoration' rooted with all IBA treatments. The control treatment resulted in a 100% rooting, whereas the rooting with 5000 or 10,000 ppm IBA and or Hormodin[™] #2 was 90%. Caddo maple (90-7185) rooted at 89% with control treatment, followed by 78% and 67% with 10,000 ppm IBA and Hormodin[™] #2, respectively. As reported previously, none of the cuttings of this maple, collected on 24 May 1995, had rooted, regardless of hormone treatment. The best rooting for *Acer xtruncatum* was 90% with 5000 ppm IBA and 80% with control and Hormodin[™] #2, respectively.

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Cold Stratification Improves Germination of Katsura Tree

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Katsura tree (*Cercidiphyllum japonicum* Sieb. & Zucc.), an ornamental tree native to Japan and China, is valued for its broad pyramidal form and apricot-yellow

fall leaf color. Another species, *Cercidiphyllum magnificum* (Nakai) Nakai, exists, but is rarely encountered outside of wild populations, except in a pendulous form. Propagation of katsura is by seed germination and softwood cuttings, although little information exists in the scientific literature regarding either method of propagation. To determine conditions for optimal seed germination, we subjected *C. japonicum* seed to a factorial combination of moist stratification and exposure to light. Two seed lots were obtained from the Arnold Arboretum of Harvard Univ., accessions 1150-67 and 882. Half of the seeds in each lot were moist stratified in petri dishes on filter paper for 8 days at 3.5°C. All seeds then were germinated at 25°C with either a daily photoperiod of 15 hr or complete darkness. Those samples not exposed to light were placed in a light-tight container. Germination was defined as the average percentage of seeds per treatment combination that showed the emergence of a radicle. Unstratified seeds germinated at 44.7% over both seed lots. Moist stratification increased germination to 92.0% and 56.7% for 1150-67 and 882, respectively. Light did not affect germination for either seed lot. Optimal seed germination conditions for *C. magnificum* will be determined in future studies. We have shown that moist stratification of katsura seeds improves germination and recommend this method as a means of promoting seed germination.

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Temperature and Light Effects on Germination of Burnet, *Sanguisorba* spp.

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Seeds of three *Sanguisorba* species native to Alaska were germinated in growth chambers with constant air temperatures of 5°, 10°, 15°, 20°, 25°, or 30°C and an irradiance of 150 $\mu\text{M}\cdot\text{m}^{-1}\cdot\text{s}^{-2}$ for an 18-hr photoperiod to identify optimum germination in relation to temperature and light. Four replicates of 100 seeds each were sown onto filter paper in petri dishes in each temperature treatment. At 20°C, four additional dishes per species were enclosed in foil to exclude light. Dishes were arranged at random by species in large clear plastic bags, and daily counts of radicle emergence were recorded. Germination of all three species was fitted to third-order polynomial equations by regression analysis. The predicted optimum germination temperature for *Sanguisorba officinalis* was 25°C; *S. menziesii* was 24°C; and *S. stipulata* was 25°C. Germination was most rapid (days to 50% germination) for each species in the 25°C treatment. *S. stipulata* did not germinate at 5°C, and both *S. stipulata* and *S. menziesii* showed less than 50% germination at 30°C. Seeds of all species germinated as well in darkness as in light.

51 POSTER SESSION 2G (Abstr. 122–126) Low-temperature Stress–Woody Plants

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A Study of Ice Nucleation and Propagation in Cranberry Plant using Infrared Video Thermography

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Infrared video thermography has recently been used to visualize ice nucleation and propagation in plants. At the UW–Madison Biotron facility, we studied the formation of ice in various parts of fruit-bearing cranberry (*Vaccinium macrocarpon* Ait.) uprights. The fruits were at the blush to red stages of ripening. Samples were nucleated at –1 or –2°C with ice-nucleating-active bacteria (*Pseudomonas syringae*). Following nucleation, samples were cooled to –6°C in ≈ 1 hour. The following observations were made: 1) When nucleated at a cut end, ice propagated rapidly throughout the stem and into the leaves at a tissue temperature of about –4°C. However, ice did not propagate from the stem through the pedicel to reach the fruit. During the 1 hour after ice propagation in the stem, the fruit remained supercooled. 2) Within the duration of the experiment, leaves could not be nucleated from the upper surface. Ice from the lower leaf surface did nucleate the leaf, and ice propagated from the leaf to the stem and other leaves readily. 3) Both red and blush berries could only be nucleated at the calyx end of the fruit. 4) Red berries supercooled to colder temperatures and for longer durations than the blush berries. 5) In support of our previous studies, red berries were able to tolerate some ice in their tissue. These observations suggest that: 1) The

upper leaf surface and the fruit surface (other than the calyx end) are barriers to ice propagation in the cranberry plant; and 2) at later stages of fruit ripening the pedicel becomes an ice nucleation barrier from the stem to the fruit. This may contribute to the ability of the cranberry fruit to supercool.

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Inheritance of Low-temperature-induced Cold Acclimation Response in Blueberry

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Mode of inheritance of cold hardiness (CH) in woody perennials is not well-understood. This study was undertaken to determine the mode of inheritance and gene action of CH in blueberry (*Vaccinium* section *Cyanococcus*). Two testcross populations (segregating for CH) derived from interspecific hybrids of *V. darrowii* (drw) x *V. caesariense* (csr) were used. Plants were cold-acclimated by a 4-week exposure to 4°C. Bud CH (LT₅₀) was defined as the temperature causing 50% injury (visual) when subjected to controlled freeze–thaw. Results show that the drw and csr parents had an LT₅₀ of –13° and –20°C, respectively. The F₁ population exhibited mean LT₅₀ of –14.7°C. The csr and drw testcross populations had a mean LT₅₀ of –18° (39 individuals) and –14°C (33 individuals), respectively. Individuals of each population were distributed between parental values with center of distribution skewed toward the testcross parent. Since individuals having LT₅₀s as same as the recurrent parents were present in each population of only 33–39 plants, data suggest that CH is determined by relatively few genes. To determine gene action, the estimates for various genetic parameters (calculated from joint scaling test) were used in generation means analysis to test various models. Results indicate that CH in blueberry can be best explained by simple-additive dominance model, whereas models including epistatic components did not satisfactorily explain the data.

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Hardiness and Ornamental Characteristics of Lacebark Elm Selections

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Numerous cultivars of lacebark elm (*Ulmus parvifolia*) have been introduced recently without adequate testing of their hardiness. A block of commercial cultivars plus numerous experimental numbers were established to observe differences in growth form, ornamental characteristics, and cold hardiness. Laboratory freezing tests were conducted from November to March over a 3-year period to determine acclimation and deacclimation to low temperatures. Stem sections approximately 5 cm long were sealed in test tubes and placed in a low-temperature programmable freezer maintained at 0°C. Samples were cooled by approximately 6°C per hour from 0 to –48°C and held for 1 h at each temperature. Samples were then removed, allowed to thaw at room temperature, and held for 7 to 10 days. Stem samples were sectioned longitudinally to observe browning in xylem and bark tissues. During the winter of 1995–96, no visible injury could be noted on trees in the field in spite of very dry, desiccating weather with temperatures reaching –23°C. Laboratory freezing tests indicated acclimation to –30°C by 18 Dec. 1995 on several cultivars. During warm periods in February, deacclimation occurred on many selections to –18°C, whereas others maintained a killing point of –30°C. Growth form, bark exfoliation, and fall color varied among cultivars.

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Genetic Study of Cold Hardiness in Rhododendron Populations

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Few genetic studies have been conducted on the inheritance of cold hardiness (CH) in woody plants. An understanding of the genetic control of CH can greatly assist the breeder in reducing winter injury. This study was initiated to evaluate the

distribution of CH phenotypes in segregating populations of evergreen rhododendrons. Naturally acclimated leaves from individual plants (parents, F_1 and 47 F_2 progeny) were subjected to controlled freeze-thaw regimes. Using slow cooling rates, leaf discs were cooled over a range of treatment temperatures from -10°C to -52°C . Freezing injury of leaf tissue was assessed by measuring ion-leakage and non-linear regression analysis (data fitted to Gompertz functions) was used to estimate T_{max} , the temperature causing the maximum rate of injury. T_{max} for the parent plants (*R. catawbiense* & *R. fortunei*) and the F_1 cultivar Ceylon, were estimated to be -51.6°C , -30.1°C , and -40.4°C , respectively. CH estimates among F_2 progeny (Ceylon, selfed) were normally distributed from -14.8°C to -41.5°C , with mean of -27.6°C . Most F_2 progeny were less cold-hardy than the tender parent, *R. fortunei*. The apparent reduction in F_2 CH may be caused by the differences in age between the parents (20-year-old mature plants) and F_2 progenies (3-year-old juvenile seedlings). Currently, we are testing age-dependent CH responses in rhododendrons, and are also characterizing CH distributions in a backcross population.

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Effect of Abscisic Acid on Nitrogen Mobilization, Dormancy, and Cold Acclimation in Apple Trees

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Spring-grafted potted 'Fuji'/M26 apple (*Malus domestica* Borkh.) trees were fertigated with Plantex (20N-10P-20K) weekly until 28 Aug., and sprayed with 1000 ppm abscisic acid (ABA) two times at 5-day intervals in early September. Nitrogen concentrations of leaves, bark, wood, and root tissues were analyzed using near-infrared reflectance (NIR) spectroscopy at 20- to 30-day intervals beginning in August. In general, during leaf senescence, the content of leaf nitrogen decreased and stem nitrogen increased. ABA enhanced leaf senescence and the mobilization of nitrogen from the leaves to the stem tissues. ABA significantly enhanced terminal bud set, endodormancy induction, and cold acclimation. Eventually, the controls attained the similar degree of nitrogen concentration in the stem, terminal bud set, endodormancy, and hardness.

101 POSTER SESSION 3A (Abstr. 127-158) Breeding & Genetics-Vegetables

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Feasibility Studies for in Vitro Grafting and Chimera Formation among *Lycopersicon* spp.

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A protocol was developed to make in vitro graft unions among *Lycopersicon* spp., and regenerates from cultured graft unions were evaluated for chimera formation. Young seedlings were preconditioned for 4 to 6 days in liquid 1/2-strength Murashige & Skoog (MS) basal medium supplemented with 8.9 μM benzyladenine and 1.0 μM indole-3-butyric acid. Preconditioned seedlings exhibited increased biomass and enhanced graft union survival. In particular, survival of cleft grafts increased from 37% to 95% with the seedling preconditioning. When graft unions among different genotypes were excised from apex-to-apex in vitro cleft grafts and plated on MS basal medium supplemented with 9.1 μM zeatin and 3.9 μM ancymidol, as many as 100 plantlets were regenerated from a single graft union. However, no chimeric regenerates were recovered, indicating that asymmetric responses to grafting may be a limiting factor to in vitro chimera formation.

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Inheritance of Resistance to Anthracnose Caused by *Colletotrichum coccodes* in Tomato (*Lycopersicon esculentum*)

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Anthracnose, caused by *Colletotrichum coccodes*, is a serious ripe tomato fruit rot disease. Genetic resistance to anthracnose is not available in commercial tomato cultivars, but has been reported in small-fruited Plant Introductions (P.I.),

and with lesser intensity in a number of breeding lines. Transfer of high levels of resistance from these breeding lines or P.I.s to elite materials has proven difficult. Inheritance of resistance has been described as complex with at least six loci influencing resistance reactions. Segregating populations originating from a cross between a susceptible tomato breeding line and a large-fruited breeding line (88B147) with resistance derived from *Lycopersicon esculentum* var. *cerasiforme* P.I. 272636, were evaluated for anthracnose resistance. Analysis of anthracnose resistance in puncture-inoculated fruit indicated small, but significant, additive genetic effects for resistance. Additional populations were developed from crosses of a susceptible inbred processing tomato cultivar with: 1) the resistant P.I. 272636, 2) an unadapted small-fruited resistant line developed from P.I. 272636, and 3) the large-fruited breeding line 88B147, also with resistance derived from P.I. 272636. Small additive effects identified in large-fruited material, in comparison to the resistant P.I., suggests that resistance loci have been lost during germplasm development. This is consistent with the relatively larger lesions observed in large-fruited lines derived from P.I. 272636. Positive correlations were noted between small fruit size and high levels of anthracnose resistance. Identification of molecular markers linked to resistance genes in the respective populations will be discussed.

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Inheritance of Resistance to *Fusarium oxysporum* f. sp. *radicis-lycopersici*, Causal Organism of Fusarium Crown and Root Rot in Tomato from *Lycopersicon pennellii* LA 1277

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Lycopersicon pennellii accession LA 1277 was crossed to tomato (*L. esculentum*) and the F_1 was backcrossed to tomato. Self-pollinated seed was saved from backcross plants and seedlings derived were inoculated with *Fusarium oxysporum* Schlecht f.sp. *radicis-lycopersici* Jarvis and Shoemaker, the causal agent of Fusarium crown and root rot (FCRR). Seed was saved from resistant plants that were self-pollinated and screened until homozygous resistance was verified five generations after the backcross. Three homozygous lines were crossed to Fla. 7547, a tomato breeding line susceptible to FCRR but resistant to Fusarium wilt races 1, 2, and 3. Subsequently, backcrosses were made to each parent and F_2 seed were obtained. The three homozygous FCRR-resistant lines were also crossed to Ohio 89-1, which has a dominant gene for FCRR resistance presently being used in breeding programs. F_2 seed were obtained from these crosses. These generations were inoculated with the FCRR pathogen. The resistant parents, F_1 , and backcross to the resistant parents were all healthy. The backcross to the susceptible parent and the F_2 segregated healthy to susceptible plants in 1:1 and 3:1 ratios, respectively. Thus, the resistance from LA 1277 was inherited as a single dominant gene. This gene was different than the gene from Ohio 89-1 because susceptible segregants were detected in the F_2 generation derived from the two resistant sources.

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Mapping of the *Frl* Locus Conferring Resistance to *Fusarium oxysporum* f.sp. *radicis-lycopersici*(FORL) in Tomato and Identification of RAPD Markers Linked to a New Source of Resistance

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Fusarium crown and root rot of tomato is caused by *Fusarium oxysporum* f.sp. *radicis-lycopersici* (FORL). A single dominant gene (*Frl*) derived from *L. peruvianum* L. (Mill.) was previously identified as a useful source of resistance to FORL. The objective of this research was to identify molecular markers linked to *Frl* and RAPD markers linked to a new source of resistance to FORL being developed from *L. pennellii* (Corr.) D'Arcy accession LA1277. The DNAs of resistant (*Frl*) and susceptible breeding lines were screened for polymorphisms using 1200 RAPD primers. Of these, only 104 yielded polymorphisms between the resistant and susceptible lines. These polymorphisms were then tested on four additional tomato lines homozygous for *Frl* and an additional pair of near-isogenic lines developed by Dr. Laterrot. Only 13 primers still produced consistent polymorphisms between all resistant and susceptible lines. Four of these polymorphisms (RAPD 116, 194, 405, 655) were determined to be linked to *Frl* in an F_2 segregating population using an inoculation procedure devised to clearly differentiate susceptible and

resistant plants. The linkage between *ah* and *Frl* reported by Laterrot [Laterrot and Moretti Tomato Genet. Coop. Rep. 45:29 (1995)] places *Frl* on the long arm of chromosome 9 of the tomato genome. The parent lines were also tested with a sequence tagged site (STS) of TG101, which is tightly linked to *Tm2²* [Young et al., Genetics 120:579-585 (1988)] and yielded polymorphic codominant bands. This STS was also tested on the F_2 segregating population and it cosegregated with the resistance and with the RAPD markers. Breeding of the second source of resistance is still in progress. The DNAs of 30 resistant BC₁F₅ plants derived from LA1277 were bulked and compared to the recurrent susceptible parent DNA using 800 RAPD primers. Of the 800 RAPD primers, 72 yielded consistent polymorphisms. None of the 72 primers were found to produce polymorphisms similar to those identified from the analysis of *Frl*, thus suggesting the possibility different genetic control being involved with FORL resistance from LA1277.

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Heterosis and Inbreeding Depression for Yield of Pickling Cucumber (*Cucumis sativus* L.) Hybrids

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Currently, both hybrid and inbred pickling cucumber cultivars are being grown commercially in the United States. Heterosis for yield in pickling cucumber has been previously reported. However, heterosis has not been repeatable in other studies. The objective of this study was to determine the existence of heterosis and inbreeding depression for yield in pickling cucumber. Six pickling cucumber inbreds ('Addis', 'Clinton', M 12, M 20, 'Tiny Dill', 'Wisconsin SMR 18') were hybridized to form four F_1 hybrid families ('Addis x M 20', 'Addis x 'Wis. SMR 18', 'Clinton' x M 12, M 20 x 'Tiny Dill'). Within each family, F_2 , BC₁A and BC₁B generations were also formed. Thirty plants of each generation within each family were grown in 3.1-m plots for four replications in the spring and summer seasons of 1996 at the Horticultural Crops Research Station in Clinton, N.C. Data were collected at once-over harvest for total, marketable, and early yield in terms of number (1000 fruit/ha) and weight (Mg/ha). In addition to yield, a fruit shape rating was collected for each plot. High parent heterosis for yield (total and marketable fruit weight) was only observed for 'Addis' x 'SMR 18' grown in the summer season. The three other families did not exhibit heterosis for total, marketable, and early yield. Heterosis for shape rating was not observed for any family. 'Addis' x 'Wis. SMR 18' also exhibited inbreeding depression for total fruit weight, marketable fruit weight, early fruit number, and early fruit weight during the spring season and for marketable fruit number and marketable fruit weight during the summer season.

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Downy Mildew Resistance of the Cucumber Germplasm Collection in North Carolina Field Tests

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Downy mildew [*Pseudoperonospora cubensis* (Berk. & Curt.) Rostov] is an important disease in most cucumber (*Cucumis sativus* L.) production areas of the world. Resistant cultivars are available, but higher levels are needed if yield losses are to be avoided. The objective of this experiment was to test all available plant introduction accessions, cultivars, and breeding lines (collectively referred to as cultigens) of cucumber for downy mildew resistance under field conditions in North Carolina. Cultigens were tested in 2 years and two replications under natural field epidemics of the disease. Mean ratings for downy mildew leaf damage ranged from 1.3 to 9.0 on a 0 to 9 scale. The most resistant nine cultigens originated from the U.S., and were primarily adapted cultivars or breeding lines. The most-resistant cultigens, for which multiple-year data were available, were Gy 4, 'Clinton', PI 234517, 'Poinsett 76', Gy 5, 'Addis', M 21, M 27, and 'Galaxy'. The most-susceptible cultigens for which multiple year data were available, were PI 288995, PI 176952, PI 178886, and PI 211985. We classified 17 cultigens as highly resistant (1.3 to 3.0), 87 as moderately resistant (3.3 to 5.0), 311 as moderately susceptible (5.3 to 7.0), and 248 as highly susceptible (7.3 to 9.0) for the 663 cultigens with multiple-year data. No plant introduction accessions were found to be more resistant than the most-resistant elite cultivars and breeding lines tested.

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Resistance in *Cucurbita* spp. to Silverleaf and Sweetpotato Whitefly

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Accessions of both domesticated and wild *Cucurbita* spp. were tested from Jan. to May 1996 in Isabela, Puerto Rico, for resistance to silverleaf and sweetpotato whitefly (*Bemisia tabaci*). None of the accessions tested were completely free of whiteflies, but some accessions were completely free of silverleaf. At 8 weeks, checks of 'Soler' and 'Butternut' had silverleaf ratings of 4.5 and 0.0, respectively (on a 0 to 5 scale, where 0 = no silverleaf). Both checks were highly infected with whiteflies. Wild Cucurbits do not appear to be a good source of whitefly or silverleaf resistance. While no strong correlations were observed between number of whiteflies and degree of silvering, all plants that were highly silvered were also heavily infested with whiteflies. Some plants with little or no silverleaf had many fewer whiteflies. Plants from ≈40 accessions from a total of about 800 were selfed for further evaluation.

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Inheritance of Ear Resistance to European Corn Borer in Sweet Corn

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European corn borer, *Ostrinia nubilalis* Hübner, is an economic pest of sweet corn. Consumer demand for high-quality, insect-free produce with minimal pesticide residue necessitates exploitation of various control options. Ear feeding resistance could reduce insecticide inputs. The inheritance of ear feeding resistance and silk channel length in the F_1 derived from a diallel cross (Griffing's model 1, method 2) of eight breeding stocks describing a wide range of feeding resistance was investigated in field experiments. Feeding damage, based on a 1 (no damage) to 9 (>10% ear damage) visual rating scale, and silk channel length of ears that had been manually infested at the ear tip with *O. nubilalis* were recorded. A significant ($P \leq 0.05$) year by location interaction was found for ear feeding damage and silk channel length. Genotype ear feeding damage and silk channel length differences were significant ($P \leq 0.01$) beyond genotype by environment (year and location) interactions. Mean feeding damage ranged from 2.5 (parents 1 x 7) to 8.8 (parent 2) and mean silk channel length ranged from 1.9 cm (parents 2 x 7) to 9.0 cm (parent 3). Ten of the 28 possible crosses (reciprocals combined) and 1 parent were classed as resistant (damage rating < 3.0). Eleven crosses, including all 7 involving parent 2, and 2 parents were susceptible (damage rating > 4.0). Pearson's correlation analysis indicated lower damage levels were weakly to moderately associated with increased silk channel length for both parents ($r = -0.18$) and progeny ($r = -0.44$). The general combining ability (GCA) component was significant ($P \leq 0.01$) for ear feeding damage, suggesting additive effects control ear feeding damage. GCA and specific combining ability (SCA) effects did not account for silk channel length variability, suggesting strong environmental influences. Improved ear feeding resistance should be possible via recurrent selection with recombination.

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Evaluation of Resistance to Bacterial Wilt and Phytophthora Blight in Peppers (*Capsicum* spp.) Collected in Ghana and Sri Lanka

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Thirty-one *Capsicum* accessions collected in Ghana and 20 *Capsicum* accessions introduced from Sri Lanka were evaluated for resistance to bacterial wilt and to Phytophthora blight. In the evaluation of resistance to bacterial wilt, 12 seedlings per accessions were transplanted to the infected field with *Pseudomonas solanacearum*. Subsequently, an inoculum suspension was poured into the soil at the base of each plant with root wounding. Disease severity of each plant was evaluated using a symptom index of 0 (no symptoms) to 4 (death) scale at 10 weeks after inoculation. In the evaluation of resistance to Phytophthora blight, 20 seedlings per accession were transplanted into a bed, the soil temperature of which was maintained at 28°C after root-dipping inoculation. Disease severity of each plant was evaluated using a symptom index of 0 (no symptoms) to 2 (death) scale at 2 weeks after inoculation. To bacterial wilt, two Ghanaian accessions and 10 Sri Lankan accessions had no symptoms and nine Ghanaian accessions and six Sri Lankan accessions showed some wilted plants, but their disease indices were less than 1. The accessions were regarded as resistant. To Phytophthora blight, two Ghanaian accessions and four Sri Lankan accessions were regarded as weakly resistant. Remaining accessions were regarded as susceptible. 'GJ93/287' collected in Ghana and 'Nil miris', 'MI 1', 'KA 11', introduced from Sri Lanka, were

resistant to bacterial wilt and weakly resistant to Phytophthora blight.

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Randomly Amplified Polymorphic DNA (RAPD) Variation Among Commercial Cultivars and Hybrids of Cabbage (*Brassica oleracea* var. *capitata* L.)

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Randomly amplified polymorphisms (RAPD) were used to assess genetic diversity among five cultivars and 10 hybrids of cabbage (*Brassica oleracea* var. *capitata* L.). One-hundred-forty bands were scored from 15 oligonucleotide decamer primers selected from Operon Techn. kits B, W, X, and Y. The similarity indices between cabbage entries were computed from RAPD data, and these ranged from 0.53 to 0.95. The RAPD data allowed us to identify all the genotypes, even some of those characterized only by few bands. The cluster analysis formed five groups. One of these groups was formed by a single entry characterized by their precocity. The traditional cultivars Chato de Quintal and Chato de Brunswick were included in the same group, together with the Brazilian hybrid 'Astrus'. Four of the six Japanese hybrids, imported and commercialized in Brazil, showed low variability between themselves.

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Screening, Identification, Improvement, and Genetics of Resistance to Bacteria Soft Rot (*Erwinia carotovora*) Disease of Brassica Vegetables

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More than 700 accessions of *Brassica* vegetables were screened for resistance to bacterial (*Erwinia*) soft rot disease using a newly developed testing procedure. Dipping a needle in 2-day-old bacterial culture and pricking petioles of plants gave the most-consistent and distinguishable results in both seedling greenhouse and mature plant field tests. High humidity (100%) and warm temperature (higher than 23°C) are the two essential conditions for this test to be successful. So far, immune material has not been found. In *B. rapa*, less than 7% of the accessions showed some degree of resistance. High correlation was found between seedling greenhouse tests and mature plant field tests. Genetic study showed that soft rot resistance in *B. rapa* is a quantitative trait. The broad-sense heritability was 60% and narrow-sense heritability was 42% in the tested population. Following three cycles of recurrent selection, the resistance level in cycle three population was improved by 2.4 disease score points (1–9 scale) compared to the original parental population and the disease score of the best line in cycle 3 was 2.7 compared to a susceptible check on which the disease score was 8 under greenhouse conditions. Under field conditions, the best cycle three line scored 2.0 in comparison to the susceptible check, which scored 7. From our study, the recurrent selection works well for improving the resistance level to the soft rot disease in *B. rapa*.

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Clonal Propagation of Cauliflower, *Brassica oleracea* var. *botrytis* for Hybrid Seed Production

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Brassica oleracea is an important vegetable crop, which includes fully cross-fertile cultivars such as broccoli, Brussels sprouts, cabbage, cauliflower, collard, kohlrabi, and kale. F₁ hybrids are desirable, as plants grown from hybrid seeds benefit from the heterotic effect of crossing genetically distinct pure lines. But, there is no practical and reliable method to create male sterility for hybrid seed production that is suitable for Brassica vegetables. We have been working to induce nuclear male sterility in cauliflower (*Brassica oleracea* var. *botrytis*) by antisense inhibition of *Bcp1*, a unique anther-specific gene of Brassica. The production of nuclear male-sterile lines will enable male lines with superior agronomic traits to be converted to female parents. Thus, vegetative propagation of parent plants for hybrid seed production by tissue culture is desirable. To achieve this objective, we compared various plant tissues, including stem, petiole, leaf, leaf rib, flower stem, pedicel, flower bud, and petal as explants for tissue culture propagation of an Australian cultivar (B-4) of cauliflower, *Brassica oleracea* var. *botrytis*. Four different MS based media containing different amounts of BAP, NAA, GA₃, and silver nitrate were used. The cultures were incubated at 25°C with a 16-hr

photoperiod. Initial response was visible within 10 days, but percentage callus, root, and shoot formation was scored after 3 weeks of culturing. Of all the explants tested, pedicel explants showed maximum shoot initiation and leaf explant did not respond to regeneration under the conditions tested. The results from these on going experiments will be presented and discussed.

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Construction of a Genetic Linkage Map and Locations of Halo Blight and Brown Spot Resistance Loci in Common Bean (*Phaseolus vulgaris* L.) using RAPD Markers

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Halo blight (HB), brown spot (BS), and rust incited by the bacterial pathogens *Pseudomonas syringae* pv. *phaseolicola* (Psp), *Pseudomonas syringae* pv. *syringae* (Pss) and the fungal pathogen *Uromyces appendiculatus*, respectively, are important diseases of common beans. The objectives were to construct a RAPD linkage map, and to locate HB and BS resistance genes and genes for some other traits. One-hundred-seventy RAPD markers were mapped in 78 RI lines of the cross BelNeb 1 and A 55. Eleven main and nine minor linkage groups were identified. MAPMAKER/QTL, interval mapping, was used to identify genomic regions involved in the genetic control of the traits. One region was found to control HB leaf reactions to strain HB16 while three regions controlled reactions to strain HB 83. These regions accounted for 22% and 18%, 17%, and 17% of phenotypic variation of resistance, respectively. Four putative QTLs were identified for resistance to BS, and accounted for 37%, 26%, 23%, and 19% of the phenotypic variation. Rust resistance was determined by a single major gene to both rust strains US85NP 5-1 and D82vc74fh. However, linked markers were not identified. The *V* gene controlling flower and stem color was tightly linked with the Operon marker O10.620.

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Specific Genomic Regions in Common Bean Condition Resistance to Multiple Pathogens

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A genetic linkage map of 170 RAPD markers mapped across 79 recombinant inbred lines (Dorado and XAN-176) reveal genomic regions that condition multiple disease resistance to fungal (Ashy Stem Blight—*Macrophomina phaseolina*), viral (bean golden mosaic virus—BGMV), and bacterial (common bacterial blight—*Xanthomonas campestris* pv. *phaseoli*) pathogens of common bean (*Phaseolus vulgaris*). A genomic site on linkage group US-1 had a major effect, explaining 18%, 34%, and 40% of the variation in phenotypic reaction to ashy stem blight, BGMV, and common bacterial blight disease, respectively. Adjacent to this region was a QTL conditioning 23% of the variation in reaction to another fungal pathogen, web blight (*Thanatephorus cucumeris*). A second genomic site on linkage group US-1 had minor affect on multiple resistance expression to the same fungal (15%), viral (15%), and bacterial (10%) pathogens. It is unknown whether these specific genomic regions represent a series of linked QTL affecting resistance to each disease separately or an individual locus with pleiotropic effect against all three pathogens.

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RAPD Molecular Markers for the Gene Controlling Seedling Lethality and Plant Crippling in Common Beans

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The genes involved in F₁ seedling abnormal development and lethality in inter-gene pool crosses have been designated as DI₁ (MesoAmerican=MA) and DI₂ (Andean=A) (Shii et al., 1980, J. Hered. 71:218–222). The different degrees of leaf crippling (C) in segregating populations of crosses was due to the interaction between the DI₁ or DI₂ loci, growing environment, and the *lcr* allele (Singh and Molina, 1996, J. Hered., In press). The objective was to identify RAPD markers linked to the genes for crippling (*lcr*) and seedling lethality (DI) using the bulked segregation analysis procedure for F₂ of MA x A crosses. Crosses were made between C lines, FB 10413-24-2, WA 7807-305, and TY 5578-220 and normal (N)

parents and tester stocks for DI_1 and DI_2 genes. The F_2 FB 10413-24-2 x Carioca segregated 13 N:3C. F_3 families segregated 3N:1C. RAPD marker OPB-10 was linked to *Lcr* at 31.2 cM. F_3 families segregated 1N:3C. RAPD marker OP016 was linked to DI_1 at 27 cM. The F_2 WA-7807-305 x Rio Tibagi segregated 3N:1C. RAPD marker OPS-03 was linked to *Lcr* at 32.6 cM.

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RAPD Markers Linked to Major Genes for Common Bacterial Blight and Purple Flower Color in a Tepary Bean Cross

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Common bacterial blight (CBB), incited by *Xanthomonas campestris* pv. *phaseoli* (*Xcp*), is an important disease of common bean (*Phaseolus vulgaris* L.). Tepary bean (*P. acutifolius* A. Gray) is of interest to bean breeders because of resistance to CBB. The objective was to identify RAPD markers linked to major dominant genes for CBB resistance and purple flower color using bulked segregant analysis in an F_2 population from a tepary bean cross Nebr#19 [resistant (R) to CBB and white flower color] x Nebr#4B [susceptible (S) to CBB and purple flower color]. Ten RAPD primers (600 RAPD primers screened) showed polymorphisms between bulked DNA derived from R and S plants. All markers showed coupling linkage with CBB resistance. The RAPD marker of G-14 primer was 5.2 cM distant from the gene for resistance to *Xcp* strain LB-2. The RAPD marker of L-18 primer was 6.8 cM distant from the gene for resistance to *Xcp* strain SC-4A. The RAPD marker of G-14 primer was 26.2 cM distant from the gene for resistance to *Xcp* strain EK-11. Seven RAPD primers showed polymorphisms between bulked DNA derived from purple and white flower plants. All markers showed coupling linkage with the gene for purple flower color. The RAPD marker of Y-6 primer was 3.6 cM distant from the gene for purple flower color.

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Breeding Great Northern and Pinto Dry Beans with Multiple Disease Resistance Combined with Improved Seed Quality, Adaptation, Yield, and Plant Type

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Common bacterial blight (CBB), rust (RU), and white mold (WM) are serious diseases of great northern (GN) and pinto (P) beans in Nebraska and Colorado. The bacterial diseases halo blight (HB) and brown spot (BS) are sporadic. Severe Fe-induced leaf chlorosis (Fe ILC) occurs on calcareous sites. Separate inoculated disease nurseries are used to screen for resistance to the pathogens causing the above diseases. Yields and seed quality of lines are also determined in non-disease trials. Sources of exotic resistance to the above pathogens and to Fe ILC have been identified and their inheritance determined. A non-structured recurrent selection scheme has mainly been used, occasionally with a backcross program, to combine high levels of the desired traits. Selection for highly heritable traits such as seed size, shape and color, maturity, plant architecture, and RU resistance occurs in early generations while traits of low heritability, such as CBB resistance, WM avoidance, yield, seed coat cracking resistance, and canning quality, are evaluated in separate replicated tests over several years and finally for yield in on-farm trials. A number of multiple disease resistant, high-yielding, well-adapted GN and P lines are or will be released; P 'Chase' (on about 30,000 acres in 1996) and GN WM 3-94-9 (for possible release).

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Development of Pinkeye-type Southernpeas with Green Cotyledons

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A breeding program was initiated in 1990 to develop a pinkeye-type southernpea [*Vigna unguiculata* (L.) Walp.] cultivar homozygous for the *gc* gene conditioning green cotyledons. The pinkeye is the leading cultivar class of southernpea grown in the U.S., and there is considerable interest in converting pinkeye germplasm to green cotyledon phenotypes because a cultivar homozygous for the *gc* gene can be harvested at the near-dry seed stage of maturity without loss of the seed's fresh green color. Seeds containing embryos homozygous for the *gt* gene are easily identified, and this ability to select in the seed stage greatly facilitated breeding efforts. A total of 25 advanced breeding lines (F_9 and F_{10}) were

evaluated in preliminary field tests in 1995, and the experimental line US-858 was selected for seed multiplication, field testing, and raw product evaluation in 1996. The results of 1996 replicated yield trials conducted in South Carolina and seed multiplication plantings grown in El Salvador, Georgia, and Florida indicate that the maturity, seed, and yield characteristics of US-858 are comparable to those of the leading pinkeye-type cultivars. Raw product evaluations were conducted at a commercial freezing facility in Georgia, and the results indicate that US-858 produces an excellent processed product. The results of field inoculation tests conducted in Georgia indicate that US-858 is resistant to blackeye cowpea mosaic virus, the major pathogen of southernpea in the U.S.

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Affinity Grouping of Lentil Accessions through Comparative Electrophoresis of Seed Proteins

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The comparison of the electrophoretic patterns of seed polypeptides and basic proteins of 40 lentil germplasm accessions revealed a wide qualitative and quantitative variation that allowed the individual characterization of all the genotypes. The statistical analysis of the variation and the clustering of the samples by multivariate methods allowed the construction of five affinity groups that were consistent with the origin and genetic relationships among the accessions. These results indicate the reliability of this simple and inexpensive biochemical analysis in lentil germplasm bank management, cultivar identification and monitoring, and the construction of affinity groups that can help breeding programs.

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Genetic Variation among Garlic Cultivars as Determined by Randomly Amplified Polymorphic DNA Markers

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A collection of garlic (*Allium sativum* L.) germplasm, including 11 cultivars currently used in South Brazil, was evaluated using randomly amplified polymorphic DNA (RAPD) markers. Objectives were to assess genetic variations and relationships among cultivars and determine the potential of RAPD markers for the identification of garlic cultivars. One-hundred-twenty-two RAPD bands were scored from 12 oligonucleotide decamer primers selected from Operon Techn. kits B, X, and Y. Of these, 46 bands (37.6%) were polymorphic. Similarity indices between garlic entries were computed from RAPD data, and these range from 0.69 to 1.00. UPGMA cluster analysis of genetic distances showed three groups: one formed by nine cultivars and two formed by single entries. The nine cultivars that form group I had common origin, which explains the high similarity observed between them.

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Random Amplified Polymorphic DNA Analysis of Garlic (*Allium sativum* L.) Germplasm Collection

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Maintenance of garlic (*A. sativum* L.) germplasm collections is based on year-to-year vegetative propagation of individual accessions. Several accessions are phenotypically similar, often originating from the same region of the world, but have been collected by different people at different times. These accessions are currently maintained as separate and unique samples, but may represent genetic duplication in the collection. In order to identify genetic duplication in the USDA collection, 45 garlic Plant Introduction accessions from the garlic USDA germplasm collection were analyzed for RAPD marker polymorphism. The samples originated from 20 countries worldwide. RAPD bands were generated by 20 decamer primers, using 100-ng DNA template, and 38 PCR amplification cycles. Polymorphism between accessions was defined as presence or absence of particular bands at given loci. However, a few distinguishing RAPD markers were established for selected accessions, identifying additional molecular markers to wholly assess the similarities or polymorphism of the garlic collection units is necessary.

Isolation, Characterization, and in Situ Hybridization Studies of the Abundantly Transcribed Potato (*Solanum tuberosum* 'Superior') Homeobox cDNA *POTH1*

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Homeobox genes contain sequences coding for DNA-binding motifs. These sequences are highly conserved across both the animal and plant kingdoms. Members of this gene family code for transcription factors that are key regulators of developmental organization. In an attempt to further elucidate the developmental process of tuberization in the potato plant, a full-length homeobox cDNA has been isolated via sequence homology from an early tuberization stage cDNA library constructed from 4-day axillary bud tubers. This cDNA, *POTH1*, has been sequenced and characterized by Southern blotting, northern analysis, sequence comparison, and in situ hybridization. *POTH1* is shown to be a class I homeobox gene with 45% overall similarity to *Kn-1* of maize and 73% match in the homeobox region. Messenger RNA accumulation studies indicate that *POTH1* mRNA, unlike most homeobox transcripts, is not limited to a particular organ or developmental stage. Instead, *POTH1* mRNA accumulates in rapidly growing cells of the potato plant: the apical meristems, the vascular cambium, the edges of young leaves, axillary buds, and root tips. In situ studies indicate accumulation of *POTH1* mRNA in the tunica and corpus layers of the apical dome of the shoot apex and the stolon apex. In the stolon, growth and proliferation of the parenchymal cells associated with the vascular cambium contribute to swelling during early stages of tuberization, and this tissue accumulates *POTH1* mRNA. It is possible that *POTH1* may be posttranscriptionally regulated in a particular organ or stage of growth, or that it is involved in a wider range of growth processes than most plant homeobox genes.

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An Ethylene-inducible Lipoygenase Gene from Potato Leaves

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Due to apparent participation of plant lipoygenases (LOXs) in the biosynthetic pathways for jasmonic acid, methyl jasmonate, traumatin, and several C-6 volatile compounds, LOXs are believed to have a role in senescence, plant growth and development, and wound- and pathogen-induced defense responses. Multiple functions that are ascribed to this enzyme family are in accordance with the heterogeneity of LOX isozyme forms. It is possible that different LOX isoforms may be involved in different physiological processes. In our search for a gene that encodes a LOX isozyme form specifically involved in potato defense responses against pests and pathogens, we have screened an abscisic acid-induced potato leaf cDNA library, and we have isolated, sequenced, and characterized a cDNA clone that we have designated POTLX-3. The high sequence homology of our cDNA clone to other reported plant LOX genes provided evidence that POTLX-3 is a lipoygenase. This cDNA clone represents a novel potato LOX gene in that it shares the least nucleotide and amino acid sequence homology to other isolated potato LOX genes. Northern analysis indicated that POTLX-3 transcripts did not accumulate in untreated potato leaves, but it was highly induced by treatment with physiological levels of ethylene. Northern analysis also was performed to study whether the POTLX-3 mRNA accumulation could be induced by other plant hormones that affect expression of the other plant LOX and defense-related genes. Treatment of potato leaves with methyl jasmonate, abscisic acid, gibberellic acid, auxin (NAA), and cytokinin (BA) did not induce POTLX-3 gene expression. Because the pattern of POTLX-3 gene expression is similar to that of pathogenesis-related (PR) proteins, especially the PR-1 and PR-5 groups, we suspect that POTLX-3 may be involved specifically in ethylene-induced defense responses against pathogens.

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Lipoygenase POTLX-1 and POTLX-2 Genes are Expressed during Potato Tuber Initiation and Development

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Plant lipoygenases (LOXs) (linoleate:oxygen oxidoreductase, EC 1.13.11.12) catalyze the oxygenation of polyunsaturated fatty acids such as linolenic and linoleic acids. Some of the final products of LOX-catalyzed reactions are traumatin, jasmonic acid (JA), methyl jasmonate (MJ), and C-6 volatile compounds, and they serve hormone-like regulatory and defense-related roles in plants. Recently, it

has been proposed that LOXs play a role in potato tuberization processes because JA, MJ, and structurally similar tuberonic acid and tuberonic acid glycoside have been shown to be tuber-inducing substances. In order to study possible lipoygenase involvement in potato tuberization, we have isolated, sequenced, and characterized the expression pattern of two cDNA clones, designated POTLX-1 and POTLX-2, that represent similar, but distinct, LOX genes. Within the scope of our experiments, northern hybridization studies with mRNA extracted from various organs of 'Superior' potato plants indicated that the expression of these two genes is restricted to developing tubers and roots only. Moreover, there is a positive correlation between POTLX-1 and POTLX-2 mRNA accumulation and the stage of potato tuber development, and this implicates LOX in tuberization processes. Accumulation of their transcripts was not detected in leaves, flowers, stems, shoot tips, or axillary buds. These results indicate that the isozyme forms encoded by these two genes are tuber-specific, and they are good candidates to study LOX involvement in potato tuberization processes. Treatment of potato leaves with abscisic acid, MJ, gibberellic acid, auxin (NAA), and cytokinin (BA) did not trigger transcriptional activation of either of these genes.

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Sensitivity and Efficiency of Randomly Amplified Polymorphic DNA for Cultivar Identification in Sweetpotato

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Detecting inter- and intra-varietal variation is essential for the management of a plant germplasm bank. The sensitivity and efficiency of randomly amplified polymorphic DNA (RAPD) for cultivar identification and somaclonal mutation in sweetpotato were evaluated. RAPD demonstrated a highly significant inter-varietal variation. Every one of the 23 tested cultivars can be identified with a RAPD profile generated by a single primer. Suspected duplicates that are morphologically indistinguishable can be unambiguously verified with a combination of three decamers. No intra-varietal variation was found using RAPD. Clones of 'Jewel' and 'Beauregard' collected from different sources all have the same RAPD profiles. Moreover, with 150 markers, the transgenic 'Chogoku' sweetpotato cannot be differentiated from its untransformed counterparts, even though the transgenic plant shows significant morphological changes. These results demonstrate that RAPD is a sensitive and efficient tool for identifying cultivar duplicates, but it is not efficient for detecting intra-clonal variation or somaclonal mutation in sweetpotato.

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Transformation of Carrot (*Daucus carota* L.) with Genes Involved in Carbohydrate Metabolism and Partitioning via Hypocotyl Tissue Cultures

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A study was initiated to characterize key enzymes that influence sweetness in carrot (*Daucus carota* L.) roots. Sucrose synthase (SS), sucrose phosphate synthase (SPS), and UDP-glucose pyrophosphorylase (UDPL) genes were isolated from potato (*Solanum tuberosum* L.) and cloned in an anti-sense orientation into *Agrobacterium tumefaciens* Bin19, which has a CaMV 35S promoter. Seedling hypocotyl sections of selected carrot lines were pre-incubated on B5 medium for 2 days, co-cultivated with *A. tumefaciens* Bin 19 for additional 3 days, and then transferred to a modified B5 medium containing 50 g/mL kanamycin and 400 g/mL carbenicillin. In 4 weeks, 18.6%, 33.3%, and 26.7% of the cultures from a breeding line (W204-C) were found to be transformed, respectively, with SS, SPS, and UDPL as determined by kanamycin resistance. In contrast, no kanamycin-resistant calli were obtained from a commercial cultivar (Navajo) in these transformation studies. The transformed calli proliferated in the medium containing 50 g/mL kanamycin and 400 g/mL carbenicillin, whereas non-transformed calli died in the same medium. These transformed calli are currently being used to regenerate plants via asexual embryogenesis using a suspension culture. The influence of these additional genes on sugar metabolism and accumulation in root tissues of transformed carrots will be characterized in the future.

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Outcrossing Techniques for Producing Artichoke Seed

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The artichoke, *Cynara scolymus*, is normally propagated by cuttings from mother plants; however, it is possible to produce some types of artichokes from seed. Methods used for producing open-pollinated seed of onion and carrots may be suitable for producing artichoke seed. Outcrossing in artichokes occurs because of differences in maturity of the staminate and pistillate phases within flowers. Producing artichoke seed by simple inbreeding techniques is usually not successful because of vigor loss and low pollen production, low seed production, and late maturity of progeny. Outcrossing is the preferred method of creating a new variety. The cultivar 'Imperial Star' was developed by crossing a thornless French line with an Italian line that had sharp woody spines, and a uniform, olive-green color. The French line was a bright green with some light purple at the base of the bracts. The F₁ generation from this cross had good hybrid vigor, and produced abundant seed and pollen. The F₂ generation segregated widely with many recombinant types that neither parent showed (e.g., extreme thorniness of leaves and petioles). Two plants were selected for sibling pollination. Subsequent generations of siblings within this type produced higher percentages of the desired type—glossiness, earliness, and high seed yield. Subsequent sibling crossing led to the selection of 'Imperial Star', PVP. 9000179.

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Inheritance and Linkage Analysis of a Blotchy Root Pigment Phenotype in Red Beet

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The primary pigments in red beet are the betalains, which include the red-violet betacyanins and the yellow betaxanthins. The recent adoption of betalain pigments from red beet as an alternative to synthetic food dyes has heightened interest in genetic modification of pigment production. Dominant alleles at two tightly-linked loci (*R* and *Y*) condition production of betalain pigment in the beet plant; however, several alleles at the *R* locus influence pigment amount and distribution. A mutant phenotype, characterized by irregular sectors of blotchy red and white root color, arose spontaneously in the beet breeding nursery. The blotchy mutant plant was used in crosses with non-blotchy inbred lines to characterize its inheritance. Chi-square goodness-of-fit tests of segregation data in backcross and F₂ generations for several genetic backgrounds did not deviate from the hypothesis that a single recessive gene controls the blotchy phenotype. Linkage analysis was conducted to determine if the blotchy phenotype was conditioned by a new locus or an allele at a previously described locus. Our data indicate the *bl* gene resides at a newly described locus linked to *R* and *Y*. Maximum likelihood estimation revealed a linkage distance between *R* and *Y* of 8.95 ± 0.49 cM. The linkage distance between *R* and *BL* was calculated at 13.99 ± 1.18 cM, and the overall linkage between *Y* and *BL* was determined to be 28.8 ± 4.2 cM. Our data suggest the *RYBL* genomic region plays a critical role in the genetic control of betalain biosynthesis.

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Randomly Amplified Polymorphic DNA (RAPD) Variation among and within Cultivated and Wild American Ginseng (*Panax quinquefolium* L.) Populations

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The magnitude of genetic differences among and the heterogeneity within cultivated and wild American ginseng populations is unknown. Variation among individual plants from 16 geographically separated, cultivated populations and 21 geographically separated, wild populations were evaluated using RAPD markers. Cultivated populations from the midwestern U.S., the southern U.S., and Canada were examined. Wild populations from the midwestern U.S., the southern U.S., and the eastern U.S. were examined. Polymorphic bands were observed for 15 RAPD primers, which resulted in 100 scored bands. Variation was found within and among populations, indicating that the selected populations are heterogeneous with respect to RAPD markers. The genetic relationships among individual genotypes were estimated using the ratio of discordant bands to total bands scored. Multidimensional scaling of the relationship matrix showed independent clusters corresponding to the geographical and cultural origins of the populations. The integrity of the clusters were confirmed using pooled chi-squares for fragment homogeneity. Average gene diversity (Hs) was calculated for each population sample, and a one-way analysis of variance showed significant differences among populations. Overall, the results demonstrate the usefulness of the RAPD procedure for evaluating genetic relationships and comparing levels of genetic diversity among populations of American ginseng genotypes.

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Evaluation of Popular Mountain Vegetables in Korea using Molecular Markers

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Five edible mountain vegetables (*Saussurea* sp., *Aster tataricus*, *A. scaber*, *Synurus deltooides*, *Ligularia fischeri*) were investigated on the basis of amplified DNA polymorphisms resulted from PCR-polymerase chain reaction analysis. The sampled plants consisted of 38 individuals in five taxa. Only 10 primers out of 62 [60 random (10-mer) primers, one 15-mer-M13 core sequence, and (GGAT)4 sequence] tested gave rise to polymorphisms in all of the tested plants, producing 176 DNA fragments amplified randomly and specifically. Intraspecific polymorphisms found in each taxa showed intra-variety constancy (31.1% to 40.9%) in the banding patterns of individual plants—*Saussurea* sp., 31.1%, 15 bands; *Aster tataricus*, 40.9%, 18 bands; *A. scaber*, 38.5%, 15 bands; *Synurus deltooides*, 34.7%, 17 bands; *Ligularia fischeri*, 38.9%; 22 bands, respectively. All five species were well-differentiated from each other at the 0.93 level of similarity index value. Genetic relationships among intraspecific and interspecific variations were closely related at the levels ranging from 0.62 to 0.99. Based on these results, our PCR analyses support the previous data derived from external morphology of the five edible mountain vegetables, but very low levels of intraspecific variations were detected in all of these taxa.

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Intraspecific Variations of *Epimedium koreanum* by Randomly and Specifically Amplified Polymorphic DNA Markers

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Randomly and specifically amplified polymorphic DNA banding patterns based on polymerase chain reaction (PCR) analysis were used to assess the intraspecific genetic variations and relationships within *Epimedium koreanum* populations. A collection of 21 individuals were classified as different accessions by morphological characters such as leaflet number, shape of leaf base, cauline length, plant height, and leaf area. PCR amplification using 12 primers out of 62 [60 random (10-mer) primers, one 15-mer primer (M13 core sequence), and (GGAT)4] resulted in 89 amplified DNA fragments with polymorphisms (80.9%) in all of the tested plants. Similarity indices between accessions were computed from PCR data, and genetic relationships among intraspecific variations were closely related at the levels ranging from 0.66 to 0.93. These DNA data were not matched well with those of morphological characters because they were divided into two major groups at the similarity coefficient value of 0.74. Primers (VII, VIII) gave rise to monomorphic bands in all of examined plants, but specific primers (M13 core and (GGAT)4 sequences) were found to be very valuable molecular markers to evaluate the interspecific variations in *Epimedium koreanum*.

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Sweet Pepper (*Capsicum annuum*) Transformation using *Agrobacterium rhizogenes*

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In vitro genetic transformation of chile pepper, *Capsicum annuum* var. New Mexico 6-4, was achieved. Seeds of 'New Mexico 6-4' were grown aseptically on Murashige and Skoog medium. Seedlings 22 days old were wounded on the hypocotyl region using a sterile hypodermic needle. *A. rhizogenes* strain K 599 harboring the plasmid p35S *GUS* Intron was inoculated on the wound site. Three days later the seedlings were transferred onto MS media with antibiotics (Cefotaxime, Carbenicillin, Amoxicillin, Clavulanic acid, and Kanamycin). New roots were seen to initiate from the wound site 15 to 20 days after inoculation. The roots were morphologically identified as "hairy roots." Glucuronidase (*Gus*) assay performed 40 days after inoculation on randomly chosen roots that had grown into the selection medium, showed that 6/25 (24%) of the inoculated seedlings had roots that showed intense blue coloration. Presence of an intron makes it impossible for the bacteria to express the reporter gene. The seedlings that had transformed roots had a different morphology with wrinkled leaves and short internodes. The pattern of expression of the introduced gene varied greatly. Some positive tissues had the root tips alone being blue; a few had the vascular tissues and the root tips blue; and others had the vascular tissues, the surrounding parenchyma cells, root tips, and the root hairs turn very dark blue.

The transformed roots did not need to grow into the selection media to be *Gus* positive. Isolated roots cultured on MS media supplemented with 0.2 mg/L IAA were maintained for 120 days and continued to express the reporter gene. Currently, methods to regenerate transformed shoots from roots are being tested. The "hairy root" transformation system in pepper could have application in the testing of root-expressible constructs for transgene expression assays.

101 POSTER SESSION 3B (Abstr. 159–164) Culture & Management—Woody Orna- mentals/Landscape/Turf

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Recycled Paper as a Growth Substrate in Container Production of *Spiraea*

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Wet Earth (WE) is a recycled paper product being tested as a potential plant growth substrate. It is composed of 80% recycled paper, 18% diatomaceous earth, 1% CaO, and 1% humic acid by volume. Use of WE by commercial growers would reduce demand for both landfill space and for slowly renewable resources such as peat and pine bark. Evidence also suggests that WE reduces nitrate runoff. Objectives included: determining effects of WE on plant growth, examining effects of WE on NO₃ and NH₄ runoff from container plant production, and determining the chemical and physical properties that characterize WE as a growth substrate. Ratios of pine bark to WE tested were 100% pine bark, 1:3, 1:1, 3:1, and 100% WE by volume. Fertilizer treatments included: 100% of the recommended rate of controlled release fertilizer (CRF), 50% CRF plus 50% liquid fertilizer (LF) and 100% LF. Plant heights, widths, and visual quality ratings were obtained monthly throughout the 16-week experiment. Leaf, shoot and root dry weights were determined at harvest. Nitrogen content of roots, shoots, and substrates were determined at planting and harvest, while NO₃ and NH₄ content of leachate was determined at each irrigation. All substrates were analyzed at planting and harvest for pH, soluble salts, exchangeable cations, and CEC. Changes in volume, bulk density, porosity, and air space were also measured. Plant size and quality varied significantly between substrate mixes. Mortality was significantly higher in mixes containing 75% and 100% WE. Changes in volume, bulk density, and percent air space were also significant and inversely related to WE concentration.

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Tree Growth in Potting Media Made with De-inked Paper Sludge

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De-inked paper sludge from a newsprint mill was evaluated as a substitute for softwood bark in container media. Whips, 1.2 m tall, of 'October Glory' red maple (*Acer rubrum* L.), European birch (*Betula pendula* Roth), and 'Royalty' crabapple (*Malus* L.) were planted in 15-L plastic pots that contained potting media amended with 0%, 20%, 40%, 60%, 80%, or 90% paper sludge and 80%, 60%, 40%, 20%, 0%, or 0%, respectively, bark (by volume). All media contained 10% sand. After 22 weeks, plant heights, trunk diameters, and shoot dry weights were determined. Initial pH of media increased as the amount of paper sludge in the media increased, with the 90% sludge mix having pH 7.2. Paper sludge had a low initial CEC. Physical properties of all sludge-amended media were suitable for tree growth, but media containing 80% or more paper sludge shrank in volume by 10% to 12% by the end of the study. All maple and crabapple trees grown in all sludge-amended media grew as well as those in 80% bark (control mix). In fact, maple and crabapples trees in 40% sludge produced at least 10% and 36% more total shoot biomass, respectively, than trees in 80% bark. Although birch trees grown in 40% or 60% paper sludge grew as well as control plants, those grown in 80% or more sludge were at least 11% shorter and produced 24% less total shoot biomass (leaves, stems, and trunk dry weight) than control trees. These results demonstrated that de-inked paper sludge was a worthy substitute for up to 40% of the bark in a container medium for the three species tested.

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Effect of Nursery Stock Type and Size on Growth of Three Deciduous Shrub Species in Containers

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Rewholesalers, garden centers, and other sellers of deciduous shrubs routinely receive bare-root stock in late winter or early spring for potting; however, bare-root plants are sometimes slow to establish in containers. Potted liners with well-developed root systems show potential for shortening the production cycle and permitting the development of higher-quality plants earlier in the growing season. To study the effect of nursery stock type and size on subsequent growth, two bare-root sizes and one potted liner size of 'Cardinal' red osier dogwood (*Cornus sericea* L.), 'Goldflame' spirea (*Spiraea xbumalda* Burv.), and 'James MacFarlane' lilac (*Syringa xprestoniae* McKelv.) were grown in polyethylene containers of different sizes. Bare-root plants (15 and 30 cm in height) were grown in 2.7- and 6.1-L, and 6.1- and 10.3-L containers, respectively. Potted liners (0.4-L container size) were grown in 6.1- and 10.3-L containers. Plant performance was evaluated 10 and 20 weeks after potting. In general, plant quality ratings increased with container volume for all species. For 'Goldflame' spirea and 'James MacFarlane' lilac, best plant quality ratings occurred with 30-cm plants grown in 10.3-L containers. But for 'Cardinal' redosier dogwood, plant quality ratings were highest and not significantly different for 30-cm bare-root plants and potted liners grown in 10.3-L containers.

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Comparison of Pour-through and Ceramic Cup Methods of Extracting Nutrients from a Pine Bark Substrate

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The pour-through (PT) nutrient extraction method involves collection of leachate at the container bottom that results from displacement of substrate solution by water applied to the substrate surface. The PT is a convenient and effective means of monitoring the nutritional status of the soilless container substrates used in the nursery industry, but is less convenient for large containers, particularly those used in the "pot-in-pot" system of growing trees in production containers within in-ground socket containers. We describe a simple vacuum method of extracting solution from pine bark in containers using ceramic cup samplers. When N was applied to a pine bark substrate at 56–280 mg/L, extractable N was slightly higher for the PT than for the ceramic cup method. The correlation between applied and extractable N was 0.99 for both methods. Further comparison of pine bark extract nutrient and pH levels for PT and ceramic cup methods will be presented.

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Water and Nitrogen Management to Reduce Nitrate-Nitrogen Leaching from Container Crops

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Plastic 208-L industrial barrels (14 total) were modified for use as soil-filled lysimeters to study the nitrogen dynamics of a typical container crop production system. The top of each barrel was removed and the bottom was fitted with a drain hole and filter fabric. The drain was then connected via tubing to a 2-L leachate collection vessel made from a length of 15.24-cm-diameter PVC pipe that had been capped on one end. All barrels and connected collection vessels were recessed into a grassed slope. Barrels were filled with homogeneous B and C horizon soil to simulate soil conditions of a typical container nursery. Uniform *Rhododendron* 'Catalawbiense Album' plants in 4.5-L containers were arranged atop the barrel-lysimeters at four plants per barrel. Irrigation/fertilizer treatments included fertilized pulse trickle irrigation (four replications), fertilized overhead irrigation (four replications), and unfertilized controls corresponding to each irrigation treatment (three replications each). All fertilized plants received 10 g of 17N–6P–10K 8- to 9-month controlled-release fertilizer at the beginning of the crop cycle. Leachate from the barrel-lysimeters was collected weekly and total volume, total Kjeldahl N, nitrate-N, and ammonium-N were determined. Peak nitrate-N levels were well above the current drinking water standard for both irrigation treatments at certain times during the year. Cumulative nitrate-N mass output was similar for both irrigation treatments. A nitrogen balance for the complete production system including fertilizer and irrigation water input, plant material, potting media, soil in the lysimeter barrels and leachate output from the barrels has also been determined.

Using Cupric Hydroxide to Reduce the Rooting-out of B&B Stock During Storage

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Cupric hydroxide formulated as Spin Out™ [7% Cu(OH)₂ in a latex carrier] was used to prevent the rooting-out of *Taxus x media* Rehd. 'Densiformis' root balls into surrounding mulch or soil during storage over a 4-month period. Treatments evaluated in one study included: painting the bottom of the root ball with copper-paint, setting the root ball on copper-treated burlap or ordinary copper-treated burlap; rewinding the root ball with copper-treated burlap before mulching or burlapping with copper-treated burlap, with appropriate controls. All treatments provided good control of rooting-out after 12 to 16 weeks storage. The most effective treatments were setting the root ball on copper-treated burlap (unmulched; 92% reduction in root count after 16 weeks) and rewinding or burlapping into copper-treated burlap (mulched; 90% and 86% reduction in root count after 16 weeks). A second study used TexR® Agroliner (Spin Out™-treated non-woven fabric), on which root balls were set (unmulched treatments), rewound or burlapped (mulched treatments). TexR® Agroliner stopped rooting-out completely without adversely affecting plant quality. Using copper-treated burlap to prevent rooting-out during storage can reduce the incidence of re-balling and root removal prior to shipping and planting B&B nursery stock.

101 POSTER SESSION 3C (Abstr. 165–172) Extension Education

Technology Transfer through the Use of Growers Clubs in Northwest Mexico

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The Growers Club provides a good alternative for technology transfer generation in experiment stations, universities, and other research institutions in Mexico. At this time, there are 10 Growers Clubs in northwest Mexico, mainly in Sonora and Sinaloa states. During 1996, in the agricultural area in Caborca, Sonora, the Grower Club "REME"-SOCOADA was formed with 10 members—all of them are willing to adopt new technologies. The main goal of this club is to improve the yield using the validation of new agricultural practices and evaluation of genetic material from different crops (annual crops, vegetables, fruit trees, and forage). We have six demonstration lots in different locations and we are planning to increase these to 11 and we will publish the results that we are going to get from these lots.

Vegetable Crops Research and Information Center World Wide Web Site

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The Univ. of California's Vegetable Crops Research and Information Center (VRIC) has developed a new World Wide Web site that allows the rapid development and peer review of multi-discipline, research-based information. The VRIC website (<http://vrichome.ucdavis.edu>) disseminates peer-reviewed fact sheets, research results, updated publications, and multi-media educational resources relating to critical issues, best management practices, postharvest handling, and marketing of vegetable crops. The website disseminates multi-discipline information originating from the Univ. of California, the USDA, and cooperating agencies and universities. The VRIC website proactively sends peer-reviewed critical-issue fact sheets to selected news media, government, industry, and academic contacts. These fact sheets help personnel frequently contacted by the media during crises to answer questions effectively. The website directs visitors to additional agricultural information resources and contains information on careers and educational opportunities available in the field of vegetable crops.

Validating a Crop Production Budget for Containerized Specialty Vegetables

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Growers producing new crops often do not understand how to price individual items. The prices of common container nursery stock items may be listed in monthly trade publications. Prices for fruits and vegetables fluctuate on a daily basis. A production budget for containerized specialty vegetables was adapted from one developed for ornamental nurseries, using some specific costs for field-grown vegetables. This gave a realistic way to calculate prices for individual products. Once the crops had been sold, the authors were able to validate the model by comparing actual costs with projected costs.

Business Profile of Australian Nurseries

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We surveyed 22 Australian nurseries in 1995 to: 1) develop a profile of Australian nurseries from a production, management, and profitability perspective; 2) compare the data to relevant U.S. benchmarks; and 3) identify trends and potential areas of improvement in the management of Australian nursery enterprises. The study confirmed that Australian nurseries incur high labor costs (38.8% of sales) that are comparable to United States nurseries, while costs of materials and supplies were lower than their U.S. counterparts. Overall, the costs of the surveyed nurseries appeared lower than their U.S. counterparts. Concerns of managers were directed towards recruiting and keeping labor and marketing rather than increasing capital investment to increase production efficiency. Capital expenditures tended to be funded from internal cash flows rather than external borrowings. Many of the nursery managers used relatively simple performance indicators and most business objectives were stated in general terms. Australian nurseries carried more diverse product ranges than the U.S. nurseries. Many of the nurseries adopted quite vigorous marketing strategies with a stronger emphasis on marketing than in those in the U.S. Concerns about the viability of the industry included oversupply, the growth in chain stores business, factors eroding the demand for nursery products and greater regulation.

A CIELAB Color Classification Scheme for Poinsettias

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Forty-two poinsettia cultivars were grown as a 15-cm single-plant pinched crop at 21/16.5°C (day/night) temperatures during Fall 1995 with standard commercial practices for irrigating, fertilizing, and pest control. On 7 Dec., 156 consumers rated the cultivars for their overall appeal. On 11 Dec., color coordinate (CIELAB) readings for bracts and leaves were taken with a Minolta 200b colorimeter. The colorimeter was set to illuminate C and has a 8-mm aperture. Bracts and leaves were placed on a white tile background for colorimetric readings. In 1996, a similar evaluation was conducted with 55 poinsettia cultivars. Using the L-value of leaves as a criterion, cultivars were separated into medium green-leafed and dark green-leafed groupings. For bracts among the red types, hue angle values were used to separate cultivars into cool red types (hue angle ≈20–22°) and warm red types (hue angle ≈24–25°). Based on the 1995 study, cultivars within the cool red bracts and dark green foliage group—those that were darker, duller red (lower L and chroma)—were less attractive (lower consumer ratings) than lighter, more-vivid red cultivars. For cultivars within the cool red bracts and medium green foliage group, consumers preferred the darker duller red cultivars. Perhaps dark foliage gives a more pleasing contrast with the more vivid cool reds than does the medium green foliage. In general, consumers rated red cultivars higher than non-red cultivars.

A Proficiency Testing Program for the Agricultural Laboratory Analysis Industry

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The accuracy of soil and plant analytical results are occasionally called into question by laboratory clientele. Although laboratories generally conduct internal quality assurance procedures, there are few external performance testing programs for the industry. In 1994, a proficiency testing program was initiated for soil and plant samples for agricultural laboratories in the western United States to provide an external quality control for the lab industry. The program involves the quarterly exchange of soil and plant samples on which soil salinity, soil fertility, and plant nutrition analyses are conducted. One hundred laboratories are annually enrolled in the program from 24 states and Canadian provinces. Results of 3 years of the program indicate soil nitrate, soil pH, extractable potassium, soil and organic matter are reproducible within 10% between laboratories. Soil-extractable phosphorus (by five methods), soil-extractable boron, and soluble chloride were only reproducible within 15% to 20% between laboratories. Plant nitrogen and phosphorus results were consistent across samples, laboratories, and methods. Variability in plant nitrate increased with decreasing tissue concentrations. Overall accuracy and precision of reported results, based on the use of NIST certified reference botanical samples, were excellent for N, P, K, Ca, and Cu. Generally, for any given analysis, the results of \approx 10% of the laboratories exceed two standard deviations from the mean. Overall, significant improvement was noted in the laboratory industry proficiency through the course of the program.

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A Method of Rapidly Assessing Post-disaster Damage to Vegetables and Tropical Fruits

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Producers of perishable commodities periodically experience natural disasters. Growers in Dade County, Fla., have suffered losses from hurricanes, freezes, and floods. Public agencies and grower groups are often asked to provide immediate estimates of loss to both official sources and the news media. Following the Jan. 1997 freeze, a method was developed to provide this information within 1 day of the disaster. This has also been used to estimate job losses for agricultural workers.

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OSU Douglas County Demonstration Farm

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The demand for horticultural information from the OSU Extension Service is sought by both commercial fresh-market vegetable growers and noncommercial clients. Educational programs at the Demonstration Farm were designed to meet the needs of these two diverse groups. At the request of local growers, vegetable trials were established to evaluate the large number of new varieties that come onto the market every year. Since 1987, nearly 250 varieties of eggplant, melons, peppers, squash, sweet corn, and tomatoes have been evaluated for their adaptability to Douglas County's Mediterranean climate and growing conditions. Annual reports on the performance of the varieties are shared with county vegetable growers and Extension Agents throughout Oregon. Many of the vegetables for the trials are grown as bedding plants in the Demonstration Farm greenhouses. A greenhouse program was established to offer Master Gardeners the opportunity to participate in all of the cultural aspects of bedding plant production. This includes: seeding, transplanting, pinching, watering, and fertilizing. When planting season arrives, Master Gardeners help transplant the seedlings to the trial plots. An average of 40 Master Gardeners have participated in the greenhouse and trial program each year, since their inception in 1987. An average of 300 people attend the field days every summer to tour the vegetable trials. An outdoor gardening class, "Summer In The Garden," is offered to the general public every summer. An average of five sessions are held in July and August on a variety of topics related to vegetable culture, pest control, and new varieties. The sessions are taught by the Horticulture Agent with the assistance of Master Gardeners. Attendance has averaged 25 students annually.

101 POSTER SESSION 3D (Abstr. 173–180) Postharvest Physiology—Fruits/Nuts

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Analysis of Volatile Evolution from Scald-developing and Non-developing Sides of Apple Fruits

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Apple fruits (*Malus domestica* Borkh. cv. 'Red Delicious') stored for 6 months at 2°C in air were analyzed for headspace volatiles by SPME-GC and for surface components by HPLC of hexane extracts. Analysis of headspace volatiles evolved from whole fruit showed five major volatiles that were identified previously as: acetic acid, hexyl ester; hexanoic acid, butyl ester; octanoic acid, propyl ester; hexanoic acid, hexyl ester; and the sesquiterpene, α -farnesene. No significant differences existed in these volatiles between scald-developing and non-scald developing apples. To explore potential differences in volatile evolution, fruit developing scald were cut (axial plane) into scalding and non-scalding halves for analysis. In all cases, volatile emission was much higher from the non-scalding side of the fruit, and the ratio of volatile levels from non-scalding to scalding averaged greater than 2. Various regions of tissue from the same fruit were extracted in hexane for estimation of levels of α -farnesene and its potential catabolites by HPLC. The levels and proportions of the components were nearly identical to those observed during headspace volatile analysis of half fruit. The results suggest that there are potential differences in α -farnesene metabolism and/or permeability of apple cuticle to volatiles between scald-developing and non-scald developing regions of apple fruit.

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Enhanced Degreening of Apple Fruit by Jasmonates

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Airborne methyl jasmonate (MJ) can modulate apple fruit ripening, including the degreening process. Degreening of 'Fuji' and 'Golden Delicious' apples by jasmonates [jasmonic acid (JA) and MJ] in aqueous solution was investigated. JA and MJ applied by dipping apples in solutions of jasmonates for 2 min enhanced degreening during ripening at 20°C. MJ was more effective at promoting degreening compared to JA. The minimum concentration of jasmonates required to promote significant degreening during the 2-week ripening period was 1 mM. Degreening of jasmonate-treated apples ripened at 4°C progressed slower compared to apples ripened at 20°C. JA stimulated apple fruit ethylene production at concentrations as low as 10 μ M. Jasmonates at 1 or 10 mM were more effective at accelerating the degreening process compared to 0.35 or 3.5 mM ethephon. Firmness, soluble solids content, and titratable acidity of 'Fuji' apples were not significantly affected by jasmonate treatments. Peel injury occurred on apples treated with 10 mM JA or 3.5 mM ethephon.

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The Effect of Acclimatization of Fruits on the Control of a CO₂-linked Disorder of 'Empire' Apples

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The "scald-like" disorder of 'Empire' apples is a CO₂-linked disorder. In this study we investigated the factors of acclimatization of preclimacteric fruits at 3°C in air or low O₂ levels prior to elevating the CO₂ concentration. Fruits were harvested at the immature stage, which had higher potential to suffer the disorder. Establishing CA conditions of 5% CO₂ + 1.5% O₂ at 3°C within 1 day of harvest resulted in the highest incidence of the 'Empire' disorder, followed by 3% CO₂ + 1.5% O₂ > 5% CO₂ + 3% O₂ > 3% CO₂ + 3% O₂. The fruits had to be acclimated at 3°C for 3 to 4 weeks at 1.5% or 3% O₂ to become insensitive to 5% or 3% CO₂. Holding the fruits in air for 1 week prior to administering 3% or 5% CO₂ was insufficient to control the disorder, whereas the fruits tolerated 3% or 5% CO₂ after holding the fruits in air for 2 weeks. But, the 2-week delay to CA resulted in accelerating flesh softening. Supplemental carbon dioxide was not necessary for at least 1 month to maintain flesh firmness at near harvest values where fruits were kept at 1.5% O₂. Whereas at 3% O₂, the presence of 3% or 5% CO₂ from the beginning of the storage period was required to retard flesh firmness decrease. Fruits stored for the entire storage duration without CO₂ softened markedly. In summary, we conclude that establishing CA conditions of 3% to 5% CO₂ with 1.5% or 3% O₂ at 3°C within 1 week of harvest can lead to serious incidence of the 'Empire' disorder with preclimacteric fruits. Moreover, fruits acclimate better in air than at low O₂ levels with respect to tolerating CO₂. This suggests a requirement of oxidative

metabolism in acclimatization for CO₂ tolerance. Beyond 7 days, acclimatization in air at 3°C before CA is established results in excessive flesh softening, even though it does prevent the disorder incidence.

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Biosynthesis of α -Farnesene in Apple Fruit

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α -Farnesene is an acyclic sesquiterpene hydrocarbon that is a constituent of the surface wax of apples (*Malus domestica* Borkh.). Although, oxidation products of α -farnesene have been implicated in the development of the physiological disorder superficial scald in apple, the mechanism of α -farnesene biosynthesis has not been studied in detail. We are currently investigating α -farnesene biosynthesis in relation to superficial scald development in apples. Radiolabelled feeding experiments using isolated tissue segments indicated that α -farnesene is derived from *trans,trans*-farnesyl pyrophosphate (FPP), mainly in the skin rather than cortex. Among the other labeled products detected, farnesol level was over a hundred-fold higher compared to α -farnesene. However, [1-³H] *trans,trans*-Farnesol was not incorporated into α -farnesene. Feeding radiolabelled FPP to skin tissue segments of scald-developing and normal apples showed differential incorporation of radiolabel into various products. Though the incorporation into α -farnesene was nearly the same, there was higher levels of incorporation into farnesyl esters in normal apples. As well, the levels of radiolabelled in the farnesol fraction was three times higher in scald-developing regions. These results indicate that there are potential difference in the biosynthesis and metabolism of farnesyl components between scald-developing and normal apples. In studies using cell-free extracts, farnesol formation was observed from labeled FPP and was two-fold higher in crude membrane extract compared to crude cytosol. Our results indicate that α -farnesene formation in apple fruit tissue is through FPP and is possibly catalyzed by a single sesquiterpene synthase enzyme. Purification and characterization of this enzyme are in progress.

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Reducing the Risk of Superficial Injury in 'Golden Delicious' Apples Caused by Postharvest Application of CaCl₂ Solutions

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'Golden Delicious' apples were pressure-infiltrated (34 kPa) at harvest with 0, 20, 35, or 50 g·L⁻¹ solutions of CaCl₂ followed without and with a water rinse, a wax or shellac emulsion treatment, or a shrink-wrap packaging, and stored at 0°C. The CaCl₂ treatments delayed senescent breakdown, but also caused superficial injury to the fruit. A water rinse in combination with a wax- or shellac-based coating or shrink wrap packaging reduced the appearance of superficial injury in fruit treated with 35 or 50 g·L⁻¹ solutions of CaCl₂ and eliminated it in fruit treated with a 20 g·L⁻¹ solution of CaCl₂. While reducing the risk of calcium-related injury to the fruit, the coating and film treatments maintained the beneficial effects of calcium on apples and reduced weight loss of the fruit during cold storage.

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Deleterious Effects of Pure Oxygen on 'Gala' and 'Granny Smith' Apples

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Exposure of 'Gala' and 'Granny Smith' apples to pure oxygen resulted in inhibition of the rise in ethylene evolution and development of visual symptoms of extensive injury akin to that which occurs under the condition of very low oxygen. Analytical data showed that fruit kept under pure O₂ accumulated ethanol. In 'Granny Smith' apples, the accumulation of ethanol was associated with increases in pyruvate and citrate concentration, and a sharp decrease in isocitrate concentration. These data indicate that an atmosphere of pure O₂ inhibited *cis*-aconitase activity in the fruit, thereby disrupting the TCA cycle. This, in turn, caused an increase in production of ethanol. The possible mechanism by which pure O₂ inhibits *cis*-aconitase will be discussed.

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Activities of Free-radical Scavenging Enzymes during Apple Fruit Maturity, Ripening, and Senescence

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Superoxide dismutase (SOD: EC 1.1.1.15.1.1) and peroxidase (POD: EC 1.11.1.7) activities were evaluated during maturity, ripening, and senescence of 'Red Spur Delicious' (*Malus domestica* Borkh.) apple fruits. SOD and POD activities did not exhibit uniform changes during fruit maturity; however, during fruit ripening, activities of both enzymes increased significantly. During fruit senescence, SOD activity continued to increase, while POD activity declined by 24% to 50%. Fruit maturity at harvest significantly affected SOD and POD activities during the progression of ripening and senescence. SOD activity was significantly higher during ripening and senescence of fruits that were harvested at full and over-mature stages than in fruits harvested at early mature stage. In contrast, POD activity was lower in fruits that were harvested at full and over-mature stages than in fruits harvested at early mature stage. Increase in SOD and POD activities during fruit ripening suggest that these enzymes are actively involved in scavenging free-radicals generated during this developmental stage. However, the decline in POD activity during fruit senescence suggest a possible disruption of the breakdown of H₂O₂ free-radicals. This disruption may have contributed to tissue senescence and the induction of a physiological disorder called senescence scald.

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Volatile Profiles of Decaying Apple Fruit

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The changes in volatile-aroma of *Penicillium expansum* and *Botrytis cinerea* fungi and apple fruit inoculated with these fungi were studied using GC-MS. A specially designed chamber with raised end glass tubes with access ports fitted with Teflon-lined septa was used to determine the volatile profile for fungi on agar. Inoculated fruit were placed in glass flow-through chambers similarly fitted with sampling ports. Volatile collection from fruits or fungi was accomplished using solid phase micro-extraction (SPME) device (Supelco, Inc.). In fungi-inoculated fruits, volatiles not produced by uninfected fruit included formic acid, 2-cyanoacetamide; 1-hydroxy-2-propanone, and 1-1-diethoxy-2-propanone, which were initially detected 6 hr after inoculation. These new volatiles are suggested to be synthesized specifically by the action of fungi on fruits as they were not detected from fungi that were grown on agar or bruised fruits. In general, esters, alcohols, aldehydes, ketones, acids, and hydrocarbons other than α -farnesene declined in fungi infected fruits.

101 POSTER SESSION 3E (Abstr. 181–189) Postharvest Physiology–Floriculture/Foliage

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Postharvest Quality Characteristic of Unrooted Geranium Cuttings in Response to Storage Conditions and Fungicides

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Experiments were conducted to evaluate the development of stored unrooted *Pelargonium x hortorum* 'Designer Bright Scarlet' cuttings. Treatments included storage temperature and duration and pre-storage fungicide application. Cuttings were harvested from stock plants treated with water or fungicide (Iprodione), and were stored at 60°F and 75°F for 2, 4, and 6 days. Leaf yellowing data (visual quality rating, chlorophyll fluorescence, and total chlorophyll content) were measured at the start of propagation and 7 days later. At both dates, cuttings stored but not treated with fungicide displayed more leaf yellowing after storage at 75°F for 4 and 6 days or at 60°F for 6 days compared to fungicide-treated cuttings and non-stored controls. Cutting quality was not affected by 2 days of storage, regardless of storage temperature or fungicide treatment. Fungicide-treated cuttings had less leaf yellowing after storage for 6 days at 60°F or 75°F compared to untreated cuttings, but they had more leaf yellowing than no storage controls after 7 days

of propagation. Root number and root length of each cutting was measured at 14 days after start of propagation. Cuttings treated with fungicide displayed better adventitious root formation after all 4- and 6-day storage treatments compared to cuttings stored but not treated with fungicide.

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Increase of Easter Lily Postharvest Flower Longevity with PBA Application to Young Flower Buds

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Case-cooled bulbs of *Lilium longiflorum* 'Nellie White' were potted on 4 Dec. 1995 and forced to flowering using standard growing procedures. Plants were illuminated from shoot emergence to visible bud with supplemental high-intensity-discharge sodium vapor light at $70 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from 1700 to 2200 HR each day. When the first primary flower bud (first initiated flower bud most proximal on the shoot) was 5 to 7 cm long, each plant was treated with 3 ml of either de-ionized water or $500 \text{ mg}\cdot\text{liter}^{-1}$ 6-(benzylamino)-9-(2-tetrahydropyranyl)-9H-purine (PBA). Sprays were directed at the flower buds and associated bracts. When the tepals on the first primary flower bud split, plants were placed at 2°C in the dark for 0, 4, or 21 days. After storage, plants were placed in a postharvest evaluation room with constant 21°C temperature and $18 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ cool-white fluorescent light. The first three primary flowers on PBA-treated plants lasted significantly longer than corresponding flowers on control plants, but there was no difference between flowers at the fourth and fifth positions. Also, the total postharvest life of the five primary flowers on PBA treated plants was 3 days longer than those on control plants. Storage time inversely affected the postharvest longevity of the first three primary flowers, but had no effect on the longevity of the fourth or fifth primary flowers or total postharvest life of the five primary flowers. There were no significant interaction effects between PBA treatment and storage duration on primary flower longevity.

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Preventing the Development of Post-production Leaf Yellowing in Easter Lily with Growth Regulators

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The marked effects of growth regulators such as GA_3 and BA in delaying leaf yellowing on excised leaves of Easter lilies decreased when studies were conducted on intact plants in a simulated interior environment. Solutions containing benzyladenine (BA) delayed the development of leaf yellowing in cold-stored plants, but solutions containing gibberellic acid (GA_3) were not effective when applied to plants at the puffy bud stage and evaluated in a $22.6 \pm 0.2^\circ\text{C}$ room illuminated 12 h/day with $11.2 \pm 0.1 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ cool-white fluorescent lamp. Treatment with commercial products containing GA_{4+7} (Provide) or GA_{4+7} and BA (Promalin) nearly completely prevent the development of leaf yellowing. Concentrations as low as $25 \text{ mg}\cdot\text{L}^{-1}$ were effective. The prevention of leaf yellowing by growth regulators was only effective on leaves that had been treated, indicating that mobilization of the growth regulators in the plants did not occur. Growth regulator solutions halted further development of leaf yellowing when applied to plants that already possessed some chlorotic, basal leaves. The striking effects of growth regulators on preventing leaf yellowing did not affect the development and opening of the flower buds and is a practical solution for the prevention of post-production leaf yellowing in Easter lilies.

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Number of Open Florets on a Flowering Stem Influences Post-harvest Life of *Antirrhinum majus* L.

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Flowering stems from three commercial inbreds and their F_1 hybrids of *Antirrhinum majus* L. were cut when the first eight basal florets opened. Tops of the stems were removed above the eighth floret and florets were removed leaving two, four, six, or eight open florets on a stem. A completely random design with 10 replications was used. Flowering stems were placed in plastic storage containers 35 x 23 x 14 cm (L x W x H) with 2.5 L deionized water for postharvest evaluation. Evaluation took place under continuous cool-white fluorescent light ($9 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) at 24°C. Postharvest life was determined as the number of days

from cutting to discard when 50% of the open florets on a flowering stem wilted, turned brown, or dried. Results showed postharvest life increased as the number of open florets on a stem decreased. Mean postharvest life increased as much as 4.7 days when only two florets remained on a stem. These results indicate a direct relationship between number of florets on a cut flower stem and postharvest life.

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Anatomy of Neck Tissue of Cut Roses as Affected by Bent-neck and Preservative Solution

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To investigate the differences of anatomical structure of neck tissue between bent-neck and strong-neck flowers, scanning electron microscopy of neck tissue during senescence of cut rose flowers held in deionized water or preservative solution (3% sucrose + 200 ppm HQS + 0.1 mM ethionine) was observed. Lignins in xylem, phloem, and interfascicular cambium of neck were stained to red by phloroglucine. More lignin was formed in the phloem of neck in rose flowers held in preservative solution than deionized water. Neck strength of cut rose could be increased by increase of lignin content, and this would prevent bent-neck and extend vase life. Parenchyma cells in neck part of rose flowers held in deionized water had thinner cell wall and less starch grains at senescence than those of flowers held in preservative solution at day 7. These starch grains would be used as energy source of rose flowers and extend vase life. Globular crystals were observed in the inner part of cells and had shape of large thorny. These crystals were cumulated in cell walls, then would prevent the activity of cell wall decomposition or increase cell wall permeability.

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Changes in Bent-neck, Neck Strength, and Water Balance According to Cultivars and Preservative Solutions of Cut Rose Flowers

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Rose (*Rosa hybrida*) cvs. Red Velvet, First Red, Sonia, and Saphir stems harvested at bud stage were kept in deionized water or preservative solution (3% sucrose + 200 ppm HQS + 0.1 mM ethionine) at 21°C under continuous light (1200 lux). Vase life of 'First Red' and 'Saphir' was much longer than those of 'Red Velvet' and 'Sonia' held in deionized water. Severe bent-neck was observed in 'Red Velvet' flowers held in deionized water in 8 days after harvest. Rose flowers held in preservative solution resulted in extended vase life and inhibited senescence and bent-neck in four cultivars. Neck strength of 'First Red' and 'Saphir' rose flowers having no bent-neck and long vase life was stronger than 'Red Velvet' and 'Sonia' having frequent bent-neck and short vase life. Neck strength was also increased by preservative solution. Faster changes of water balance to minus value were detected in the rose flowers held in deionized water than those held in preservative solution. 'Red Velvet' flowers having much absorption of water but more transpiration caused a fast change to a minus value in water balance and early bent-neck. Cell sap pH gradually increased in petal and stem of rose cultivars during senescence. Cell sap pH of flowers held in distilled water were higher than those held in preservative solution. Increased cell sap pH of rose flowers caused rapid change to blueing and yellowing of petals.

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Effect of Prestorage Treatments on the Vase-life of Fresh-cut Peony Flowers Held under Long-term Cold Storage

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Peony flowers are among the few fresh-cut flowers that can be stored dry at cold temperatures for weeks and still produce a viable product for the marketplace. Devising new ways to extend that storage period could open new markets for peony growers. In the northern hemisphere, more peonies could be available for summer weddings, and in the southern hemisphere, red peonies could be used for Valentine's Day. Being able to control and extend the vase-life of peony flowers could also be useful for companies that freeze-dry peonies. Their production is limited by the length of their processing cycle and the size of their freeze dryer. Being able to extend their production season could make them more profitable. Three treatments were applied to peony flowers harvested in the colored bud

stage before flowers were placed in cold storage, 2°C. An untreated control was included. Flowers were removed from storage every 2 weeks for 14 weeks. Vaselife and fresh weights were evaluated. Total nonstructural carbohydrate levels of the petals, leaves, and stems of the flowers are to be analyzed. Preliminary analysis of the data shows some treatment differences.

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Effects of Silver Thiosulfate, Sucrose, and Calcium Nitrate on Vaselife of *Ebenus cretica* L.

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Ebenus cretica, Leguminosae, an endemic perennial bush of Crete, is being studied as a potential new cut flower crop. Forty-centimeter-long spikes with two to three inflorescences and six to eight compound leaves were harvested from 5-year-old plants grown from seed at the farm of the TEI, when 1/3 of the florets had opened, and were treated with various preservatives. Flower quality was evaluated morphologically combined with measurements of chlorophyll content in leaves and anthocyanin in petals. Without any postharvest treatments, inflorescences held in a solution of 100 ppm 8-hydroxyquinone sulfate (HQS) in DI water had an average vaselife of 6.8 days. Pulsing with 0.6 mM silver thiosulfate (STS) for 2 h extended vaselife up to 8.4 days. However, when ethephon was added in the solution, vaselife was significantly reduced, causing leaf yellowing and flower senescence, which suggests sensitivity to exogenous ethylene. A solution of 0.2% Ca(NO₃)₂ prolonged vaselife by 2.7 days, whereas higher concentrations resulted in flower discoloration and decreased flower quality. Sucrose solutions of 0.5%, 1%, 2%, and 4% had no positive effect on flower longevity. Furthermore, the higher concentrations caused leaf yellowing and petal discoloration decreasing vaselife and quality of flowers compared to control. Samples of inflorescences were taken every second day for chlorophyll (a and b) and anthocyanin measurements. The concentrations recorded were highest in the 0.2% Ca(NO₃)₂ treatment and were significantly correlated to flower longevity. Results indicate that *Ebenus cretica* may be used as a cut flower crop; however, due to the genetic variability of the *Ebenus* plants, a breeding line should be developed before the crop reaches the floricultural market.

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Heat Treatments Delay and Reduce the Ethylene Climacteric in Carnation Flowers (*Dianthus caryophyllus* L. cv. 'White Sim')

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High-temperature treatments can be used for disinfestation of a variety of horticultural crops. Carnation flowers were subjected to a heat treatment in order to determine if it is a viable option for disinfestation of this crop. Flowers were exposed to 45°C for 24 hr in the dark, while control flowers were held at RT for 24 hr in the dark. Subsequently, the flowers were held at RT in the light and monitored for ethylene production, an indicator of imminent floral senescence. In the heat-treated flowers, the ethylene climacteric occurred at 96 hr after the heat treatment, a delay of 12 hr when compared to the control. Peak ethylene production was decreased by 25% to 30% in heat-treated flowers. Northern blot analysis of the ethylene biosynthetic pathway genes, ACC synthase, and ACC oxidase, showed that the expression of these genes is delayed by 8 to 16 hr in heat-treated flowers. This indicates that the delay and decrease in ethylene production is at least, in part, due to a delay or reduction in the expression of these genes. Further investigation revealed a decreased responsiveness of the petals to ethylene. Petals from heat-treated and control flowers were exposed to 1 ppm ethylene for 0, 0.5, 1, 2, 4, 6, 12, and 32 hr. The heat-treated petals again showed a delay and a decrease in maximum ethylene production after exposure to ethylene. A delay in expression of ACC synthase and ACC oxidase was also observed. The beneficial effects of exposing carnation flowers to high temperatures, a delay in ethylene production, and reduced responsiveness to ethylene, suggest that heat treatments could be used for disinfestation of this crop.

102 POSTER SESSION 4A (Abstr. 190–196) Cell & Tissue Culture—Floriculture/ Foliage

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Bulb Quality and Traumatic Acid Influence Bulblet Formation from in Vitro Micropropagated *Lilium* Species and Hybrids

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Micropropagation is an advantageous technique for commercial *Lilium* propagation. The aim of this work was to evaluate the impact of genotype, traumatic acid [TA, 10(E) dodeca-1,12-dicarboxylic acid] treatment and an initial bulb quality on lily in vitro propagation. Genotypes were: *L. longiflorum* Thunb. 'Snow Queen', *L. lancifolium* Thunb., one Oriental hybrid (*L. x* 'Stargazer'), and four Asiatic hybrids (*L. x* 'Enchantment', *L. x* 'Connecticut King', *L. x* 'Sunray', *L. x* 'Cote d'Azur'). Assays were done with good-quality bulb genotypes—chosen by water content, sprouting degree, and appearance—with exception of *L. x* 'Cote d'Azur', where poor-quality bulbs were also included. Surface-sterilized 3-mm scale bulb sections were cultured in MS medium with 100 mg·l⁻¹ myo-inositol, 0.4 mg·l⁻¹ thiamine·HCl, 0.1 mg·l⁻¹ NAA, and 3% sucrose and 0.8% agar, pH 5.7. Cultures were kept in darkness at 25°C during 8 weeks. One μM TA was used to immerse half of the explants during 1 hr before culturing. Genotypes showed a wide variability in bulblets' number (1.7–2.9 bulblets per explant) and biomass (55–147 mg per bulblet). The same variability was observed after TA treatment, which produced an increase in bulblets number per explant (14% to 59%) and also a significantly augmented their fresh mass (9% to 42%). Poor-quality *L. x* 'Cote d'Azur' bulbs adversely affected both biomass and number of bulblets produced on the scale sections, which was not overcome with TA treatment. These results suggest the convenience of TA application in *Lilium* micropropagation protocols on good-quality bulbs, irrespective to the genotype source.

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Effect of Different Concentrations of Plant Growth Regulators on in Vitro Propagation of *Curcuma roscoeana* Wall.

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Curcuma roscoeana Wall. is a tuberous perennial plant with tuberous rhizomes. It is an endangered species. In nature, it has a very low rate of multiplication. Propagation of *C. roscoeana* in vitro was done by culturing 0.5 x 1.0-mm shoot tips from young buds onto modified Murashige and Skoog (MS)+ 0.25 mg/L kinetin. Stem explants 10.0 mm in size, measured from the base of the plantlets longitudinally cut in half, were used in the experiments. The first experiment was done by varying the concentration of both kinetin and NAA, in MS liquid medium, at 0–8.0 mg/L and 0–0.05 mg/L, respectively. There were no significant differences of kinetin and NAA concentrations on the number of plantlets obtained. The 0.5-mg/L kinetin treatment gave the highest yield in number of new plantlets (3.1 plantlets/cultured explant). In the second experiment, various concentrations of BAP from 0 to 8.0 mg/l were tested. 2.8–3.7 plantlets were formed in the media with 0.05–2.0 mg/L of BAP. The most-suitable concentration of BAP was at 1.0 mg/L, providing 3.7 plantlets/cultured explants. Kinetin or BAP alone could be used in MS medium for rapid clonal propagation of *C. roscoeana*. The rooted plantlets could be successfully transferred into growing pots. **Acknowledgement:** The studies were supported in part by The King's Initiative Centre for Fruit and Flower propagation and Development, Ban Rai, Chiang Mai.

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Organogenesis and Cormel Production from Callus Culture of *Gladiolus* cv. 'Balady'

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Callus was initiated from leaves of *Gladiolus* cv. 'Balady' on MS medium containing 1.0 mg/L NAA, 0.1 mg/L 2,4-D, and 0.5 mg/L kinetin. Organogenesis from callus was induced on medium containing 0.5, 1.0, 1.5, or 2.0 mg/L of either BA, kinetin, or TDZ. TDZ was more effective and resulted in a higher percentage regen-

eration and regenerant number. The microshoots produced were then propagated in vitro and cormel production was studied. Maximum shoot number (25.1) was obtained on medium containing 1.0 mg/L TDZ without auxin supplements in liquid shaking culture. In vitro cormel formation was significantly enhanced by B-9 and paclobutrazol. Increased sucrose concentration (4% to 5%) proved the most effective for cormel formation. Optimal dormancy break was obtained by storing cormels at 5°C for 1 month or by soaking them for 5 sec with 50 mg/L GA₃. In-vitro rooting was achieved on solid medium containing NAA, IAA, or IBA, with higher root number recorded on NAA-treated cultures. Rooted microshoots were successfully acclimatized for ex vitro conditions and grown in the greenhouse. Plants produced from in-vitro propagation showed similar morphological characteristics of plants propagated by direct corm planting in the greenhouse.

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Production of Dihaploids in Carnation (*Dianthus caryophyllus* L.)

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Callus and shoot organogenesis were obtained from anthers of *Dianthus caryophyllus* L. 'Manon', 'Amapola', 'Elsy', and 'IB212', harboring mid-uninucleated microspores. Significant differences between genotypes were observed on number of responsive anthers (10.4% to 72.1%) and rescued plants per responsive anthers (1.2% to 4.8%). A modified H medium (Nitsch and Nitsch, 1969) with 20 g/L maltose and 0.25% Gelrite, supplemented with 10 µM 2,4-D and 1 µM TDZ, was most appropriate for callus induction. Plants were regenerated after subsequent subculture to the same medium, but amended with 0.1 µM TDZ. Zymogram types for aminopeptidase (AAP) in polyacrilamide gel electrophoresis proved that all 40 plants regenerated from 'Amapola', 'Elsy', or 'IB212' were heterozygous, and consequently not originated from the microspores but from somatic tissue. Alternatively, in situ-induced parthenogenesis through pollination with gamma-irradiated pollen and in vitro embryo rescue was tested. A total of 92 embryos, including normal and no cotyledonary embryos, were rescued from 38 fruits harvested out of 70 crosses between 'Scania' and 'Amapola'. Embryos were rescued 21 to 28 days after pollination by culture in a modified E20A (Sauton and Vaulx, 1987) medium. Phosphoglucose isomerase (PGI) and Shikimic dehydrogenase (SDH) zymograms in starch gel electrophoresis, and AAP in polyacrilamide gel electrophoresis, indicated the parthenogenic origin of three of the regenerated plants. Flow cytometry of nuclei proved the early diploidization, during in-vitro micropropagation, of the parthenogenic carnation haploid plantlets.

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Shoot Proliferation and Growth of Gardenia (*Gardenia jasminoides* Ellis) in Response to pH and Sugar Concentrations in Vitro

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Stem cuttings of greenhouse-grown gardenia (*Gardenia jasminoides* Ellis) were surface-sterilized and planted on modified Murashige and Skoog (MS) medium supplemented with 2.0 mg/L (BA) and 0.5 mg/L (NAA). This study examines the effects of pH and various sugars on the growth and proliferation of in vitro-cultured gardenia. The highest average shoot number and shoot length were obtained at pH 4.0 to 5.0. In determining the effect of sugars on shoot proliferation, our findings indicated that sucrose and glucose at 30 and 40 g/L, respectively, produced a higher shoot number when compared to fructose and xylose. In addition, sucrose and glucose produced the highest root number, root length, and rooting percentage, while fructose and xylose had no effect on rooting. Sucrose and fructose produced more calli in comparison to other sugars. Xylose at 40 g/L produced the highest dry weight (18.5%), while xylose at 10 g/L produced the highest fresh weight (94.4%).

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Effect of Meristem Position and Medium on in Vitro Meristem Culture of *Alstroemeria*

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Meristems from three different positions were excised from in vitro plants of *Alstroemeria* genotype A30. Explants were removed from the most-distal vegetative

shoot apical meristems, rhizome tip apical meristems, and rhizome tip axillary meristems. Meristems were cultured on four different media to compare the effect of meristem position and medium on the ability to produce *Alstroemeria* rhizomes from meristems. The meristem culture media were Murashige & Skoog salts plus 8.39 µM pantothenic acid, 1.19 µM thiamine, and 0.55 mM myo-inositol (MSM), MSM plus 8.88 µM of 6-benzylaminopurine (BA), MSM plus 8.88 µM BA, and 0.72 µM gibberellic acid (GA₃), and MSM plus 0.72 µM GA₃. Meristems that were removed from the vegetative shoot apices did not develop rhizomes on any medium. Rhizome tip apical meristems developed less than 10% rhizomes when subcultured on media containing BA and GA₃. However, rhizome tip axillary meristems developed rhizomes on all media with best results achieved when the medium was supplemented with BA.

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In Vitro Multiple Shoot Production of *Medicago sativa*

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Multiple shoots were produced directly from each explant. BA, zeatin, or TDZ were evaluated on callus initiation, development, and shoot organogenesis. Callus production was promoted when BA or zeatin was added in culture medium. However, no shoots were produced from such calli. Multiple shoots were produced directly through shoot organogenesis from each seed explant when TDZ was added to culture medium. As many as 30 to 40 shoots were produced per seed explant in about 7 weeks from culture initiation. Different alfalfa cultivars were also tested. The established multiple shoot production protocol provides an efficient way to produce transgenic alfalfa plants, thus could significantly advance alfalfa genetic transformation.

102 POSTER SESSION 4B (Abstr. 197–201)

Cell & Tissue Culture—Landscape Plants

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Plant Regeneration from Cell Suspension Culture of *Ulmus americana* L.

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Leaf segments of greenhouse-grown *Ulmus americana* L. plants cultured on a Murashige and Skoog basal salts medium supplemented with 0.22 mg/L thidiazuron formed friable type of callus and regenerated shoots. This friable callus readily formed a cell suspension when the callus was placed in a liquid MS medium containing 2 mg/L 1-naphthaleneacetic acid and 1 mg/L 6-benzylaminopurine. Shoots were regenerated from 3-month-old suspension cell cultures after the suspension cells had been cultured on solid medium. Shoots developed roots on MS medium containing 0.1 mg/L indole-3-butyric acid. Intact plants were successfully established in soil.

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Plant Regeneration from Hypocotyl of 'King's Choice' Elm

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Seeds of Chinese elm cultivar King's Choice were collected from field-grown plants and germinated aseptically. Hypocotyl segments were excised from 2-week-old seedlings and cultured on Murashige and Skoog (MS) medium supplemented with TDZ alone or in combination with 0.05 mg/L NAA. At least 50% of explants produced shoots 4 weeks after culture initiation. At thidiazuron (TDZ) from 0.05 to 5.0 mg/L, the number of shoots/explant increased as concentration increased. Addition of 0.05 mg/L NAA stimulated shoot regeneration when TDZ concentration was 0.5 mg/L or less, but suppressed it if TDZ concentration was higher than 0.5 mg/L. Regenerated shoots elongated quickly on MS medium supplemented with 1 mg/L gibberellic acid and initiated rooting on MS medium containing 0.1 mg/L indole-3-butyric acid.

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Somatic Embryogenesis of the Cedars of Lebanon (*Cedrus libani*)

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Somatic embryogenesis offers a great potential for large-scale production of *Cedrus libani*, which is important not only as a forest tree, but also for the development of a timber industry. In an attempt to optimize conditions for embryogenic callus induction, we used zygotic embryos at different developmental stages as explants, compared different media, and used several hormone levels and combinations. Results indicated that post-cotyledonary immature embryos had highest induction efficiency. Four different media namely 1/2 MS, Durzan, Litvay's, and Von Arnold supplemented with similar hormone levels showed no significant difference in efficiency of callus induction. Induction frequencies of embryogenic callus from explants subjected to different hormone levels and combinations were dependent on the developmental stage of the explant.

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Micropropagation and Field Establishment of *Hexastylis shuttleworthii* (Britten & Baker) Small

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Hexastylis shuttleworthii is a highly ornamental shade-tolerant evergreen herbaceous plant native to the southeastern U.S. that is difficult to propagate using traditional methods. Micropropagation would make possible the wider distribution of selected clones. Seeds were surface-sterilized and germinated in vitro. Seedling clones were maintained on a MS basal medium containing 1 mg/L BA and were subcultured monthly. Proliferation of clones 2 and 3, maintained on media supplemented with 1, 2.5 or 5 mg/L BA for 6 months, increased slightly with increasing BA concentration; however, proliferation decreased slightly over the experimental period. Rooting medium (perlite, vermiculite, MetroMix 510, Bacto Growers Mix) did not effect microcutting root production or subsequent plant survival. Microcuttings rooted in vitro (67% survival) generated more leaves compared to microcuttings rooted under humidity domes with mist in the greenhouse (8% survival). After rooting in vitro, multiple-shoot clumps (95%) survived better than individual shoots (29%) under greenhouse conditions. Plants were easily established when planted in raised beds in a lath house.

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Effect of Sucrose and PEG Concentration on Embryo Maturation and Hyperhydration in Date Palm Suspension Cultures

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Cell suspension cultures of four date palm cultivars were established, namely, Niboat Saif, Madjhoor, Sukarri, and Berhi. In this study, two factors were tested for their effect on embryo maturation and hyperhydration. The effect of sucrose concentration was assessed by inoculating 0.5 g of embryogenic callus into a liquid MS basal medium supplemented with 10 mg/L inositol, 3 mg/L glycine, 20 mg/L glutamine, and 0, 20, 30, 40, 50 g/L sucrose. Polyethylene glycol (PEG) concentration effect on embryo maturation and hyperhydration was tested. PEG (molecular weight 7000–9000) was added at concentrations of 0, 10, 30, and 60 g/L to the date palm suspension cultures. Cultures were examined and subcultured every 3 weeks for 2 months. Embryos formed were then transferred to a solid MS medium supplemented with 10 mg/L inositol, 3 mg/L glycine, 5 mg/L glutamine, and 30 g/L sucrose. The number of embryos germinated from each treatment was counted to compare cultivar differences. Preliminary data suggests that the medium containing 30 g/L sucrose is most effective for embryo maturation, and those embryos germinated when transferred to a solidified MS medium. The study found that incorporating PEG into the medium reduced the hyperhydration of date palm tissues. The various cultivars reacted differently to the treatments employed.

102 POSTER SESSION 4C (Abstr. 202–210) Culture & Management—Vegetables

202

Effect of Planting Dates and Variety on Maturity and Yield of Southernpea

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Southernpea (*Vigna unguiculata*) is a popular home garden, fresh-market, and processing vegetable in the southeastern United States. Processing schedules are normally controlled by planting the same variety at different dates. Difference in genetic maturity would allow growers to stagger harvest dates by planting different maturity peas on the same day and allow genotype to alter harvest dates. This procedure would allow growers to better utilize available soil moisture and optimum planting dates. Ten southernpea varieties and breeding lines representing early, medium, and late maturity were planted in Kibler, Ark., during the summers of 1994 and 1995. Five different planting dates were used. Flowering dates and days to maturity were recorded and plots were harvested for yield. Results indicate that relative days to maturity can be significantly shortened or lengthened by the time of planting. Varieties planted in early June or early August took longer to mature than when they were planted in late June or early July.

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Abstract withdrawn

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Pollination and Fruit Set of Pumpkins in Growers' Fields in New York's Capital District

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Reports of sharply reduced feral bee populations (*Apis mellifera*) due to harsh winters and prevalence of several bee diseases have raised concerns that pollination and fruit set in pumpkin fields will be adversely affected. In 1995 and 1996, five and eight pumpkin (*Cucurbita pepo*) fields, respectively, were inventoried on three occasions per season for pollinator activity and percent fruit set. Pollen removal from male flowers was determined visually using a rating scale, while deposition of pollen on stigmata of female flowers was judged by rating fluorescence of pollen on the stigmatic surface under a "black light." Samples were taken from 15 to 30 locations in each field, and female flowers tagged. These were considered set if they had enlarged to fist size within 14 days. In both years, the amount of pollen remaining on male flowers was negatively correlated with female flower fluorescence ratings. Neither pollen on male flowers nor stigma fluorescence were significantly correlated with percent fruit set. Fifty-two percent of tagged flowers set fruit in both years, with a range of 24% to 84%, and 17% to 78% in 1995 and 1996, respectively. Presence of bee hives in or near the fields had no effect on fruit set. The results indicate that the pollen removal and deposition ratings used were not reliable for predicting fruit set in farmers' fields. In these 2 years, bee hives were not needed in the sampled fields.

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Yield Effects and Economic Comparison of Using Fresh or Composted Dairy Manure Amendments on Double-cropped Vegetables

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In many areas, dairies and other concentrated animal operations must modify their waste handling systems. Utilization of locally produced manures by vegetable production operations may increase crop yields while preventing discharge of potentially polluting nutrients into waterways. Composting is often recommended to stabilize nutrients, lower the volume of manure, and produce a product that may control some plant diseases. However, composting has costs in time and equipment, so some growers prefer using uncomposted manure. Dairy manure compost at 22 (LC), 45 (MC), or 90 (HC) t·ha⁻¹ or dairy lot scrapings at 45 t·ha⁻¹ (FM) were tilled into soil before seeding a dryland cantaloupe (*Cucumis melo* L.) crop. All plots, including an unamended control (UC), were fertilized with a total of 23N–14P–0K (kg·ha⁻¹). After removal of the cantaloupe in late summer, drip irrigation was added, broccoli (*Brassica oleracea* var. *botrytis* Mill.) seedlings were transplanted into the identical plots, and 112N (kg·ha⁻¹) was sidedressed. Cantaloupe yields from FM, LC, MC, HC, and UC plots were 5.4, 3.4, 2.1, 4.5, and 1.5 t·ha⁻¹, respectively. Broccoli yields from FM, LC, MC, HC, and UC plots

were 4.1, 3.6, 4.4, 4.1, and 2.2 t·ha⁻¹, respectively. All rates of compost or manure increased yields of cantaloupe, and the subsequent broccoli crop. Use of the manure resulted in highest increase in potential net income from sales of cantaloupe and broccoli.

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Omega-3-Fatty Acid Concentration in *Portulaca oleraceae* L. is Altered by the Source of Nitrogen in Hydroponic Solution

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Omega-3 fatty acids (O3FA) are essential for normal human growth, development, and disease prevention. Purslane (*Portulaca oleraceae* L.) is an excellent source of the O3FA α -linolenic acid (LNA)—with higher concentrations than any green leafy-vegetable examined to date—and is being considered for cultivation (by USDA-ARS) in an effort to improve the balance of essential fatty acids in the western diet. Twenty-five-day-old seedlings of both a green-leafed and a golden-leafed type of purslane were transplanted into a closed hydroponic system. Nitrogen, at 200 ppm, was provided as NO₃ and NH₄ forms to yield NO₃:NH₄ ratios of 1:0, 0.25:0.75, 0.5:0.5, and 0.75:0.25. Treatments were arranged in a randomized complete-block design with five replications. The experiment was repeated. Young, fully expanded leaves were harvested 18 days after treatment initiation, frozen (-60°C), and then analyzed for fatty acids using gas chromatography. Although the two types of purslane did not differ in LNA concentration, the green-leafed purslane produced greater total dry mass than the golden-type. On a leaf dry mass basis, plants grown with a NO₃:NH₄ ratio of 0.5:0.5 produced 241% and 53% greater LNA than plants grown with NO₃:NH₄ ratios of 1:0 and 0.75:0.25, respectively. Plants grown with NO₃:NH₄ ratios of 1:0 and 0.25:0.75 produced similar leaf LNA concentrations. Total dry mass was not affected by the nitrogen treatments.

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Specialty Potato Varieties in Pennsylvania

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Acreage of white potato production in Pennsylvania has steadily declined in the past 20 years, from ≈25,000 acres in 1976 to 18,000 acres in 1996. This decline in acreage has occurred mainly with potatoes used for chips, with a much smaller acreage loss for tablestock potatoes. The most common tablestock varieties on the market are round white or long russet varieties, which have been around for 30 to 50 years. However, the 90's consumer is more perceptive and creative with food choices, such that color, texture, and taste have become important characteristics in choosing new food items. Specialty new potatoes represent a relatively unexplored market with excellent potential for sales expansion in the fresh market and tablestock industry. Today's consumers are demanding more variety with respect to virtually all produce commodities and potatoes are no exception. Consumers demand different size, color, and taste of fresh vegetables, including potatoes. New specialty potato varieties (Yukon Gold is an example) are currently in demand by restaurants and some retail markets, and it appears that relatively high returns are possible with these specialty potatoes. Twenty-nine red, buff, or blue-skinned and white-, yellow-, purple-, or red-fleshed potato varieties were planted in a replicated study at the Hort Research Farm, Rock Springs, Pa., in 1996. Yield and quality characteristics of these varieties will be presented along with some consumer acceptance/evaluation data collected from a local supermarket.

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Effects of Plant Density, Row Arrangement and Cultivar on Fruit Size and Yield in Honeydew Melons

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Melon growers in the Lower Rio Grande Valley of Texas have observed in the past that particular sizes of melons and the earliness of melons had a direct effect upon economic returns. A replicated study was carried out during two seasons to determine what specific effects plant density, row arrangement, and cultivar would have on fruit size and yield. The study combined six spacing treatments with three cultivars in a randomized design utilizing five replications on top of raised beds on 80-inch centers. Work was initiated by direct seeding and then thinning to the desired spacing interval in plots located in a commercial field. Plots were harvested by commercial harvesting crews. Results indicate that different plant spacings and honeydew cultivars can result in differences in fruit size, earliness, and returns/acre

over different seasons and environments although spacing and cultivar acted independent of one another. Lower plant populations resulted in the production of larger fruit and higher plant populations resulted in the production of smaller fruit. Cultivar did affect the size of fruit produced, with some cultivars resulting in larger melons and others producing more small melons. In both seasons, the double-row 24-inch spacing resulted in an earlier harvest and exhibited a higher percent harvest for the first harvest in both years. Cultivar Sure 7050 was significantly later than either 'Honeybrew' or 'Morning Ice'. Returns/acre were significantly different between spacing treatments for a majority of harvests. The double-row 24-inch spacing resulted in the highest returns/acre. Both 'Morning Ice' and 'Sure7050' had significantly higher returns when compared to 'Honeybrew'.

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Growth and Productivity of Tropical Leaf Vegetables in the Virgin Islands

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Four tropical leaf vegetables commonly used as pot herbs for "kallaloo," a local West Indian dish, were grown in replicated plots during the fall season of 1996 to determine growth and productivity. Leaf vegetables included green malabar spinach (*Basella alba* L.), red malabar spinach (*Basella rubra* L.), sweetpotato (*Ipomoea batatas* L.), and bush okra or jute mallow (*Corchorus olitorius* L.). Plants were harvested periodically and data on number of stems or vines, fresh weight of stems and leaves, leaf area, and leaf area index (LAI) were recorded. Except for leaf fresh weight, cultivars or species did not differ significantly in all parameters measured. Leaf fresh weight ranged from 27 g for jute mallow to 198 g for red malabar spinach. LAI was highest for sweetpotato (2.90) and lowest for jute mallow (0.86). Among the species, productivity (fresh weight) was highest (6.78 g/m² per day) for green malabar spinach and lowest (3.22 g/m² per day) for jute mallow.

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Yield and Plant Characteristics of Mint Germplasm in Virginia

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A collection of 35 mint (*Mentha* spp.) lines was evaluated during 1996 for fresh and dry yield, percentage of leaves, leaf moisture, and stem moisture to study suitability for fresh markets. These lines were categorized based on geographic origin (domestic vs. foreign), ploidy level (diploid vs. polyploid), mint type (peppermint vs. spearmint), and genetic makeup (pure lines vs. hybrids), and statistical comparisons were made between these categories. Fresh yield and proportion of fresh leaves in the total harvest were affected by type and genetic makeup of mint accessions. Spearmint had significantly greater yield than peppermint (4.1 vs. 2.5 kg/m²) and higher proportion of leaves (69% vs. 63%). Species had higher fresh yield than hybrids (4.1 vs. 2.7 kg/m²) and higher proportion of leaves (69% vs. 65%). Domestic accessions, peppermint, and hybrids had significantly higher leaf moisture than foreign accessions, spearmint, and species (26% vs. 22%, 28% vs. 23%, and 27% vs. 24%, respectively). None of the categories affected moisture content in the total plant harvest or stems. Further details of these data will be presented and discussed.

102 POSTER SESSION 4D (Abstr. 211–217)

Growth & Development—Vegetables/Herbs

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Influence of *Suaeda salsa* as a Companion Crop with Tomato Plant in a Closed Root System

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The use of the halophyte *Suaeda salsa* as a salt absorber in saline soils has been exploited as an attempt to increase crop productivity in marginal saline soils. The shoot and root salt contents of this halophyte has been documented to reach up to 27% and 12% of dry weights. The sodium salinity stress of the growth media [peat:vermiculite (1:1 by volume)] may be alleviated by planting the *Suaeda* with tomato plant in the same root pouch of a completely closed root environment, referred to as the closed insulated pallet system (CIPS). The CIPS is a continuous

sub-irrigation capillary system with water moving from reservoir to rootzone in response to plant uptake. In CIPS, fertilizer reserve is placed at the top surface of the root matrix, so fertilizer ions move downward by diffusion. The objective of the present research was to utilize the *Suaeda salsa* as a bio-desalinant, so salinity of the growth media is reduced, thus reducing the salt uptake by the tomato cv. 'Pik Red'. Two salinity levels (control and 4 g/L NaCl in the sub-irrigation water) were imposed on tomato plants or tomato grown with *Suaeda* in the same pouch. Sodium contents were reduced 56.4% and 37.1% in the growth media and tomato foliage, respectively, in the presence of the halophyte during a 110-day growing period. Likewise, the electrical conductivity of the growth media was reduced by 31.1% with *Suaeda* companionship. The *Suaeda* had accumulated salts up to 4.1 mg/g dry weight tissues. The results seem promising; however, growth and yield of tomato plants grown with the halophyte were significantly decreased, probably due to competition for nitrogen and/or light. Research is underway for development of the CIPS to better accommodate crop companionship.

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Flow Rate as an Important Physiological Factor Associated to Calcium Concentration in Pods of Snap Bean (*Phaseolus vulgaris* L.) Plants Grown Aeroponically

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To understand physiological factors associated with genetic differences for pod Ca concentration between snap bean genotypes, flow rate and Ca uptake of sieve sap were measured, as well as pod Ca concentration. Measurements for flow rate and Ca uptake were done at three developmental stages (flowering and 1 and 3 weeks after) in two commercial snap bean cultivars (Hystyle and Labrador) grown aeroponically. Pods were collected 2 weeks after flowering only. Flow rate and Ca uptake sampling began 4 weeks after transplanting and consisted of: 1) decapitation of the plant at the first node; 2) covering the stem with pre-weighed dry cotton; and 3) removing the cotton, reweighing it, and saving it for Ca determination. Flow rate was defined as the difference in cotton weight (expressed as ml) per 17 hr divided by foliage mass. Ca uptake was defined as mg of Ca per total volume of sieve sap after 17 hr divided by foliage mass. Ca determinations were made using an atomic absorption spectrophotometer. A positive correlation between flow rate and total Ca uptake of sieve sap ($R^2 = 0.90$), flow rate and pod Ca concentration ($R^2 = 0.47$), and Ca uptake and pod Ca concentration ($R^2 = 0.42$) were found. Hystyle reflected 1.5 times more flow rate and pod Ca concentration than Labrador. Significant differences between genotypes for pod Ca concentration, Ca uptake, and flow rate were observed. Results were consistent across developmental stages.

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Chemical Characterization of Basil (*Ocimum* spp.) Germplasm from Brazil

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Ocimum species are largely used in Brazil both as a condiment and in traditional medicine against bronchitis, cough, and sorethroat in the form of tea or syrup. As little research has examined the natural products from Brazilian basil, 14 accessions of *Ocimum*, including *O. basilicum* (4), *O. campechianum* (3), *O. gratissimum* (6), and *O. kilimandharicum* (1), collected in Brazil were grown in the Purdue Univ. greenhouse and upon maturity harvested, the volatile oil extracted and analyzed by GC/MS. Thirty-one constituents were identified. Three accessions of *O. gratissimum* showed high content of eugenol (40% to 66%), while the other accessions contained either high thymol (33%) or p-cymene (28% to 42%). The constituents of the single *O. kilimandharicum* included 1,8-cineole (39%), methyl-chavicol (21%), and β -bisabolene (23%). *O. campechianum* accessions contained either high 1,8-cineole (62%) or high β -caryophyllene (79%). *O. basilicum* could also be separated chemically: a linalool:methyl chavicol type (47:28%); one methyl chavicol type (72%), and a third, methyl cinnamate (61%). One accession was identified containing >90% *trans*-methyl cinnamate, which crystallized during extraction. Plants rich in targeted compounds, such as the one with 90% *trans*-methyl cinnamate, can be used as source of germplasm for breeding and potential commercialization

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Predicting Dry Bean Yields in Phenological Time

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A multiple regression model was developed to predict dry bean yields for the dry bean-growing region of western Nebraska. Within the context of the dry bean phenological growth stages, the model assesses the significance and magnitude of weather, climatic and irrigation disasters, and technology. Yield data was taken from four western Nebraska counties (Box Butte, Morrill, Scotts Bluff, and Sheridan) for 1940 to the present. Weather data used to predict yield were daily maximum and minimum temperatures and precipitation from a single weather station in each respective county. Farmers and industry personnel in each county provided historical recollections of years when county-wide disaster events occurred, such as hail and early frost. Four 21-day growth stages were defined as: emergence and stand establishment, rapid vegetative growth, flowering and pod development, and pod fill and maturation. The model predicts current season yields at the end of each growth stage as the season progresses. In 1995, the model predicted a yield of 1731 lb/A—3% below the final USDA estimate for Scott Bluff county. The 1996 predicted value is for 2162 lbs/A—the fifth largest in history. Providing accurate real-time yield predictions assess which weather-related factors are significant, and ranks the relative impacts of weather effects on dry bean yields. Technological progress in yield can also be measured. This information aids farmers in the selection of varieties and management practices that reduce yield losses, predicts regional crop production for agribusiness planning, and provides plant breeders the guidelines for variety development.

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Light Quality Effects on Flower Sex Expression in Cucumber and Spinach

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Using spectral filters to reduce the amount of far-red (FR) light perceived by plants has been shown to effectively reduce internode elongation of many floriculture crops. It is theorized that gibberellin (GA) function is inhibited in some way by the increase in the red : far-red light ratio. Sex expression of flowers are effected by exogenous applications of gibberellin and cause a shift in flower sex expression towards maleness. The use of growth regulators (GA inhibitors) have demonstrated a shift towards femaleness. Flowering of spinach, a dioecious species, and cucumber (staminate and pistillate lines), a monoecious species, were surveyed for shifts in flower sex expression, indicating a suppression of GA. Male : female flower ratio decreased from 7.6:1 to 4.06:1 when comparing the controls and -FR for the staminate cucumber line and 1:13 to 1:40 for the gynecious cucumber line. The decrease in male flowers on plants grown in a -FR environment are an indication that the function of GA is inhibited. There was no significant effect on the male : female flower ratios of the spinach.

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Identification and Characterization of Basil Anthocyanins

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The importance of anthocyanins as a food coloring, UV protectant, inhibitor of pathogens, and medicinal compound has been well-documented, with more than 300 anthocyanin compounds being reported in plants. The Lamiaceae family, including sage, thyme, and basil, has long been recognized as a rich source of diverse and unique anthocyanins. Because purple basil varieties have become more popular in the ornamental and herb trade, we conducted a study to identify and characterize the anthocyanins present in eight varieties of purple basil (*Ocimum basilicum*) utilizing high-pressure liquid chromatography, spectral data and plasma-desorption mass spectrometry. Nine different anthocyanins were identified. Seven of the pigments were cyanidin-based, with cyanidin-3-(6"-p-coumaroylglucoside)-5-(6"-malonylglucoside) as the major pigment. Two minor pigments based on peonidin were also identified. Total anthocyanin content was also determined and comparisons made to other anthocyanin sources.

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"Black Spot," a Physiological Disorder of Seed Development in Watermelon

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Production of watermelons for seed consumption is popular in many regions of the world. In the Mediterranean area, large white seeds are preferred. Six breeding lines were selected for investigating the nature of black spot, an undesirable feature

reducing the commercial value of the seeds. Black spot is expressed as blackened areas of the seed coat, mostly near the margin in mild cases, but extending over much of the seed coat in severe cases. Sowing date had a significant effect on expression of black spot. Seeds that developed in early summer (June) had low frequency and severity of black spot expression, whereas seeds that developed later in the summer (July–August) had markedly increased expression. Large differences were also observed among the breeding lines. There was a significant negative correlation between severity of black spot and seed weight, suggesting that black spot is a stress-related phenomenon.

102 POSTER SESSION 4E (Abstr. 218–223) Sustainable Agriculture—Cross-commodity

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Alternative Crop-growing Strategies: Use of Winter Cover Crops on Bell Pepper Production

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The effects of two winter cover crops, rye and crimson clover, on bell pepper yield were studied. Cover crops were planted in fall and incorporated into the soil prior to bell pepper planting. Both cover crops increased the marketable number and weight of bell peppers, and reduced the cull number of bell peppers compared to fallow (control) treatment. Delaying the harvest increased the marketable yield in both cover crops. Since there was no difference in bell pepper yield between two cover crops, both cover crops can be used effectively for bell pepper production. Use of cover crops may reduce the production costs and harmful effects on the environment by reducing chemical dependency, and increase the crop yield.

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Winter Legume Cover for Sustainable Tomato Production

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The purpose of this study was to compare the efficacy of winter cover cropping with legumes for replacing synthetic N fertilization in tomato production. The following winter/spring fertility treatments were applied: 1) 0 N winter/0 N spring, 2) 0 N winter/90 kg·ha⁻¹ N spring, 3) 0 N winter/180 kg·ha⁻¹ N spring, 4) 0 N winter+rye/0 N spring, 5) 0 N winter+hairy vetch/0 N spring, and 6) 0 N winter+crimson clover/0 N spring. In the spring of 1996, tomato cultivar 'Mountain Pride' was planted in all plots. The effects of different treatments on plant dry weight and fresh fruit yields were determined. Tomato following legumes or supplied with 90 kg·ha⁻¹ fertilizer N produced highest plant dry weight, while 0 N winter/0 N spring and 0 N winter+rye/0 N spring produced plants with least dry weights. Treatments differed in a similar fashion also for fresh fruit yields. The results suggested that winter legumes were at par with commercial N fertilizer in supplying needed inorganic N to the succeeding tomato crop soil.

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Stand, Growth, and Yield of Snap Beans in Conventional Tillage and No-till Hairy Vetch Mulch

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Stand, plant growth, and yield were determined on 'Matador' and 'Carlos' snap beans (*Phaseolus vulgaris* L.) that were planted as a summer crop in a 3-year study using conventional tillage (CT) and no-till hairy vetch (*Vicia villosa* L. Roth) mulch (HV) systems. The CT plots received (kg·ha⁻¹) 67 N as ammonium nitrate at preplanting and both CT and HV plots received (kg·ha⁻¹) 17N–34P–17K with the planter. Stand differences between CT and HV were not significant. Average yields in CT and HV over a 3-year period were 13.3 and 19.8 t·ha⁻¹, respectively. Average plant dry mass 2 days before harvest was not significantly different between CT and HV. Leaf area per plant 2 days before harvest was 1992 and 3092 cm² in CT and HV, respectively. Higher yield in the HV mulch system, as compared to CT, can be attributed to larger leaf area per plant, higher soil organic matter and water-holding capacity, and less soil compaction in the HV plots.

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Effects of Seed Treatments on Germination of Seed Collected from Native Populations of *Oenothera*

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Oenothera biennis, common evening primrose, is grown commercially for its seed, which contains high levels of gamma-linolenic acid (GLA), a fatty acid with pharmaceutical and dietary importance. Other native species of *Oenothera* are being evaluated for the presence of GLA in their seed and their potential as a commercial source of GLA. Native evening primrose species have shown slow emergence and low germination percentages. Studies were conducted to determine the effects of chilling, scarification, and priming on germination of seed for six species of native evening primrose. Overall, seed germination was improved by seed treatments. However, responses to the various treatments differed among species.

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Use of Sphagnum Peatmoss in a Composting Process

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The general population is constantly reminded of the need to adopt a more environmental-friendly approach to waste disposal on all scales. Commercial fishing generates large proportions of waste, ranging from 40% to more than 80% of the catch! The objective of conserving the nutrients and other organic values contained in this type of waste is unlikely to be fully met by bulking for aerobic composting with materials of low buffering capacity, such as straw or wood wastes. However, the capacity of peat for deodorizing of decomposing organic wastes as well as its high buffering capacity has been well demonstrated. This presentation shows how the incorporation of sphagnum peatmoss in a composting process contributes significantly to the production of a valuable organic soil amendment.

223

Surface Mine Land Reforestation: Using Poultry Litter

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Poultry and coal production are two major industries concentrated in north-central Alabama. Standard surface coal mine reclamation procedures were compared to procedures utilizing poultry litter in an 3.24-ha mine site. Three 0.4-ha plots amended with litter at rates of 25, 50, and 100 ml/ha, were compared to a plot with mineral fertilizer (13N–13–P13K) at standard reclamation rates of 672 kg/ha, and a plot receiving no fertilizer or litter. All plots were amended with ground limestone and disced in 31 cm. A mix of fescue, lespedeza, rye, and clover was broadcast over all plots uniformly. Eight tree species; northern red oak, nuttall oak, willow oak, red maple, yellow poplar, royal paulownia, loblolly pine, and eastern red cedar were planted in all plots at 1482 trees/ha. Forage yields (1995–96) in litter-amended plots were two to three times higher than statewide hay production averages. High litter rates have had no negative effects on ground cover, tree survival, or ground water nitrates (NO₃). This project demonstrates broiler litter use as an organic-matter amendment in a self-sustaining reclamation success.

102 POSTER SESSION 4F (Abstr. 224–233) Photoperiod/Temperature/Growth—Floriculture

224

Effect of Photoperiod on Stem Elongation and Flowering of 10 Hanging-basket Crops

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Argeranthemum frutescens 'Butterfly' and 'Sugar Baby', *Brachycome hybrid* 'Ultra', *Helichrysum bracteatum* 'Golden Beauty', *Scaevola aemula* 'New Wonder', *Supertunia axillaris hybrids* 'Kilkenny Bells' and 'Pink Victory', *Sutera cordata* 'Maue Mist' and 'Snowflake', and *Verbena hybrid* 'Blue' were grown in a glass greenhouse maintained at 20°C under seven different photoperiods (10-, 12-,

13-, 14-, 16-, 24-hr, and 4-hr night interruption). Black cloth was pulled at 1700 and opened at 0800 HR; incandescent lamps provided $2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ to extend light hours to the designed photoperiods. Seedlings were pinched 3 days after transplant. Responses to photoperiod were clearly species-dependent. The tested species can be classified into three groups: 1) stem elongation and flowering were promoted in the long-day treatment (*A. frutescens* and *S. axillaris* hybrids), 2) only stem elongation was promoted in the long-day treatment (*S. aemula*, *H. bracteatum*, and *B. hybrid*), and 3) neither flowering nor stem elongation were affected by photoperiod (*S. cordata* and *V. hybrid*).

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Lupine (*Lupinus polyphyllus*) Flower in Response to Long-day Photoperiod by Day Extension

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Ninety-six uniform plants of each 'Russell hybrid' and 'Gallery' mix lupines sown 9 June 1995 were randomly assigned to 32 unique treatment combinations. On 14 Dec 1995, plants were either placed in a 17/13°C day/night temperature (DT/NT) greenhouse (COOL) or 22/18°C DT/NT greenhouse (WARM) as controls, or in a constant 4.5°C cooler in the dark for 6, 8, 10, or 12 weeks. After cooling, plants were transplanted to #1 nursery cans (2.75 liter) using Sunshine mix #2 and were assigned randomly to the COOL or WARM greenhouse. Greenhouse control plants under natural days were transplanted at intervals similar to cooled plants. Days until visible bud and flowering were analyzed using SAS PROC GLM. Plants receiving long day (LD) flowered 7 to 10 weeks (46 to 70 days) after the start of LD forcing. Buds were visible in 30 to 35 days. Plants receiving natural days (ND) did not flower uniformly unless they were cooled for 12 weeks, yet flowering took longer (8 to 12 weeks) when compared with LD. Unfortunately, LD lighting for the entire forcing period caused excess stretching, so plants finished too tall for quality potted plants. Forcing in a COOL greenhouse delayed flowering about a week compared to the WARM greenhouse.

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Flowering Response of *Anemone coronaria* to Photoperiod and Temperature

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Eight-week-old plants of *Anemone coronaria* L. 'Mona Lisa Series' were transplanted into 10-cm pots and placed in growth chambers at 12, 16, or 20°C and 8, 12 or 16 hr of day length. The irradiance was 12 mol/day per m². Following the exposure to treatment conditions for 8 weeks, the plants developed in a greenhouse at 16°C and 16 hr of 10-12 mol/day per m². The fastest appearance of flower buds and flowering were observed for plants grown at 16 hr of day length and 16°C (77 ± 5.4 days from transplant, 133 days from seeding). However, the rate of development was not significantly different from the plants at 12°C and 12 hr of day length (81 ± 3.6 days). Flowering at 20°C required significantly more time at an average 93 ± 9.9 days from transplant. Leaf number at flowering increased with temperature from 9.5 leaves at 12°C to 12 ± 3.4 leaves at 16°C and 15 ± 3.4 leaves at 20°C. Flower stem length was significantly longer for plants grown at 12°C or 16 hr of day length (32 ± 0.5 cm) than plants grown at any of the other conditions (26 ± 0.5 cm). The average flower size (length of the petals) was 3.8 ± 0.6 cm for all plants in the study.

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Photoperiod and Temperature Affect *Lamium*, *Scaevola*, *Verbena*, and *Calibracoa* Development and Propagation

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Lamium maculatum L. 'White Nancy', *Scaevola aemula* R. 'New Blue Wonder', *Verbena x hybrida* Groenl. & Ruempl. 'Tapien Blue', and *Calibracoa x hybrida* 'Cherry Pink' were placed under different photoperiod treatments at constant 15, 20, 25, or 30 ± 2°C air temperature. Photoperiod treatments were 9 hr, ambient daylight (≈8 hr) plus night interruption lighting (2200–0200 hr, $2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from incandescent lamps), or ambient daylight plus continuous light (100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ light from high-pressure sodium lamps). Data on plant development and rootability of cuttings from each environment was collected. Days to anthesis was lowest when plants were grown under the continuous lighting

treatment across species. *Verbena* and *Calibracoa* stem elongation was greatest when grown under 30°C under continuous lighting. Species were classified as to photoperiodic flower induction groups. Implications of these data with respect to propagating and finishing these crops are discussed.

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Photoperiod and Temperature Interact to Affect *Viola x witrockiana* Gams. Development

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Viola x witrockiana Gams. cvs 'Delta Pure Rose' and 'Sorbet Yellow Frost' were grown under different photoperiod and temperature treatments (12–24 ± 2°C) for different lengths of time at different stages of development during the first 6 weeks after germination. Plants were grown with ambient light (≈9 hr) at 16°C before and after treatments. Days to anthesis and leaf number were lowest when plants were grown under night interruption from 2200–0200 hr ($2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from incandescent lamps) and daylight plus continuous light (100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from high-pressure sodium lamps) for 'Sorbet Yellow Frost' and 'Delta Pure Rose', respectively. Days to anthesis decreased as temperature increased from 12 to 24°C. Plant height and internode elongation were greatest and least in the night interruption and continuous light treatments, respectively. Branching decreased as temperature increased from 12 to 24°C. Implications of these data with respect to classification of *Viola x witrockiana* flower induction and development of pre-finished seedlings is discussed.

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Factors Affecting Flowering of *Hibiscus* spp.

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Hibiscus spp. seed were germinated and placed under different photoperiod treatments at 15, 20, or 25 ± 2°C. Photoperiod treatments were 9 hr, ambient daylight (≈9 hr) plus night interruption lighting (2200–0200 hr, $2 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from incandescent lamps), or ambient daylight plus continuous light (100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ light from high-pressure sodium lamps). Treatments were terminated at anthesis or after 20 weeks. Variation in flowering form and plant habit were documented and will be discussed. Temperature/photoperiod effects/interactions on plant development will be presented. Species were classified into appropriate photoperiodic groups. Those species with potential as new commercial floriculture crops will be presented.

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Phases of Flower Development in Opium Poppy under Various Temperatures

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Flower development in opium poppy (*Papaver somniferum* L.) has been divided into four phases from emergence to anthesis, which mark changes in its sensitivity to photoperiod: a photoperiod-insensitive juvenile phase (JP), a photoperiod-sensitive inductive phase (PSP), a photoperiod-sensitive post-inductive phase (PSPP), and a photoperiod-insensitive post-inductive phase (PIPP). To predict flowering time under field conditions, it is essential to know how these phases are affected by temperature. Plants were grown in artificially lit growth chambers and received three temperature treatments: 15/10, 20/15, and 25/20°C in a 12-hr thermoperiod. Plants were transferred within each temperature regime from a non-inductive 9-hr to an inductive 16-h photoperiod or vice versa at 1- to 4-day intervals to determine the durations of the four phases. Temperature did not affect the durations of the first two phases (i.e., JP lasted 3 to 4 days and PSP required 4 to 5 days). The most significant effect of temperature was on the duration of PSPP, which lasted 28, 20, and 17 days at 15/10, 20/15, and 25/20°C, respectively. The temperature effect on PIPP was small (maximum difference of 3 days for treatments) and the data too variable to indicate a significant trend. Our results indicate that PSPP is the only phase that clearly exhibits sensitivity to temperature.

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Growth of Cyclamen as Affected by Day and Night Temperatures

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The growth of *Cyclamen persicum* Mill. 'Laser Scarlet' and 'Sierra Scarlet' was evaluated for plants grown at day/night temperature differences of +9, +3, 0, -3 or -9°C. The day temperature was maintained for the duration of the 16-hr photoperiod and the day and night temperatures were selected to provide an average daily temperature of 16°C. The plants were grown at the specific temperatures starting 15 weeks from seeding until flowering. Total daily irradiance was 10 mol/day per m². There was no significant difference in time to flower for plants of 'Laser' (115 10.3 days from transplant). Flower buds appeared earlier above the foliage for 'Sierra' plants grown at negative differences of 3 or 9°C (113 11.4 days) compared to plants grown at constant 16°C (124 9.7 days). At flowering, plants grown with a positive difference of 9°C were significantly taller (22 1.9 cm for 'Laser' and 24 2.0 cm for 'Sierra') than the plants at 16°C (19 1.9 cm for 'Laser' and 21 2.1 cm for 'Sierra'). Plants of 'Laser' grown at +3°C difference were also taller (21 2.1 cm) than the control plants at 16°C. Plant dry weight was larger for plants of both 'Laser' and 'Sierra' grown with +9°C. There were no differences in flower number or flower size among plants within each cultivar grown at the different temperature conditions.

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Factors Affecting Flowering of *Asclepias* spp.

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Asclepias sp. seed were germinated and placed under different photoperiod treatments at constant 15, 20, or 25 ± 2°C. Photoperiod treatments were 8 hr, 8 hr plus night interruption lighting (2200–0200 hr, 2 μmol·m⁻²·s⁻¹ from incandescent lamps), day extension lighting 1700–2000 HR (100 μmol·m⁻²·s⁻¹ from high-pressure sodium lamps), or daylight plus continuous light (100 μmol·m⁻²·s⁻¹ light from high-pressure sodium lamps) treatments. Treatments were terminated at anthesis or after 15 weeks. Variation in plant habit and flowering were documented. Also, temperature/photoperiod effects/interactions on plant development are discussed. Lastly, species were classified into appropriate photoperiodic groups and evaluated for potential use as new floriculture crops.

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Annual Growth and Development of *Scilla peruviana*

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Scilla peruviana is a bulbous plant whose distribution extends from South Africa, into Europe and Asia. It belongs to the family Liliaceae (subclass Monocotyledonae). *S. peruviana* is an attractive floral species with excellent commercial potential, but it does not produce many bulblets and its multiplication rate is very low. Increasing the multiplication rate, and regulation of its growth and development, cannot be achieved without knowledge of its basic patterns of ontogenesis. We studied the annual growth and development of *S. peruviana*, from initiation until differentiation, giving special attention to cytological changes at the apical meristem. We also investigated the cytophysiological changes occurring in scales during ontogenesis. Two generations of daughter bulbs are present in each mother bulb. Flowering of the mother bulb coincides with vegetative development of the apical meristem of the primary daughter bulb (March–April). During gradual senescence of leaves and roots of the mother bulb, the apical meristem of the primary daughter bulb undergoes a transition from vegetative to prefloral development (June). Intensive flower organ differentiation occurs in the daughter bulb during the mother bulb's rest period (July–August). Initiation of the apical meristem of the secondary daughter bulb occurs within the primary daughter bulb, which is itself enclosed within the mother bulb (August). The development of the apical meristem of a daughter bulb, from its initiation until flowering, thus occurs without interruption and takes ≈20 months. By modifying external factors such as temperature and growth regulators, we can now control time of flowering and increase the multiplication rate of *S. peruviana*.

102 POSTER SESSION 4G (Abstr. 234–247)

Disease Control–Cross-commodity

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Evaluation of Fire Blight Resistance of *Malus sieversii* Populations from Central Asia

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Malus sieversii is one of the primary progenitors of the cultivated apple. Since 1989, several collecting trips have been made to central Asia by personnel of the USDA and Cornell Univ. to collect seeds of wild *Malus sieversii* from many diverse ecosystems. In 1992, an ex situ plot in Geneva, N.Y., was established with trees grown from seed that was collected in three different habitats in Kazakhstan, Tajikistan, and Uzbekistan in 1989. In 1995, trees grown from seed that was collected in five additional habitats in Kazakhstan and Kyrgyzstan in 1993 were added to the ex situ plot. In the summers of 1995 and 1996, tips of vigorously growing shoots of 1135 seedlings from 79 different populations were inoculated by hypodermic syringe with 5 x 10⁸ cfu/ml of *Erwinia amylovora* strain Ea273. Seedlings from the 1989 collection were in the fourth and fifth field-growing seasons, with some beginning to bear fruit. Seedlings from the 1993 collection were in first and second field-growing seasons. Results from both seasons indicated that individuals within each of the 79 populations of *M. sieversii* are resistant to fire blight (defined as ≤20% shoot length infected). Resistance differed among populations, with some populations having no resistant individuals and others having >80% of the seedlings resistant. The range of resistance is quite similar to that seen among apple cultivars from North America and Europe. In another test, some accessions from 1989 collection had sufficient bloom for inoculation in 1995 and 1996. At full bloom, blossoms on these trees were inoculated with the *E. amylovora* suspensions (5 x 10⁷ cfu/ml) using a backpack sprayer. These also gave diverse resistant reactions.

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Hydrophobic Particles for Pest Control in Deciduous Tree Fruit Production

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Fruit production requires extensive use of pesticides to control pest damage and maintain high product quality. Hydrophobic particles alter the leaf surface due to the hydrophobic and reflective nature of the particles and impart characteristics that make the plant surface incompatible, and/or unrecognizable to the pest. Hydrophobic particles were applied to apple and pear in field and greenhouse studies. Specific diseases, insect pests, plant growth, and yield were monitored and evaluated on treated plants in comparison to untreated and chemically treated controls. Powdery mildew in apple and Fabrea leaf spot in pear were controlled by the hydrophobic particles. Aphids, mites, and psylla were controlled in apple and pear. Hydrophobic clays have the potential of cross-protection for several disease and insect pests while imparting beneficial horticultural effects that would increase long-term productivity and sustainability of fruit production systems.

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Protection of Long English Cucumber against Powdery Mildew through Induced Resistance using Milsana (Leaf Extracts)

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Application of Milsana, a commercial formulation of leaf extracts from *Reynoutria sachalinensis*, has been shown to reduce the incidence of cucumber powdery mildew (*Sphaerotheca fuliginea* Schlecht, ex Fr. Poll.) under both small- and large-scale conditions. This treatment could therefore have a potential in a scheme of integrated control of powdery mildew. Increased chlorophyll values due to the treatment were recorded, but could not explain the prophylactic properties of the extracts. Also peroxidases, polyphenoloxidases, and PAL were shown to be activated, but no phytoalexins could be detected before in cucumber. In this work, phenolic compounds extracted from cucumber leaves were separated and analyzed for their differential presence and fungitoxicity in relation to the Milsana protection against powdery mildew. Six compounds were shown to display a significant increase in concentration as a result of the elicitation, this being particularly evident when the plant was stressed with the pathogen. These compounds were the first evidenced phytoalexins in cucumber. The major compound was identified as the methyl ester of p-coumaric acid.

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Effect of Chitosan on Growth and Toxin Production by *Alternaria alternata* f. sp. *Iycopersici*

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The antifungal activity of chitosan, a biopolymer of β -1-4 glucosamine, against *Alternaria alternata*, causal agent of black mold of tomato, was investigated. Chitosan was incorporated into potato dextrose broth (PDB) at concentrations of 100, 200, 400, 800, 1600, 3200, and 6400 $\mu\text{g}\cdot\text{ml}^{-1}$, growth and toxin production by the fungus were assessed after a 15-day incubation period. Chitosan significantly affected both growth and toxin production at higher concentrations. However, at lower concentrations, toxin production was affected more than the growth, as evidenced by minimum inhibitory concentrations (MIC) of chitosan derived for toxin production and mycelial growth. Excess sporulation of the fungus was observed in the presence of chitosan, but the spore viability was affected. Chitosan induced aggregation of fungal cells, abnormal shape, excess branching, and hyphal contortion. It also induced leakage of proteins from the fungal cells. The virulence of the toxin in culture filtrate of the fungus from different concentrations of chitosan was assayed by administering on tomato discs. Phospholipid content, electrolyte leakage, xylanase, and pectin methylesterase activity were measured in the culture filtrate administered tomato tissue. Decreased trend in causing electrolyte leakage, phospholipid degradation, and activation of xylanase and pectin methylesterase were observed with increasing concentrations of chitosan. The results showed that chitosan inhibits fungal growth at higher concentrations than toxin production. Further toxin produced at lower concentrations of chitosan was less virulent. Thus chitosan has potential as an antifungal agent.

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Field Applications of Fungicides Improve Postharvest Quality and Storage Life of Some Pumpkin Cultivars

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Commercial producers of pumpkin (*Cucurbita pepo*) in the Mid-Atlantic region frequently experience losses from the fungal diseases powdery mildew (*Erysiphe cichoracearum*) and black rot (*Didymella bryoniae*). In addition to loss of fruit size in some cultivars, the diseases can result in poor-quality handles (fruit stems) and pre- and postharvest decay. Since the pumpkins are grown for fresh market ornamental use, their appearance, size, and quality are important in marketing strategies. Applications of recommended fungicides during the growing season, although costly, reduce losses in fruit size and quality from fungal pathogens. Subsequent storage studies have documented reduced losses and maintenance of handle quality of pumpkins treated with fungicides during the growing season. This suggests that those who want or need to store pumpkins prior to sale can evaluate costs and benefits of the program. Producers can also choose cultivars that are better suited to storage if fungicides will not be used.

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Rapid Screening of Rhizobacteria for Suppression of Rhizoctonia Damping-off

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A rapid screening system was developed to identify plant-beneficial rhizobacteria useful in protecting nursery seedlings against damping-off caused by *Rhizoctonia solani*. Ornamental and agricultural crops were planted into 100 soil samples that were collected from various fields throughout California. More than 7000 bacterial strains from the rhizosphere of these crops were isolated and tested in vitro for antibiosis against *R. solani* AG4. In a second tier, 600 active strains were tested in planting trays seeded with radish (*Raphanus sativus* 'Cherry Belle'). Each planting cell filled with commercial potting mix contained millet-grown *R. solani* inoculum in the center and eight radish seeds at the periphery. Bacteria were cultured for 24 hr at 25°C in 10% tryptic soy broth and were applied as a drench at 1×10^7 cfu/cc to each cell. Trays were incubated in a growth chamber at 21°C and a 10-hr photoperiod. Post-emergence damping-off occurred within 8 to 9 days after planting, and no further losses were observed after 14 days. Approximately 0.5% of the original 7000 bacterial strains tested reduced damping-off significantly. Fifteen bacterial strains controlled Rhizoctonia damping-off by 30% to 60% compared to the non-treated control.

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Microbial Populations and Potential Phytotoxicity of Rhizobacteria Isolated from Jamaican Anthurium

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Pesticides are used extensively in ornamental production. Studies of repeated pesticide applications indicate that microbial changes occur in the rhizosphere of the plant. In addition to controlling the target pest, often a population shift of bacteria may occur. This has been previously shown in research associated with leatherleaf fern [*Rumohra adiantiformis* (Forst.) Ching] and the fungicide benomyl. Rhizobacteria (root-associated bacteria) of anthurium (*Anthurium andraeanum*) were investigated with respect to total populations and isolates that are potentially phytotoxic. The anthurium sample roots were taken from commercial Jamaican production sites. The sites had either a benomyl or non-benomyl history. Rhizobacterial populations were estimated by dilution plating and subcultures were taken for a phytotoxicity bioassay. Micrographs of samples were prepared to examine treatment effects on the morphology of roots. Rhizobacteria populations were frequently at 10^6 colony forming units per gram fresh weight. Consistently, greater than 50% of the isolates from each treatment were potentially phytotoxic. However, in the benomyl history samples, there was a greater diversity of phytotoxic isolates.

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Influence of Root Flooding Interval on *Phytophthora* Root Rot of Blueberry

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Phytophthora root rot is a severe disease on blueberry (*Vaccinium corymbosum* L.) in poorly drained soils. The objective of the study was to determine the frequency of water-logged conditions on disease severity of blueberry. *Phytophthora cinnamomi* was grown on rice hulls and incorporated into the soil at the rate of 10% v/v. Water logging conditions were inflicted for 48 hr on mulched and non-mulched blueberry plants at 1-, 2-, and 4-week intervals. Non-water logging conditions were used on both mulched and non-mulched control plants. There was a significant linear relationship between disease severity of shoots and roots and the frequency of water-logging conditions. Disease symptoms were low in control plants, but disease ratings were high in mulched and non-mulched plants that were treated with water-logging conditions every week. There was also a linear trend between shoot dry weight and root dry weight of plants with frequency of water logging. Higher dry weights were seen on control plants. There was a significantly higher shoot, root dry weight and number of leaves of mulched plants than non-mulched plants. The percentage of infection on roots were high with frequent water logging. The study revealed high disease incidence with frequent water loggings. However, growth of mulched blueberry plants were comparable in control plants and plants that were subjected to water logging at 4-week intervals.

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Preplant Soil Amendments influence the Incidence of *Phytophthora* Root Rot in 'Heritage' Red Raspberry

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Phytophthora is a severe root rot disease in most raspberry production regions throughout the world. Disease control options are limited to raised bed culture and fungicide applications. Few *Phytophthora*-resistant varieties are available that have commercial quality. Little is known about how soil amendments (i.e., composts, fertilizers, and limestones) influence *Phytophthora* control in raspberry. We evaluated the effects of preplant soil modification on the incidence of *Phytophthora* root rot in red raspberries. The experiment was conducted simultaneously at two sites to differentiate between the nutritional value of the amendments and the disease control value. One site has a known history of *Phytophthora* and a the second site is assumed to be free of the causal organism. Raspberry plant growth and fruit yield measurements were taken for all treatments. Preplant soil application of Gypsum (CaSO_4) and post-plant applications of phosphorous acid sprays (H_3PO_3) had the greatest fruit yields compared to all other treatments in the *Phytophthora*-infested site. Gypsum-treated plots had greater cane diameter, cane height, and cane density compared to the control plots on the *Phytophthora*-infested site. A second experiment was conducted to further investigate the use of gypsum for control of *Phytophthora* in raspberries. Field soil was collected for use as potting medium from each of the aforementioned sites and pathogen free 'Titan' plants were established in the greenhouse. After subsequent floodings, gypsum-treated soils delayed foliar disease symptoms compared to the control

plots. At the end of the experiment, the control plants had 100% foliar disease symptoms and gypsum-treated pots had 33% disease symptoms. This study suggests that gypsum could be used in an integrated approach to *Phytophthora* management in raspberries. Future research should identify minimal effective rates of gypsum, examine other calcium sources, and determine effectiveness in other fruit crops.

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Methionine–Riboflavin Mixture Reduces Powdery Mildews in Strawberry

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Foliar application of a mixture of methionine and riboflavin was effective in reducing the severity of powdery mildew [*Sphaerotheca macularia* (Wallr. ex Fr.) Jacz. F. sp. *Fragariae*] infection in 72 strawberry progenies and over 110 clonal genotypes. This biocidal activity was enhanced by supplement of copper, iron, and surfactants [such as sodium dodecyl sulfate (SDS), Triton X-100, or Tween-20]. Compounds free radical scavengers (n-propyl gallate, thiourea), or antioxidants (α -tocopherol, -carotene) reduced its biocidal activity. Plants treated with the MR formulation (26.6 μ M riboflavin, 1 mM D,L-methionine, 1 mM copper sulfate pentahydrate and 1 mg·ml⁻¹ SDS) or 29% SP formulation of MR (Technical Division of the American Cyanamid Corporation, Taiwan Subsidiary at Taipei) not only showed decreased powdery mildew infection but also showed increased chlorophyll content and leaf area and improved fruit quality. Results in this study suggest that treatment with mixture of methionine and riboflavin is beneficial to strawberry plants and may serve as an alternative to fungicides for controlling powdery mildew.

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Screening Onion Lines for Resistance to *Sclerotium cepivorum* Berk. using Field and Onion Scale Assessments

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Resistance to *Sclerotium cepivorum* was investigated over 3 years at field sites with known histories of white rot in the Holland Marsh, Ontario, Canada. Onion lines from three sources (Petoseed, Asgrow Ltd., and Univ. of Wisconsin), including commercial cultivars, were direct-seeded (1995) or hand-transplanted (1994 and 1996) and the bulbs were assessed for white rot incidence at harvest. The incidence of white rot in 1994 was low (0% to 2.6%) and not significantly different among lines and cultivars. In 1995, white rot incidence was moderate at sites 1 and 2 (maximum 21.5% and 24%), but low at site 3 (0% to 6.3%). In 1996, white rot incidence ranged from 0.8% to 41.1% at site 1, but was not observed at sites 2 and 3. The results of the 1995 and 1996 assessment suggested that the breeding lines could be divided into two major groups with high (Univ. of Wisconsin) or low (Asgrow Ltd. and Petoseed) resistance to the fungus. Scale segments of harvested bulbs from the 1995 field trial and 35 commercial cultivars were inoculated with mycelial plugs of two isolates of *Sclerotium cepivorum*. The resulting lesions were measured. Significant differences in lesion diameters among onion lines (9.1–22.4 mm) and cultivars (10.5–26.75 mm) were found within isolates. There was a significant, high, and positive correlation between diameters of lesions formed by the two isolates on the 23 lines ($r^2 = 0.76$, $P = 0.05$) and 35 cultivars ($r^2 = 0.62$, $P = 0.005$). Both techniques demonstrated a wide range of resistance to white rot. This suggests a strong potential for increasing resistance through breeding.

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Evaluation of Garlic Germplasm for OYDV and LYSV Infection using Dot Blot ELISA

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Garlic is an asexually propagated crop in which the greatest yield losses are attributed to virus infection. Currently, virus-free garlic is produced through shoot tip culture, and there are no known naturally occurring resistant clones. This study evaluated garlic germplasm (propagated from typical bulbs, not shoot tips) for

incidence of two viruses known to infect garlic (onion yellow dwarf virus, OYDV and leek yellow stripe virus, LYSV) using dot blot ELISA. Young leaf tissue was collected from 173 garlic clones. For 118 clones, plants grown in the field from typical bulbs only were evaluated. For 55 clones, plants grown in the greenhouse from both bulbs and topsets (bulbils) were evaluated. Topsets are small bulbs that are produced in the inflorescence of stalking garlic. Each clone was tested at least three times for incidence of both viruses. In field grown bulbs, we found that 70% were infected with OYDV and 85% were infected with LYSV. In greenhouse grown samples, incidence of OYDV was generally higher in plants from topsets than those from bulbs while no differences were seen for LYSV. Three clones were negative for both viruses and might be a useful source of resistance that can be used in producing virus resistant lines.

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A Disease Management Program Enhances Bean Production in the Dominican Republic

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Bean golden mosaic (BGM), rust (RU), web blight (WB), and common blight (CB) are major constraints affecting bean yields in the Dominican Republic (DR). The objectives of the USAID DR supported project were to educate graduate students, improve research facilities and equipment, institutionalize the project, and develop a comprehensive bean disease management program. The project trained 25 researchers. A national center for bean improvement (CIAS) was established. Facilities for plant pathology, germplasm storage, and screenhouses were built and equipment and vehicles were acquired. The high-yielding rust-resistant red mottled bean variety 'PC-50' was introduced and grown on about 60% of the hectareage. However, BGM became a serious problem with the increase of the white fly population (vector of BGMV) due to increased vegetable production. Under severe BGM, yields were low in plantings made after 15 Dec. The combination of the use of 'PC-50', along with a fallow period with delayed planting until early November, reduced the populations of white fly, BGM, RU, and CB and led to a dramatic yield increase of beans and to self sufficiency in beans in the DR. PC-50 became damaged by a new RU race and a resistant line PC-21-SMA (UPR) was released. New bean lines with resistance to BGM, WB, RU, and CBB are being tested for release.

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Disease Forecasting on Stake Culture Tomatoes: Effectiveness of TOM-CAST Forecasts Generated from On-site or Electronic Meteorological Service Weather Data

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Five variations of TOM-CAST and two sources of weather data were used to schedule tomato early blight control for research trials at the Snyder Research and Extension Farm, Pittstown, N.J. TOM-CAST scheduled fungicide applications were initiated at 15, 25, or 35 disease severity values (DSV) and resprayed at 15 or 25 DSV. Weather data for generating the DSVs was obtained on-site with a Sensor Instruments Field Monitor™ or through subscription to the electronic meteorological service SkyBit, Inc. Bravo 720, 3 pints/acre, was used for disease control. Foliar disease, yields, and postharvest decays were evaluated. Daily DSVs, cumulative DSVs, and forecast spray schedule varied with weather data source. Because SkyBit data generated more DSVs during the season than Field Monitor data, the SkyBit-based forecasts called for one or two more sprays than the Field Monitor-based forecasts. However, the number of sprays actually applied was the same, one more or one less for each combination of initiation and respray thresholds. All treatment schedules reduced disease compared to the untreated control. Variation in initiation threshold did not affect disease control. All TOM-CAST schedules respraying at 15 to 20 DSV were as effective as the weekly schedule. All fungicide treatments increased total yields and reduced postharvest decays compared to the untreated control. Most treatments also increased marketable yields. The most efficient, effective Field Monitor-generated TOM-CAST schedule required nine sprays compared to 13 weekly sprays. The comparable SkyBit-generated schedule called for 10 applications. Chemical name used: tetrachloroisophthalonitrile (chlorothalonil).

102 POSTER SESSION 4H (Abstr. 248–253)

ACB Poster Competition

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Plant Regeneration from Cotyledons of Five Watermelon Cultivars

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Cotyledon explants of five watermelon cultivars ('Desert King', 'Mickylee', 'Sangria', 'Sweet Princess', and 'Male Sterile') were prepared from 7-day-old in vitro-germinated seedlings. Explants were incubated on shoot regeneration medium for 6 weeks, followed by several 3-week cycles on shoot elongation medium. The five cultivars differed in their ability to form shoots within 9 weeks on the selected media. Shoot regeneration frequency was about 1.5- to 2.9-fold greater for 'Mickylee' (60%) than 'Sangria' (47%), 'Sweet Princess' (27%), 'Male Sterile' (26%), and 'Desert King' (24%). Rooting of elongated shoots (>2 cm) occurred within 2 weeks on medium containing 1 µM IBA and ranged from 25% ('Desert King') to 92% ('Sangria'). Plantlets were transferred to six-pack containers filled with soilless medium (1 Sunshine Mix : 1 coarse perlite) and covered with a transparent plastic lid. Plants were acclimatized to ambient conditions by gradually removing the lid over a period of 3 days after new growth was observed. The percentage of acclimatized plants ranged from 50% ('Sweet Princess' and 'Mickylee') to 100% ('Male Sterile'). Acclimatized plants were transferred to the greenhouse and grown for at least 4 weeks before screening for ploidy variants. Ploidy of regenerated plants was estimated by counting the number of chloroplasts per guard cell pair. Plants with an average of 18 or more chloroplasts per guard cell pair were declared tetraploids. Plants with fewer chloroplasts per guard cell pair were declared diploids and discarded. Tetraploid plants were transferred to the field, grown to maturity, and self-pollinated for seed increase.

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Yield and Disease Resistance of Six Tomato Cultivars Grown in Two Media and Three Calcium Concentrations

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Calcium has been linked to disease resistance in fruits and vegetables. The effects of calcium nutrition on six hydroponically grown tomato cultivars ('Switch', 'Match', 'Blitz', 'Caruso', 'Trust', and 'Celebrity') were evaluated in the fall of 1996. Disease resistance and yield were measured for plants grown in either perlite or pine bark mulch. Plants were fertilized with a 5N–11P–26K water-soluble fertilizer solution containing micronutrients and either 60, 120, or 185 mg·L⁻¹ calcium. Disease resistance was determined by measuring disease lesion diameters on mature green harvested fruit 3 to 5 days after inoculating with *Botrytis cinerea* Pers.: Fr. There was no significant difference in disease when evaluated by medium, cultivar, or calcium treatment. Foliar analysis by Inductively Coupled Argon Plasma Atomic Emission Spectrophotometer (ICAP) indicated that leaf calcium content ranged from 27,000 to 54,000 µg·g⁻¹ dry weight (leaf above fifth flower cluster), but was not significantly different when analyzed by medium, cultivar, or calcium treatment. There was no significant difference in marketable yield due to medium or calcium treatment. Among cultivars, 'Trust' had the highest marketable yield at 2.7 kg per plant, which was significantly different from 'Celebrity' at 1.6 kg per plant. This experiment suggests that a cheaper medium (pine bark) and lower calcium levels can be utilized in fall tomato production.

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Abstract withdrawn

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Pinching of *Lagerstroemia* for Use as a Potted Florist Crop

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Lagerstroemia has potential for development as a potted florist crop for early spring sales. The number and timing of pinching or number of liners per

container were examined as a means of developing a more compact plant that is in proportion to the container. On 20 July 1996, either one or three rooted liners of *Lagerstroemia* 'Victor' or 'Zuni' were planted into 1500-ml (15 cm in diameter) containers in a pine bark: peat moss (3:1 v/v) substrate amended with 6 kg·m⁻³ MicroMax plus (Scotts Company, Inc., Marysville, Ohio). The plants were topdressed with 10 g SierraBlen 17–6–12 (Scotts Company, Inc., Marysville, Ohio) slow-release fertilizer. The liners received 0, 1, 2, 3, or 4 pinches and were pinched in a complete factorial 0, 2, 4, and 6 weeks after potting. There were 32 pinching treatments with 5 replications. The plants were grown outside until 30 Sept. 1996, when they were moved into a greenhouse. Plant height, width, and a visual rating were collected 13 Nov. 1996. There was no significant difference in plant size or visual rating of 'Victor' regardless of the number or timing of pinches or of the number of liners per pot. 'Zuni' had significantly the best visual ratings and largest size when grown with three liners but the timing and number of pinches had no significant effect. 'Victor' is a dwarf cultivar growing to only 1 m in the landscape while 'Zuni' is a semi-dwarf, growing to 2.7 m.

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Seed Viability in *Miscanthus* Grown in Different Hardiness Zones

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Miscanthus is one of the most popular ornamental grasses. Reports of self-seeding however, have occurred in the Central Atlantic states, making it a possible weed threat. Ascertaining whether *Miscanthus* self-seeds or not may determine its continued use as an ornamental, decorative plant. With more than 50 named cultivars of *Miscanthus sinensis* and several other *Miscanthus* species available in the trade, wide morphological variation appears to exist within this genus. Because *Miscanthus* is a warm-season grass requiring a relatively long growing season, self-seeding may vary depending on the USDA Hardiness Zone in which the plant is grown. Mature inflorescences from 35 different cultivars or species of *Miscanthus* were collected or acquired from nurseries or arboreta in USDA Zones 4, 5, 6, and 7 in the fall or early winter of 1996. Inflorescences were examined for seed set by hand cleaning. The percentage of viability seed and seed germination was determined by germination in laboratory conditions. Results varied by cultivar or species and as well as by source. A comparison of results will be presented and the implications of *Miscanthus* self-seeding or becoming a potential weed threat will be discussed.

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The Effect of Composted Organic Wastes on Weed Control Provided by Preemergence Herbicides

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Community waste management programs that include the composting of sewage sludge and yard wastes have become a necessity. Using these composts provides many benefits; however, increased levels of organic matter may reduce the effectiveness of preemergence herbicides. Determining how herbicide application rates may need to be adjusted when composted waste is incorporated into the soil may permit the use of these amendments without any decrease in weed control. This experiment examined the effect of two types of compost (composted sewage sludge and composted yard waste) on the weed control provided by four preemergence herbicides. The soil was a Hagerstown silt loam amended with 10%, 20%, or 30% compost by volume. Each mix was placed in half-gallon cardboard milk cartons. The cartons were seeded at 1/2 and 1/4 inches with a mixture of broadleaved weeds and grasses. Each soil mix was treated with simazine, oxyfluorfen, oryzalin, and metolachlor at two rates. Control was evaluated both visually by number and by the dry weight of the harvested weeds. Preliminary results indicate composted sewage sludge causes a greater reduction in herbicide efficacy than composted yard waste. Oryzalin and metolachlor were affected less than oxyfluorfen or simazine. The experiment was repeated using lower application rates. In one replication the soil mixes from the previous experiment were used. The second replication used a Hagerstown silty clay loam soil with fresh compost. The results of this experiment will provide preliminary information for future field studies designed to determine if the application rates of preemergence herbicides need to be adjusted when fields are amended with composted organic matter.

148 POSTER SESSION 5A (Abstr. 254–264) Cell & Tissue Culture–Vegetables

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Manipulation of Low Temperature and Light Quality for Storage of Broccoli in Vitro

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Storage systems for tissue-cultured plants offer versatility in managing labor to meet market availability. Storage systems that minimize growth and yet sustain photosynthetic and regrowth potential require temperature, light quality, and light intensity to be manipulated for plantlet quality during and after storage. Broccoli (*Brassica oleracea* L. Botrytis Group 'Green Duke') plantlets were cultured photoautotrophically (without sugar) or photomixotrophically (with sugar) on cellulose plugs in liquid medium 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 days under different temperatures (1°C, 5°C, 10°C, 15°C), different light intensities (1.6 PPF, 4.1 PPF, 8.6 PPF), and different light spectra (white, blue, red). Plantlets stored under 5 PPF and 5°C maintained a zero carbon balance. Subsequently, plantlets were stored for 4, 8, or 12 weeks at 5°C under darkness or 5 PPF of white, red or blue light. Stem elongation was observed for plantlets stored under blue light. Plantlets stored under red light were characterized by increased chlorophyll, increased specific leaf mass (leaf dry mass per unit leaf area, SLM), increased starch in leaf tissue, and increased total soluble sugars in leaf and stem tissue. Plantlets grown with sucrose were characterized by increased dry mass, regardless of light treatment. After 8 weeks, plantlets grown with or without sucrose and stored in darkness did not survive acclimatization to greenhouse.

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Adventitious Shoot Formation and Plant Regeneration from Bell Pepper (*Capsicum annuum* L.) Cultivars and Dihaploid Lines

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Adventitious shoots and viable plants were regenerated from bell pepper (*Capsicum annuum* L.) cultivars and dihaploid lines (DHLs) obtained from F₁ hybrids via androgenesis (Dolcet-Sanjuan et al., in press). Hypocotil and cotyledon sections from in vitro-germinated seeds were used as explants. A modified MS medium (Murashige and Skoog, 1962) supplemented with IAA (0 to 3.2 μM) and BAP (0 to 100 μM) was used in a 3-week-long shoot primordia induction phase. Shoot elongation was best performed in the same basal medium, but supplemented with silver thiosulfate and GA₃. Shoots were regenerated from eight selected DHLs ('C213', 'C215', 'C218', 'C2123', 'C2125', 'C3111', 'C3113', and 'P493') and two cultivars ('Padrón' and 'Yolo Wonder'). The percentage of cotyledon sections with shoot primordia after the induction phase was not genotype-dependent and always higher than with hypocotil sections (93.4% and 17.9%, respectively). The number of shoot primordia per responsive cotyledon section was also higher than with hypocotil sections (3.3 and 1.7, respectively). The genotype had a significant effect on the number of shoots regenerated per responsive cotyledon (1.1 to 5.5) or hypocotil (0.5 to 3.5) section. All adventitiously regenerated plants were fertile. This adventitious shoot regeneration protocol is being used to obtain transgenic plants from sweet bell pepper genotypes.

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The Influence of Spear Number on in Vitro Rooting of Asparagus (*Asparagus officinalis* L.)

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Asparagus is a vegetable of great economic importance. It is a dioecious and perennial species mainly propagated by seeds, which makes difficult the breeding work as far as results are concerned. New biotechnological techniques such as tissue culture have been used in order to shorten the release of new cultivars. On the other hand, this process depends mainly on the rooting phase, which, for this

species, is to some extent difficult. The aim of this work was to verify the influence of spear number on asparagus rooting. Two genotypes were studied: Clone M14 and cv. Deco, which is a hybrid (M14 x G27). These genotypes were tested with one, two, three, and four spears in a medium containing in mg/L: NAA (0.1); kinetin (2.0); ancymidol (0.5). Sucrose was added to 30 g/L and agar at 6.0 g/L. The pH was adjusted to 5.9. The evaluations were performed 30 days later. Four-spear asparagus rooted better than the others; it was also observed longer roots for this treatment. Clone M14 rooted better than cv. Deco. These results show the importance of the starting explants to improve the in vitro rooting in asparagus.

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In Vitro Multiplication of Two Genotypes of Asparagus (*Asparagus officinalis* L.)

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Asparagus is a vegetable that presents an increase in yield when propagated by meristem culture. On the other hand, the rooting phase in asparagus is greatly affected by the previous phase, i.e., multiplication. This species presents a better rooting performance when callus is formed at the shoot base. So, the aim of this work was to evaluate treatments during the multiplication phase, which also leads to callus formation at the shoot base. The initial explants came from shoots being cultivated in vitro. It was tested kinetin at: (0.0, 0.5, 1.0, 1.5, and 2.0) μM ; ancymidol at (0.0 and 0.5) μM and NAA at (0.0 and 0.5) μM for both genotypes, which were cultured in a MS medium added to sucrose (30 $\text{g}\cdot\text{L}^{-1}$), agar (6.0 $\text{g}\cdot\text{L}^{-1}$) and *myo*-inositol (100.0 $\text{m g}\cdot\text{L}^{-1}$). Shoots bearing two buds were inoculated in 10-ml test tubes and placed in a growth room for 30 days when they were evaluated. The addition of kinetin significantly improved the number of buds and at 1.3 μM this growth substance presented the best results as number of shoots is concerned. NAA application promoted a negative effect on spear bearing. The addition of ancymidol in this phase did not improve the bud multiplication. It was shown that clone M14 performed better than the hybrid cv. Deco as multiplication is concerned.

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In Vitro Multiplication of Potato (*Solanum tuberosum* L.) cv. Cristal under Different MS Salt and Sucrose Concentrations

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The potato cultivar Cristal has recently been released by the CPACT/EMBRAPA Breeding Program. Such cultivar was selected for having high dry matter and low sugar content, which makes it desirable for the chip industry. However, this is a recalcitrant cultivar as far as in vitro multiplication is concerned. The aim of this work was to improve the rate of multiplication for this cultivar when it was submitted to different MS salt and sucrose concentrations in the culture media. Two-bud microcuttings were inoculated in test tubes (20 x 150) mm with 10 ml MS media at 3/4-, 1/2-, and full-strength and MS vitamins added to: *myo*-inositol (100 $\text{mg}\cdot\text{L}^{-1}$), agar (7.0 $\text{g}\cdot\text{L}^{-1}$) and sucrose as follows: 10, 20 and 30 $\text{g}\cdot\text{L}^{-1}$. Each treatment was repeated eight times and each replicate had eight explants. After inoculation the whole material was kept in a growth room at 25 \pm 2°C, 16-hr photoperiod and 2000 lux. The evaluation was done 35 days later. It was found and increase in the number of buds as the sucrose concentration in the media decreased. As far as MS salts are concerned no difference in bud number was observed. The rate of multiplication was slightly higher for MS media at full strength and sucrose at low concentration (10 $\text{g}\cdot\text{L}^{-1}$). This treatment could be recommended for this cultivar.

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In Vitro Multiplication of Potato (*Solanum tuberosum* L.) cv. Cristal II—Microcutting Origin

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The potato cultivar Cristal recently released by the CPACT/EMBRAPA Breeding Program has high dry matter and low reduce sugars. These are desirable charac-

teristics as industry processing is concerned. Nevertheless, this is a recalcitrant cultivar. The meristem culture is difficult to establish along with a very low multiplication rate. The aim of this work was to improve the multiplication rate for this cultivar. Two-bud microcuttings derived from apical, mid, and basal regions were inoculated in test tubes with 10 ml MS culture media and vitamins as follows: *myo*-inositol (100 mg·L⁻¹); sucrose (10 g·L⁻¹). No growth regulator was added. All treatments were placed in a growth room in a 16-hour photoperiod; 25 ± 2°C and 2000 lux. One month later, although it was observed that the final growth was more pronounced for basal microcuttings, no difference could be detected for number of shoots and multiplication rate. It was concluded that it makes no difference whatsoever kind of microcutting is used to start the micropropagation process.

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In Vitro Bioassays as Indicators of Salinity Tolerance in Potato

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The relative salinity tolerance of three potato cultivars, including 'Russet Burbank', 'Kennebec', and 'Norland', were compared using three in vitro bioassays (single node cuttings, root tip segments, and microtuberization) and yield data from field lysimeters irrigated with salinized water. The single-node cutting bioassay was simpler to perform than the root tip segment and microtuberization bioassays. The single-node cutting bioassay can be recommended as a substitute for more labor-intensive and costly field assessments of salinity effects on yield.

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Cryopreservation of Sweetpotato Shoot Tips by Vitrification

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Cryopreservation offers the simplest and most economical way for the long-term conservation of germplasm and vitrification is the preferred method to accomplish this. Undefined endogenous compounds are produced during plant growth and shoot tip preculture conditions. These may influence "cryopreservability" and interact with cryoprotectants that are artificially added during the cryogenic protocol. We are beginning to examine these aspects to improve cryopreservation. Nodal segments of PI 296057 were propagated on a hormone-free modified Murashige and Skoog (MS) solid medium and were grown with 16 hr/8 hr photoperiod. Shoot tips were excised at 0, 3 or 10 hr in light after the dark period. Excised shoot tips were precultured in 0.06 M sucrose in MS for 24 hr and 0.3 M sucrose in MS for 24 hr and then treated with 0.4 M sucrose plus 2 M glycerol for 20 min or 1 hr before being dehydrated in PVS2 [30% (w/v) glycerol, 15% (w/v) ethylene glycol and 15% (w/v) dimethylsulfoxide in MS and 0.4 M sucrose] for 10, 16 or 26 min at 22°C. Shoot tips were placed on thin strips of aluminum foil, which were folded to enclose the shoot tips and then immersed in a liquid nitrogen (LN) slush. Rapid warming and dilution were achieved by transferring the foil strips from LN into 3 ml of 1.2 M sucrose at 22°C for 20 min. All cultures were incubated in darkness for 2 days then dim light for 3 days before transfer to the usual light intensity. Elimination of iron and nitrogen from MS medium in post thaw culture for 5 days increased the viability of LN-treated samples. Maximum survival after LN exposure was achieved with excision immediately after the dark photoperiod, cultured for 1 hr in 0.4 M sucrose plus 2 M glycerol and exposed for 16 min in 100% PVS2 at 22°C. Previously, Towill and Jarret (1992, Plant Cell Reports 11: 175-178) reported that surviving shoot tips developed callus and a variable percentage subsequently formed shoots. In this line all surviving shoot tips eventually formed shoots.

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Efficient Methods to Differentiate between Transgenic and Wild-type Mosses

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As ancestors of higher plants, mosses offer advantages as simple model organisms in studying complex processes. The moss *Physcomitrella patens* became a powerful model system in the last few years (Cove and Knight, 1993). Adaptation of PEG-mediated DNA uptake procedure has permitted the establishment of efficient molecular genetic approaches. To study possible effects of a Type I phytochrome, the potato *phyA* gene was introduced into the moss *P. patens*. Stable transformants exhibited a range of similar phenotypes (Schaefer et al.,

1991). The aim was to differentiate the wild type from the transgenic moss plants with simple, quick measurements providing data suitable for analyzing offspring populations. Ten different morphological and biochemical methods were used to investigate the phenotype in order to choose the best phenotypical category to indicate the presence and the effect of the phytochrome transgene. Two selected strains were used with the most and the least intensive phenotypical features (3^{*}, 29), along with their selfed progenies, as well as progenies from crosses with the nicotinic-acid auxotrophic mutant. The best methods to differentiate between wild type and transgenic plants were the statistical analysis of the number of gametophores, photometric measurement of pigment contents and composition under different light conditions, color evaluation by PC-based vision system, and visual observation of morphogenetic changes. Our investigations support that the potato phytochrome transgene has a pleiotropic effect in the moss *P. patens*. The methods used would be applicable for the characterization of mosses with different transgenes.

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Plant Regeneration from Axillary Buds of Triploid Watermelon (*Citrullus vulgaris* Schrad.)

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Watermelon (*Citrullus vulgaris* Schrad.) is a widely grown crop throughout the tropics and subtropics. In Mexico, it is an economically important crop. In vitro adventitious shoot regeneration of watermelon has been reported from shoot tip culture, leaf, hypocotyl, and cotyledons. Hence, the objective of this study was to evaluate in vitro plant regeneration from axillary buds of triploid watermelon. Axillary buds explants were prepared from shoot of commercial cultivar in field of 60 old day plants. Explants of 2 to 3 mm were incubated 2 weeks on Murashige and Skoog (MS) shoot regeneration medium containing 2.5 mg/L kinetin (KT) or indole-3-butyric acid (IBA), or gibberellic acid (GA₃), followed by 3 weeks on shoot elongation medium supplemented with different combinations of the same phytohormones. The percentage of explants (83% to 90%) that produced shoots, expansion in size of explant (0.81-1 cm) and shoot length (6 mm) were highest in MS medium containing KT or IBA. In the shoot elongation step, shoot length (0.9-1 cm) and leaves number (6-7) were highest in MS medium supplemented with 2.5 mg/L of KT or GA₃ and 0.2 mg/L IBA, but the better induction of roots in elongated shoot occurred on MS medium with 2.5 mg/L KT and 0.2 mg/L IBA. The results show that axillary buds from watermelon is an alternative for the micropropagation of this crop.

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Pod Development Dynamics and Culture Response in Lima Beans

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In this study, the pod development dynamics and culture response in lima bean (*Phaseolus lunatus* L.) were investigated. The average percentage of flowers to form pins was 17.5%. Pin length and width (mm), and weight (g) were all highly correlated with the days after pollination (DAP), with correlation coefficients of 0.98, 0.99 and 0.97, respectively. Pods grew relatively faster between 12 and 20 DAP, and reached their maximum length at about 35 DAP. Explants from pods of 5, 10, 15, 20, 25 DAP were cultured onto B5 medium containing BA (2 mg/L), kinetin (0.5 mg/L), 2,4-D (1 mg/L) or NAA (1 mg/L), sucrose (5%), and agar (0.7%). Soft calli only formed from the cut region on the seed coat or the suspensor attachment site of 5 and 10 DAP seeds. The 15 DAP explants were cultured as embryos (cotyledons 2 mm in length), and no callus was observed on them after 30 days of culture when they became brown. Twenty and 25 DAP embryos initiated calli and/or organ-like structures on the abaxial surface of cotyledons or embryo axes after 20 days of culture.

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Growth and Performance of Four Summer-ripening Disease-

resistant Apple Cultivars on M.27 EMLA, M.26 EMLA, and Mark Rootstocks

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The growth, productivity, and fruit characteristics of four summer-ripening disease-resistant apple cultivars, (DRCs), 'NY 66305-139', 'Williams' Pride', 'Redfree', and 'Dayton' on M.26 EMLA, M.27 EMLA, or Mark rootstocks were compared. 'NY 66305-139' was the earliest-ripening cultivar, with the smallest tree size, lowest yield, and the smallest, softest fruit. 'Williams' Pride' trees were large, productive, and produced large fruit with the highest red skin color in this trial. The loss of marketable yield of this cultivar, due to moldy core and bitter pit in 1996, raise concerns about its commercial potential. 'Redfree' trees were intermediate among the four cultivars in vigor and precocity, and produced high yields of medium-sized fruit. 'Dayton' trees were large, high-yielding, and produced the largest, firmest, sweetest fruit; however, the ripening date for 'Dayton' was 10 Sept., late for a summer cultivar. Mark and M.26 EMLA produced similar-sized trees, while M.27 EMLA produced very small trees. A significant cultivar x rootstock interaction resulted from 'Dayton' trees being larger than 'Williams' Pride' when both were on M.26, while both cultivars produced similar-sized trees on M.27 or Mark. Of the four cultivars in this trial, we consider 'Redfree' to be the best summer DRC for commercial orchards, based upon ripening date, yield, and fruit quality. Mark rootstock was preferable to M.26 or M.27 for the cultivars in this trial, with the best tree growth and precocity.

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Growth and Performance of Five Disease-resistant Apple Cultivars on M.27 EMLA, M.26 EMLA, and Mark Rootstocks

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The growth, precocity, yield, and fruit size of 'Liberty', 'NY 75414-1', 'NY 74828-12', and 'NY 65707-19' on M.27 EMLA, M.26 EMLA, and Mark rootstocks, and 'McShay' on M.26 EMLA and Mark, were compared. 'Liberty', 'McShay', and 'NY 74828-12' trees were larger than 'NY 75414-1', while 'NY 65707-19' trees were the smallest. Among rootstocks, trees on Mark were larger than trees on M.26, while trees on M.27 were the smallest. There were no interactions between cultivar and rootstock on tree growth in this study. 'NY 74828-12' produced the most flower clusters in the 3rd and 4th years of the study, and 'NY 65707-19' the least. In 1993, trees on Mark had more flowers than those on M.26, while trees on M.27 had the fewest flower clusters. 'Liberty', 'NY 75414-1', and 'NY 74828-12' produced higher cumulative yield than 'McShay' and 'NY 65707-19'. Trees on Mark had higher cumulative yield than M.26, while trees on M.27 produced the smallest yields. Fruit size was greatest for 'NY 65707-19' and smallest for 'NY 74828-12'. Trees on M.27 produced smaller-sized fruit than trees on M.26 or Mark. 'NY 75414-1' had moderate vigor, high precocity, yield, and yield efficiency, with acceptable fruit size. 'NY 74828-12' also performed well in this trial, but possesses Vm resistance to apple scab, not Vf, and is unlikely to be named. Based on tree vigor, precocity, yield, and fruit size, 'Liberty' and 'NY 75414-1' have the best potential for commercial production among DRCs in this trial. Mark rootstock produced the largest trees with the highest yields, and was superior to M.26 as a rootstock for the DRCs in this study.

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Growth and Fruiting of Apple Trees on Dwarf and Semi-dwarf Rootstocks in Different High-density Orchards

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An orchard trial was established by planting an orchard with between-row intervals of 4 m. The French Axe was trained for trees with intervals in the row of 1 and 1.5 m. The hedgerow was used for treatments of 2–2.5 and 3 m between trees in the row. Semi-dwarf rootstock of Bud54-118 and dwarf one Bud62-396 were used. The growth of these rootstocks was analogous to MM106 and M26, respectively. The trunk cross-sectional area of 7-year trees on 54-118 rootstock was 2.3 times more than on 62-396 for cv. Antey and 1.5 times more for cv. Tellisaare. The height of tree with French Axe crown at 7 years after planting on 54-118 rootstock reached 3.5–4 m. The height of tree was 0.5 m smaller on 62-396. The crown habit of tree on 62-396 rootstock was more comfortable for high-density orchard than trees on 54-118. The sum length of twigs that were cut out during 1993–96 to attain of normal density of crown was 2–4 times more than on 62-396 rootstock. Commercial fruiting of cv. Antey started at the 3rd leaf, but it was on 4th leaf for the more-dwarf

rootstock 62-396. Average yield of fruit at 3–6 years after planting of cv. Antey for treatment of distance between trees in the row of 2 or 1.5 m was 6.8 kg/tree per year-1 for 54-118 rootstock, 3.4 and 3.5, respectively, for 62-396 rootstock. Yield at the 7th year after planting reached 24 and 32 kg on 54-118 rootstock, 16 and 15 kg on 62-396, respectively. Analogous date obtained for cv. Tellisa are. cv. Spartan on both rootstocks started to fruiting at 5-6 years after planting. The fruit quality was very high in all treatments of the trial.

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Apple Orchard as Twin-row Tree-belt on Dwarf and Semi-dwarf Rootstocks

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Growth and fruiting of apple trees in twin-row tree-belts were studied during 5 years after planting the orchard. Distance between belts was 4 m, between rows in a belt was 1 m, between trees in row 3 or 1.5 m, giving tree densities of 1335 or 2670 trees/ha, respectively. Control was a single-row planting 4 x 3 or 4 x 1.5 m, producing densities of 833 or 1665 trees/ha. Trees were trained as hedgerow in treatments with a density of 1335 or 833 trees/ha. Each tree in a twin-row belt had a separate crown with narrow passage between trees. This passage was cut through every year. Fruiting of 'Tellisaare' began at 2nd leaf, 'Antey' at 3rd, and 'Spartan' at 4th leaf after planting. Total yield for 3 years in the highest density treatment of single-row planting of 'Antey' and 'Tellisaare' was >50 t·ha⁻¹ and in twin-row orchard construction from 36 to 57 t·ha⁻¹, depending on orchard density. The two-fold increase in orchard density from 1335 to 2700 trees/ha raised yield of 'Antey' by 58% and 'Tellisaare' by 33%. Single-row treatment with a tree density of 1665/ha averaged 17.1–17.5 t·ha⁻¹ without great expenditure on pruning of trees. The fruit quality was very high in all treatments.

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Testing a Power Duster for Pollination of 'McIntosh' Apples

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This study was undertaken to test the efficacy of a power duster for supplemental pollination of 'McIntosh' apple trees, where lack of nearby pollinating cultivars was thought to be a limiting factor to productivity. The pollen duster was ineffective in increasing fruit set, fruit size, or seed number in fruits on limbs that were covered with spun-bonded rowcover material prior to bloom. Applying supplemental pollen to open-pollinated 'McIntosh' trees had no effect on fruit set, yield, fruit size, or seed number, regardless of pollen dose, timing, or number of applications. Dispersal of supplemental pollen with a power duster appears to be an inefficient method of pollinating apple trees.

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Vegetative Growth of Coffee Cultivars under Mechanical Pruning Systems

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Pruning methods 1.5 x 1.5 m (topping and hedging) and stumping to 0.70 m were used on coffee cultivars Guatemalan, Red Catuai, Yellow Caturra, and Mokka. In the hedged treatment, 'Mokka' had the longest laterals, followed by 'Guatemalan', with 'Red Catuai', and 'Yellow Caturra' having similar lengths. 'Mokka' had the most nodes/lateral. 'Guatemalan' showed the fastest growth (height), followed by 'Mokka', with 'Red Catuai' and 'Yellow Caturra' having similar growth. For 0.70-m pruning, vertical lengths of 'Guatemalan' were the longest. 'Mokka' had the most vertical nodes. 'Guatemalan' had the longest vertical internodes, followed by 'Red Catuai' and 'Yellow Caturra', with 'Mokka' having the shortest. 'Yellow Caturra' had the most laterals/vertical, followed by 'Red Catuai' and 'Guatemalan'. 'Mokka' had the fewest. Lateral lengths, nodes/lateral, and internode length were similar for all cultivars. Two-meter pruning height may be best for 'Red Catuai' and 'Yellow Caturra' because of slow growth, shorter laterals, and fewer nodes/lateral. These two cultivars grew well after being stumped due to faster regrowth and more laterals remaining on new verticals. 1.5-m pruning appears optimum for 'Guatemalan', but it grew very well after stumping. It may be better to prune 'Mokka' to a 2-m height with a narrow canopy remaining because of its good multiple verticals, fast lateral growth from new verticals in canopy but not in full sun, and more vertical nodes but less laterals regrowing from new verticals on main trunks exposed to full sunlight.

Performance of Three Guava Cultivars in Middle Georgia

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Two-year-old trees of 'Red Flesh' (RDF) and 'Lucknow-49' (L49) guavas from India and 'Beaumont' (BMT) guava from Hawaii were established in the field during Spring 1995, inside an open wooden structure equipped with electric heaters and fans. Trees were cold-protected from November to the middle of April by covering the wooden structure with 6-mil clear polyethylene and using heaters and fans. Trees of RDF grew compact, while those of L49 and BMT were open, upright, and grew taller. Other than blossom-end rot on few fruits, no incidents of insect-pest and diseases were observed on trees or fruits. All cultivars bloomed from March to June 1996. Fruit set was heavier on BMT and L49 than on RDF trees. Fruit harvest extended from Sept. 1996 to Jan. 1997. Cultivar significantly influenced harvest and fruit weight. Peak harvest date was earlier for BMT, followed by RDF and then L49. Mean fresh weight (g/fruit) was 535.7, 284.2, and 150.7 for RDF, L49, and BMT, respectively. Fully developed RDF fruits were round, sometimes flat vertically, with blush on green skin when ripe, and had a small core in red flesh. Fruits of BMT were round to elliptical, yellow when ripe, and had numerous seeds in red flesh. Fruits of L49 varied from round to elliptical to pyriform with yellow to light green skin color and cream flesh with fewer seeds in a large core. The fruit flavor was strong and astringent for both BMT and L49, whereas RDF had a mild fruit flavor.

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Abscisic Acid as a Defoliant for Deciduous Fruit Tree Nursery Stock

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Artificial defoliation of deciduous fruit tree nursery stock is often necessary so that plants can be dug early enough to escape inclement fall weather. In this research, we assessed the efficacy of abscisic acid (ABA) as a defoliant. ABA was applied as a foliar spray at one of three concentrations—500, 1000, or 2000 ppm a.i. Trees were sprayed either once or twice for a total of six chemical treatments, plus untreated controls. The defoliation and growth responses of eight cultivars were evaluated with the cooperation of commercial nurseries in Washington State. While all treatments caused significantly greater defoliation than was observed in untreated trees, ABA at 500 ppm applied once or twice, or 1000 ppm applied only once, was generally sufficiently effective only on 'Bartlett', 'Gibson Golden Delicious', and 'Law Red Rome', but not on 'Imperial Gala', 'Scarlet Spur Delicious', 'Granny Smith', 'Braeburn', or 'Red Fuji'. Single or double applications of 2000 ppm or double applications of 1000 ppm often produced faster defoliation than double applications of 500 ppm, but defoliation was not always superior after 4 weeks. No pre-digging field damage was noted, but some treatments appeared to reduce trunk diameter increase after replanting, with no consistent trends among cultivars, except with 'Bartlett' pear, which was frequently negatively affected. ABA appears to be very promising as a nursery tree defoliant.

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Bag and Liner Color Greatly Affect Apple Temperature Under Full Sunlight

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Some apple growers place specially designed bags with liners around fruit in the field to produce a unique surface color required by some premium markets. However, heat damage has been observed on 'Fuji' apples that were bagged and reached high temperatures in the field. We tested different colored apple bags and their liners to determine the amount of light that is transmitted and whether bag color affected heating of the apples inside. Apple bags and liners were very effective at screening out sunlight; however, the absorbed light substantially warmed the bags and apples inside. No UV-A or B and less than 1% of photosynthetically active radiation (PAR) passed through the outer bag regardless of bag color and the inner liners transmitted ≈9% of the UV-A, 3% of the UV-B, and 30% of the PAR. When ambient air temperatures were only ≈25°C, dark green bags or red or green liners warmed the sun-facing apple surface to ≈43°C, while light green bags warmed to ≈36°C. Wrapping apple bags in aluminum foil to increase bag reflectivity greatly reduced heat buildup and maintained sun-facing fruit surface temperatures only

slightly above air temperature (≈27°C). Possible design improvements for apple bags used in hot, sunny climates will be discussed.

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Evaluation of Different Pear Cultivars in Northwest Mexico

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Pear production in Mexico is low; there are about 4500 ha. One of the main problems in this tree fruit is the unknown number of new varieties for each area. The objective of this study was to evaluate 23 common pear cultivars and seven Asian pears. The experiment was carried out at the Experimental Station "El Tasicuri" of Magdalena, Sonora, Mexico. The trees were planted in 1990 on *Pyrus calleryana* rootstock. The main results were that common pears were not adapted to the area because of the lack of cold weather; however, 'Bartlett' was the only cultivar that was adapted. Asian pears showed good adaptation into the region ('Shinseiki', 'Kikusui', 'Hosoui', 'Twenty Century', and 'Ya-Li'). The ripening date of these cultivars were from the 7 and 20 of Aug. and the weight of the fruit was 146 and 198 g/fruit. There were no pests or diseases in any of the Asian cultivars.

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Phenology, Breeding System, and Fruit Development of Cultivated Argan [*Argania spinosa* (L.) Skeels]

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Argan is a wild tree native to southwestern Morocco, appreciated for its edible, high nutritional oil, extracted from the kernels of the drupe-like fruit. Aspects of its reproductive biology were studied with the aim to domesticate argan as an oil crop. Flowering of fertigated trees cultivated in the Negev Highlands of Israel was confined to the spring months. The flowers were found to be protogynous, the stigma protruding from the flower before anthesis. Stigma receptivity at the pre-anthesis phase was a third of that at anthesis. Results of different pollination treatments showed that a pollen vector was necessary for pollination and that fruit set was significantly higher in cross and open pollination (7% to 9%) than in self pollination (0.5%). Since in-vivo pollen germination and pollen tube growth in the pistil were similar for foreign and self pollen, the lower fruit set obtained in self pollination may have been related to postzygotic discrimination. Pollen transfer by wind was restricted to short distances, and flies (family Calliphoridae), were proven to be involved in pollination. In contrast with stands in argan's native habitat, where fruit growth is inhibited in summer, fruits of the cultivated trees grew continuously throughout the summer. The pattern of growth of fruit fresh weight was similar to that shown for typical fleshy drupaceous fruits, with an initial and a final phase of rapid growth interrupted by a phase of slow growth.

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Date Production in the Coachella Valley, Southwest California

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Approximately 90% of total date production in the U.S. is localized in the Coachella Valley, southwest California. The remainder is in the bordering Imperial Valley, Calif., and Yuma, Ariz. The date trees (*Phoenix dactylifera* L.) occupy 2282 ha, have an annual yield of 24,000 tons, and a product value of \$62 million. Major varieties include 'Deglet Noor', 'Khadrawi', 'Zahide', and 'Majhool'. Although climatic requirements for date production prevail in the Valley, major problems related to soil and water have adverse effects on yield and fruit quality. These include water and soil salinity, high water table, high soil compaction and stratification, and low fertility. Slip plowing has been a recommended practice for decompacting the soil. However, soils get recompacted by machinery used in cultural operations. We recently introduced planting cover crops in a no-till system to improve soil fertility, reduce compaction, and improve drainage.

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Rootstock Influences Yield, Nut Quality, and Leaf Analysis of Pecan Trees

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The nuts of 10 pecan cultivars were used to produce rootstock trees for the propagation of two scion cultivars—Posey and Pawnee. Seed sources included: 'Chickasaw', 'Colby', 'Dooley', 'Giles', 'Greenriver', 'Major', 'Mohawk', 'Peruque', 'Posey', and 'Shoshoni'. Leaf analysis performed in 1994 and 1996 revealed that rootstock influenced K and Zn concentrations. Scions propagated on 'Posey' seedlings contained the greatest amount of K, while scions propagated on 'Greenriver' seedlings contained the least. Zn levels were highest in trees with 'Chickasaw' seedling rootstocks and the least in 'Major' seedlings. Yield and nut quality was influenced by a major drought during the late summer and fall of 1995. Nuts produced by trees with 'Chickasaw' and 'Colby' rootstocks had the highest kernel percentage, while trees grown on 'Major' and 'Posey' had the lowest. The greatest yields, during the drought year, were produced from scion cultivars grafted on 'Giles' and 'Chickasaw' seedling rootstocks. 'Major' and 'Greenriver' seedlings produced trees with the smallest yields.

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Improved Orchard Establishment of *Asimina triloba* Seedlings on Acid Soils Supplemented with Calcium Sulfate

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Asimina triloba (L.) Dunal (pawpaw), a deciduous tree indigenous to the eastern U.S., is being considered as a potential new fruit crop. The difficulty in establishing transplanted pawpaw seedlings has been identified as an important research need for successful cultivation of this species. We have addressed the possible benefits of soil-applied CaSO₄ in establishing pawpaw seedlings on acidic, low-Ca orchard soil. Two-year-old seedling rootstocks were planted at a spacing of 1.5 m (within rows) x 5.5 m (between rows), and trickle-irrigated (with N, P, and K) for two growing seasons. Before planting, CaSO₄ was applied at rates of 0, 11, and 22 t/ha and incorporated to a depth of 15 cm. Seedling trunk cross-sectional area (TCA) growth increased with increasing CaSO₄ application. After the first season, increases in TCA averaged 27% and 44% greater with CaSO₄ treatments (11 and 22 t/ha, respectively), as compared to the 0 t/ha treatment. This effect was accentuated by the end of the second season. Average qualitative ratings (based on seedling vigor and appearance) were also improved with CaSO₄ treatment. These findings indicate that establishment of pawpaw seedling rootstocks may be improved with Ca fertilization in orchards of low-Ca status. Additional data, including seedling dry matter accumulation, will be presented.

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Floral Biology and Fruit Set of 'Taifi' Pomegranate in Relation to Heat and Drought Stress

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Floral biology of 'Taifi' pomegranate was studied on trees grown in extreme high temperature and drought conditions. Measurement included flowering date, duration and type, pollen viability, diameter, initial and horticultural fruit set percentage, and fruit drop percentage and fluctuation. Heat and drought stresses were found to greatly influence some floral characteristics in addition to fruit set and productivity of 'Taifi' pomegranate.

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Effects of a Combination Application of Hydrogen Cyanamid (Dormex) and Ethephon (Ethrel) on Fruiting of 'Redhaven' and 'Surecrop' Peach

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Early flowering of peach in the southeastern U.S. often results in some annual crop loss as a result of late winter–early spring freezes. It has been shown in peach and other prunus that a fall application of ethephon delays flowering 4 to 7 days and possibly affords increased bud hardiness. However, delayed harvest and smaller fruit size of certain varieties may occur. Hydrogen cyanamide replaces lack of chilling in peach, but can also advance harvest date and possibly enhance or maintain fruit size. A randomized complete-block experimental design was used to evaluate whether hydrogen cyanamide could offset the delayed harvest and smaller fruit size disadvantages of using ethephon without advancing bloom dates over a 3-year period. Treatment combinations of ethephon (at 20%, 50%, and 90% of required chilling) and hydrogen cyanamide (at 90% to 100% of required

chilling) were applied as whole-tree foliar sprays to near point of drip. Results exhibited a possible trend toward hydrogen cyanamide overcoming smaller fruit size and delayed harvest.

148 POSTER SESSION 5C (Abstr. 281–286)

Stress Physiology–Cross-commodity

281

Isolation and Characterization of the Vascular-specific 22-kDa Zn-binding Protein

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A 22-kDa Zn-binding protein (ZBP) was isolated from the phloem tissue and evacuated xylem sap of 'Valencia' sweet orange [*Citrus sinensis* (L.) Osbeck] on rough lemon [*C. jambhiri* (L.)], as well as Valencia on Rangpur lime [*Citrus limonia* Osbeck]. Phloem and xylem Zn was associated with the 22 kDa ZBP. The M_r value of this ZBP was estimated to be 19,500 by size exclusion chromatography and 22,800 by SDS-PAGE. This protein was isolated with an isoelectric point of 7.5. Ion exchange chromatography demonstrated that 22-kDa ZBP was highly anionic, requiring 0.43 M NaCl for elution from QAE Sepharose. The 22-kDa ZBP appears unique to citrus, having no cross reaction with protein from several tissues from a range of plant species. Accumulation decreased under Zn-deficient conditions, was enhanced by osmotic stress, and the protein completely disappeared with wounding. Amino acid composition demonstrated that the protein was rich in aspartate, and glutamate; and contained 6 cysteine, and 4 histidine residues. These amino acids may be involved in metal binding. N-terminal amino acid sequencing demonstrated that the 22-kDa ZBP had identity with sporamin A&B precursors, Kunitz-type trypsin inhibitors, and miraculin. It is suggested that the genes that encode these proteins are derived from a common ancestral gene.

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Effect on Yield and Incidence of Blossom-end Rot of Foliar Application of Calcium Products on Tomato Cultivated in Saline Conditions

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The appearance of blossom-end rot (BER) in tomato is related to a decrease in the absorption and translocation of Ca due to excessive salinity in the soil solution. An experiment was conducted to investigate the effects of calcium nitrate (NT), EDTA-Ca (ED) and Aminoquelant-Ca (AQ)—a product containing Ca, B and protein hydrolisate—on the yield and incidence of BER when applied to the leaves of tomato (*Lycopersicon esculentum* Mill. 'Durinta') grown in the open with a drip irrigation using saline water from a well (mean EC_w 5.2 dS·m⁻¹). The three calcium treatments and control were replicated four times, with 12 plants per replication, in a completely randomized design. Although yield per plant was higher with AQ, the difference was not statistically significant. Fewer fruit were affected by BER after treatment with ED and AQ than with NT and in the control. Leaf Ca concentration did not differ significantly between treatments. However, leaf B concentration was higher after treatment with AQ. Fruit Ca and B concentrations did not differ significantly in any treatment. The total free amino acids content in leaves was higher after AQ treatment than in the other treatments and control, although no significant difference was observed between the treatments in the fruit.

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Performance and Yield of Potato Grown in the Jordanian Desert

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The relative growth and yield performance (tuber number and fresh weight) of 13 North American and European potato cultivars were assessed at a site in the Jordanian desert near Zarqa. These cultivars included 'Spunta', which has long been grown in Jordan, and 'Minerva' and 'Ellona', which are new to Jordan. The other 10 cultivars were selected from a population of 130 cultivars that were ranked

for salinity (NaCl) tolerance, using an in vitro single-node cutting bioassay. They represented top (4), medium (4), and poor (2) performers in salinized medium, in vitro. The field performance of the 10 in vitro-ranked cultivars generally validated the in vitro rankings. 'Spunta' was the worst-performing cultivar.

284

Development and Abortion of Flowers in *Capsicum annuum* Exposed to High Temperatures

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Reduction of floral number in *Capsicum annuum* has been observed during growth at high temperature. To determine whether decreased flower production or increased flower abscission is a direct response to high temperatures or a response to water stress induced by high temperatures, we compared flowers and fruit produced and flowers aborted to leaf growth rate, osmotic potential, stomatal conductance, and chlorophyll fluorescence of two cultivars. To determine the stage(s) of floral development that are most sensitive to high temperatures, flower buds were wax-embedded and examined at each stage of development during heat treatment. Rate of floral development also was examined. At first visible floral bud initiation, plants were transferred to each of three controlled environment growth chambers with set temperatures and vapor pressure deficits (VPD) of 25°C, 1.1 kPa; 33°C, 1.1 kPa; and 33°C, 2.1 kPa. Flower bud production and leaf growth rate were not significantly affected by high temperatures. Pepper fruit set, however, was inhibited at 33°C at either VPD. Preliminary water relations data suggested that water potentials were more negative under high temperature conditions. Differences in leaf fluorescence were statistically significant for temperature treatments, but not for VPD. Temperature is the primary factor in the decrease of fruit production in pepper. Decreased production is due to flower abortion and not to decreased flower initiation or plant growth.

285

Chilling Tolerance in Cucumber Seed Selections from China

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Four cucumber seed lines obtained from the Inst. of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, Beijing, China, were tested for chilling tolerance. Comparisons were made with 'Poinsett 76', a commercially available cultivar from the United States. Seeds germinated at 25°C were exposed to 2°C for time periods up to 108 hr. Root injury was assessed by measuring subsequent root growth at 25°C at 72 hr after the chill. Electrolyte leakage measurements were taken on roots excised immediately after the chill. Total seedling root length and electrolyte leakage studies showed significant tolerance to chilling in the selections from China as compared to 'Poinsett 76'. 'Poinsett 76' seedling roots began to show stress after 72 hr of chill and were irreversibly damaged, with abortion of root tips, after 96 hr at 2°C. The China seed selections were more tolerant to a 96-hr chill and even at exposure times up to 108 hr only began to approximate chilling effects exhibited by 'Poinsett 76' at 72 hr of treatment.

286

Water Transfer in a Papaya/Corn Split-root Culture System

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'Honey Jean #3' sweet corn was planted in one-half of a split-root culture system containing 'Tainung 1' or 'Known You 1' papaya seedlings to determine if papaya roots could transfer water to the corn seedlings. After the corn seedlings were established, water was withheld from both compartments (2/2) or only the compartment containing the corn seedlings (1/2). Control plants were grown with both halves well-watered. Pre-dawn relative water content (RWC) of corn leaves was measured as an indicator of drought stress. Following 11 days, root competition was relieved in half of the 1/2 plants by cutting the papaya root connection between the half with corn from the rest of the papaya culture system. RWC of 1/2 corn plants was maintained above that of 2/2 plants, but below that of control plants. After relieving root competition, the 1/2 plants in competition with papaya roots maintained higher RWC than the 1/2 plants relieved of competition. Leaf tissue of all corn plants except the control plants was necrotic by 30 days. The results indicate that development of drought stress in corn using this culture system was retarded by watering a portion of the papaya roots not associated with the corn roots. Drought stress was accelerated by relief of competition with papaya, which is evidence that water was being supplied by the papaya roots within the

papaya/corn system.

148 POSTER SESSION 5D (Abstr. 287–291)

Propagation–Floriculture/Foliage

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Seed Germination of Four Lupine Species under Differing Osmotic Condition

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Seeds of four lupine species (*L. microcarpus* var. *aureus*, *L. havardii*, *L. succulentis*, and *L. texensis*) were subjected to 0, -2, -4, -6, or -8 bars osmotic potential using PEG 8000 solutions. Seeds of all species were acid scarified prior to placement in petri dishes containing the osmotic solutions. Petri dishes were placed in a seed germination chamber at 25°C with germination data collected daily for 15 days. Seeds of *L. havardii*, a desert species native to west Texas exhibited the greatest germination as osmotic potential declined while *L. succulentis*, a species adapted to moist sites, exhibited the greatest decline in germination as osmotic potential decreased. The other species exhibited intermediate germinability under the lower osmotic potentials.

288

Effect of Humidity, Temperature, and Scarification during Storage on Seed Germination of *Lupinus havardii* and *L. texensis*

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Lupinus havardii and *L. texensis* are two commercially important species of lupines (bluebonnets) in Texas. There is no current information for the storage requirements of these two bluebonnet species seeds. A study was undertaken to examine the effects of relative humidity, temperature, and scarification on seed germinability. Seeds of the two bluebonnet species were stored under five relative humidity treatments (11%, 23%, 52%, 75%, and 95%) and two temperature treatments (3°C or 22°C) either scarified or nonscarified in factorial combination. Seed samples were removed monthly. Nonscarified seed were scarified and all seed were placed in a seed germination chamber and germinated in petri dishes containing moistened filter paper. All samples of seed stored under 95% relative humidity were lost to seed-borne contamination. Germinability of scarified seed of both species decreased within 5 months in the 22°C/75% RH treatment. Other treatments had no effect on germinability during 7 months of seed storage.

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Rooting Performance of Hydrangea Cutting Types in Propagation Media Containing Coal Bottom Ash

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Rooting performance was evaluated for three different hydrangea (*Hydrangea macrophylla* Thunb. 'Blaumeise Lace Cap') cutting types in propagation media containing peat:sand amended with 0%, 25%, 50%, and 100% coal bottom ash (CBA) sieved through 2-mm mesh. Electrical conductivity (EC) values of all media were in acceptably low ranges, whereas pH was suboptimal in all but 100% CBA, ranging from 3.8 to 4.6 vs. 6.0 to 6.75 for 100% CBA. Available Ca was significantly higher at up to 189 mg·kg⁻¹ in the 100% CBA. Rooted cuttings were analyzed for root counts and dry mass. Terminal tip cuttings produced 96.1 mean roots/stem compared to butterfly cuttings (76.4) and single-eye cuttings (60.7), and there was no significant difference in root dry mass among the different cutting types. Propagation media containing 50% CBA produced greater numbers of roots/stem (99.89 and 89.59, respectively). The dry mass of roots/stem was significantly higher in media with 100% CBA. Root numbers per cutting were higher in terminal tip cuttings grown in 50% and 100% CBA and butterfly cuttings in 50% CBA. On the other hand, dry mass per cutting was higher in 100% CBA as compared to the rest, except for the terminal tip and butterfly cuttings in

50% CBA. The higher pH and Ca concentration may be factors causing the better rooting performance in 100% CBA.

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Humic Acid Promotion of Root Development on *Euphorbia pulcherrima* Cuttings

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Vegetative 6-cm *Euphorbia pulcherrima* 'Freedom' cuttings were placed in black 200-ml bottles containing humic acid solutions, nutrient solutions, or deionized water. Humic acid solutions were prepared using Enersol SC (American Colloid, Arlington Heights, Ill.). Concentrations of 500, 750, and 1000 mg/L humic acid were compared to solutions containing mineral element concentrations equivalent to those contained in humic acid solutions. After 4 weeks, 88%, 75%, and 88% of cuttings had rooted in the 500, 750, and 1000 mg/L humic acid solutions, respectively. Cuttings placed in nutrient controls or deionized water failed to form roots after 4 weeks. Average root fresh mass was 175, 80, and 72 mg for cuttings placed in 500, 750, and 1000 mg/L humic acid solution, respectively. Average number of roots formed per cutting ranged from 21 in the 500-mg/L solution to 6 in the 1000-mg/L solution. Average lengths ranged from 26 mm in the 500-mg/L to 12 in the 1000-mg/L solution. As humic acid concentration increased, average root fresh mass, average number of roots, and the length of the longest root significantly decreased.

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Adventitious Shoot Formation on Hypocotyl Explants of *Antirrhinum majus* L.

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One-centimeter hypocotyl explants from 2-week-old *Antirrhinum majus* L. (snapdragon) seedlings germinated and grown in vitro under 12-h cool-white fluorescent light and 12 h dark or 24 h dark were placed on Murashige and Skoog (MS) medium containing 0, 0.44, 2.22, 4.44, 8.88, or 44.4 μ M N⁶-benzyladenine (BA). Cultures were maintained under the light/dark regime at 25°C. After 2 weeks, adventitious shoots were counted. A shoot was considered adventitious and counted if a stem and leaf developed. Shoots developed along the entire length of the hypocotyl sections. Mean shoot production per hypocotyl explant ranged from 2.4 to 6.1 shoots when seedlings were germinated and grown in 24 h darkness and 2.2 to 10.9 shoots when started in the light/dark regime. Highest shoot counts were attained from hypocotyl explants when seedlings were germinated and grown under the light/dark regime for 2 weeks and transferred to 2.22, 4.44, or 8.88 μ M BA. Shoot development appeared normal at the 2.22 and 4.44 μ M level, while at 8.88 μ M BA, development was slightly abnormal along with slightly more callus production.

148 POSTER SESSION 5E (Abstr. 292–296)

Propagation—Fruits/Small Fruits/Nuts

292

Date of Collection and Rooting Environment Affect Propagation of Erect Blackberries by Floricane Cuttings

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In an early study we reported the feasibility of propagating erect blackberries by floricanes cuttings obtained during winter pruning. But how soon during the dormant season can the stem cuttings be collected? And, is a mist system really needed to promote rooting? Experiments were conducted to address these questions. Stem cuttings of 'Arapaho', 'Choctaw', and 'Shawnee' blackberries were collected on two dates, 15 Nov. and 15 Dec. 1996, stuck in peat-perlite mix, and placed in two rooting environments, with and without intermittent mist. Data was recorded on 15 Jan. 1997. Percentage of cuttings rooted was affected by the cultivar-by-date and cultivar-by-environment interactions. Values of 98%, 88%, and 75% were observed for cuttings taken on 15 Dec. of 'Choctaw', 'Arapaho', and 'Shawnee', respectively, while only 19%, 17%, and 45%, respectively, for cuttings of 15 Nov. Intermittent mist promoted higher rooting (85% vs. 31% without mist)

and lower death of cuttings (4% vs. 45% without mist) only of 'Shawnee'. Greater number of cuttings died when taken on 15 Nov. (21%) than on 15 Dec. (6%). These findings suggest that accumulation of chilling units is an important factor to take into consideration when propagating blackberries by floricanes cuttings.

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Propagation of 'Guardian' Peach Rootstock by Rooted Cuttings and Seed

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'Guardian' peach rootstock has shown improved survivability in areas where root-knot nematode and peach tree short life are a problem. Many peach rootstocks are typically propagated from seed. Availability of seed may vary and the long-term genetic uniformity of rootstock material may be difficult to maintain due to out-crossing during seed production. A reliable, successful vegetative propagation method would potentially increase the rate at which material could be made available and more closely ensure genetic uniformity. Production of liners was compared between rooted cuttings and seed of mature 'Guardian', 'Lovell', and 'Nemaguard' peach trees. Seed were stratified under uniform conditions, planted at initial germination, and seedling emergence recorded 30 days after planting. Terminal softwood and semi-hardwood cutting were treated with KIBA and rooted under intermittent mist in a greenhouse. Rooting percentage was equal to or greater than percent seedling emergence. Optimum results were obtained with semi-hardwood cuttings taken in July and August. Rooted cuttings transplanted to the field produced liners of equal or greater quality than liners produced from seed. Seedlings exhibited variability in growth in the nursery area. Rooted cuttings had fewer lateral branches in the lower 15 cm of rootstock where trees were T-budded with certified, virus-indexed buds of 'Cresthaven' peach.

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Super-density Planting and Lower Canopy using Hardwood Cuttings of 'Sunaga Wase' Peaches

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In order to investigate the super-density planting in peach orchards, the experiment was carried out using nursery trees out of hardwood cuttings in 'Sunaga Wase' peach (*Prunus persica* L.). The nursery trees were planted with various planting densities of 1 x 0.5 m (20,000 trees/ha), 1 x 1 m (10,000 trees/ha), 2 x 0.5 m (10,000 trees/ha), 2 x 1 m (5,000 trees/ha), and 6 x 5 m (330 trees/ha) as traditional density on 22 Mar. 1995. As soon as fruit harvest in mid-July, the peach trees were pruned by thinning and heading-back the shoots to induce the new shoot as well as to limit the tree height and lower the canopy. During the second year after planting, nursery cutting trees yielded the most peach fruits from the planting density of 1 x 0.5 m, as much as 14.37 t, which was 14 times higher than the 6 x 5 m of traditional density, followed by 2 x 0.5 m, 1 x 1 m, 2 x 1 m, and 6 x 5 m, respectively. According to summer pruning just after harvest, remaining vegetative buds burst and then the new shoot grew very vigorously in several days. The floral bud differentiation on the new shoots was lower, as much as 32.2%, than that of 77.9% in no-pruning shoots. There were no differences in fruit characteristics among various planting densities.

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The Concept of "Foundation Clones" in Source Selection for Vegetative Propagation of Almond

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The term "clone" is a key biological term that designates a number of horticultural situations. In breeding, many cultivars are designated as clones, originating from consecutive vegetative propagation from individuals within a seedling population, from individual plants of a clone exhibiting "bud mutations," and, more recently, from genetic engineering and biotechnology. Extensive vegetative propagation of a limited numbers of clones in modern horticultural systems has been accompanied by systemic incorporation by serious pathogens (viruses, viroids, phytoplasmas, etc.), and in some cases by horticultural deterioration (e.g., noninfectious bud-failure in almonds). Control of these problems in clonal propagation is achieved by 1) propagation source selection 2) maintenance of the source in a registered foundation block under protected conditions and 3) multipli-

cation in controlled "mother blocks" or "increase blocks" from which commercial material is distributed after a minimum of consecutive generations of vegetative propagation. This system is the basis for Registration and Certification programs and "clean stock" in general. In many crops the selected propagation source is a single plant, its progeny constitutes a "clone," and the new entity is given a unique name or number. To distinguish this "new" clone from the "original" clone, the designation of FOUNDATION CLONE is suggested. Biological and horticultural significance is illustrated in almond (*Prunus dulcis*).

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Improving Production of MM.106 Apple Rootstock Stools using Hydrogen Cyanamid Dormancy-breaking Agent

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Dormex (aqueous solution of 48% hydrogen Cyanamid) was applied by the end of December at 2%, 4%, and 6% in the first season and at 3%, 4%, and 5% in the second season to 1-year-old shoots of MM.106 apple rootstock. Dormex at 4%, 5%, and 6% increased significantly the percentage of bud burst, stool diameter, stool length, internode length, and leaf area; moreover, it decreased the number of days required to reach 50% bud burst. However, Dormex at 4% and 6% enhanced the stool Grand Period of Growth (GPG) by 1 and 2 months, respectively, compared with the untreated plants. Dormex treatments resulted in a significant increase in stool content of N, Ca, and Zn.

148 POSTER SESSION 5F (Abstr. 297–303) Postharvest Physiology—Vegetables

297

Heat Stress and Chilling Sensitivity of Tomato Fruit

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Mature green 'Sunbeam' tomato fruit (*Lycopersicon esculentum* Mill.) were treated in water for 1 hr at 27 (ambient), 39, 42, 45, or 48°C, and then either ripened at 20°C (nonchilled) or stored at 2°C (chilled) for 14 days before ripening at 20°C. The most-effective heat treatment was 42°C, which reduced decay 67% in chilled fruit and 53% in nonchilled fruit. Heat treatment had no effect on time required to ripen the fruit. Red-ripe tomatoes had higher respiration rates and evolved more ethylene following nonchilling storage, but heat treatment had no effect on respiration or ethylene evolution. Red color development was enhanced by heat treatment, and inhibited by chilling. At red ripe, fruit were firmer as a result of storage at the chilling temperature, while heat treatment had no effect on firmness. Heat-treated fruit were preferred in terms of taste and texture over nontreated fruit in informal taste tests, with the exception of the 45°C treatment. With increasing temperature of heat treatment, there was increased electrolyte leakage following chilling storage. Of the 15 flavor volatiles analyzed, the levels of five were decreased with increasing temperature of heat treatment. Storage at the chilling temperature reduced the levels of six flavor volatiles. Prestorage heat treatments can reduce decay with only minimal adverse effects on tomato fruit quality.

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Influence of Potassium and pH on the PG-mediated Hydrolysis of Pectin in Tomato Fruit Cell Wall

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The catalytic capacity of tomato polygalacturonase (PG) toward soluble pectic polymers is in excess of activity expressed in vivo; however, in vitro assays of PG have traditionally been performed under conditions (pH 4.0 to 4.5, 150 mM NaCl) that likely do not reflect the apoplastic environment of ripening tomato fruit. In this study, hydrolysis of pectin by purified tomato PG (isozyme 2) was examined in response to K⁺ (the predominate apoplastic cation) and over the pH range from 3.0 to 6.0. In the presence of K⁺, PG activity toward polygalacturonic acid measured reductometrically increased nearly 3.5-fold from pH 4.0 to pH 5.5. In the presence of Na⁺, activity decreased 90% over the same pH range.

PG-mediated degradation of cell wall from mature-green fruit showed divergent hydrolytic patterns in response to pH and K⁺. At pH 4.5 in the presence of K⁺ (as KCl), catalysis resulted in both solubilization and extensive depolymerization of cell wall pectin, with oligomers accounting for a significant portion of the hydrolysis products. At pH 5.5, the total quantity of wall pectin released in response to PG2 was similar to that at pH 4.5; however, oligomer production was strongly suppressed at the higher pH. At pH values favoring extensive depolymerization, low mol mass products were produced at 5 mM K⁺ and increased to a maximum at 100 mM K⁺. At higher pH, hydrolysis patterns were not affected by [K⁺]. pH and ionic effects may contribute to the distinctive patterns of pectin hydrolysis observed for different fruits.

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Influence of Ethephon and a Surfactant on Ripening of Harvested Tomato Fruit

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The objective of the research was to determine the optimal concentration of ethephon treatment on anticipation of ripening in harvested tomato fruits. Mature-green fruits of cv. Santa Clara were sprayed with 0, 1000, 2000, and 3000 mg/L ethephon solution. In another set of experiments, the fruits were sprayed with 0, 500, and 1000 mg/L ethephon solution containing 1.0% surfactant (Dyrol) or not. The visual color and firmness changes during ripening at 24.1°C and 81.3% relative humidity were evaluated. Concentrations of 1000, 2000, and 3000 mg/L ethephon had similar effect on the anticipation of fruit ripening. The use of 500 mg/L ethephon delayed the fruit color changes when compared with the treatment of 1000 mg/L ethephon; however, firmness changes were nonsignificantly affected ($P = 0.05$). Treatment with 1000 mg/L ethephon hastened the color changes by 3 days when compared with control fruits, but no difference on color intensity was observed after 12 days. The use of 1.0% surfactant mixed to ethephon caused slight delay on color changes; therefore, 1000 mg/L ethephon solution in absence of surfactant was more efficient in hastening tomato ripening.

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Short-term Controlled-atmosphere Storage of Tomatoes Improves Marketing Options

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Mature-green tomatoes stored up to 8 weeks at 11.5°C under 4% oxygen with no accumulation of carbon dioxide above ambient had reached turning stage of color by the end of the storage period. Control tomatoes stored at identical temperature without CA quickly turned red and were unmarketable after 4 weeks due to overripeness and high incidence of decay. Tomatoes held under CA for 8 weeks and then transferred to 20°C without CA ripened normally to full-red color within 10 days with less than 10% decay and no apparent mealiness or other symptoms of chilling injury. Weight loss from tomatoes stored under CA increased with storage time, but, after 8 weeks, the fruit still did not have noticeable shrivelling and visual appearance was excellent compared to tomatoes purchased from a local supermarket. Results of this research suggest that short-term CA storage is a feasible method of expanding the market window for tomatoes. This could be particularly useful for production regions such as South Carolina, where the harvest is practically completed within a 3-week window and low prices often prevail during the harvest period.

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Seasonal Fluctuations of Sugar Accumulation and the Activities of Related Enzymes Accompanying Maturation of Different Tomato Cultivars

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Seasonal fluctuations of carbohydrate levels and compositions and the activities of related enzymes of three cultivated tomato (*Lycopersicon esculentum* Mill. cv. Lady First, Momotaro, and Minicarol) cultivars were examined at 45-days interval with seven different sowing in the relatively warm climate of Japan. Fruits picked on early winter to spring seasons had higher sugar concentrations compared to hot season. Fructose and glucose in nearly equal amounts were the predominant sugar in all the seasons. Sucrose was present in trace quantities, but cherry cultivar Minicarol accumulated higher levels than the other two large-fruited types.

Acid invertase (EC 3.2.1.26) was highest at red stage during December to April, while fruit matured during May to August had lowest activity. The activity levels of soluble invertase were predominant compared to cell wall-bound fraction. The sucrose synthase (EC 2.4.1.13) showed highest activity in rapidly growing fruits followed by a very low activity with fruit maturation. Sucrose synthase showed the higher activity during November to February, and almost low activity during all the experimental periods. The sucrose phosphate synthase (EC 2.4.1.14) also showed higher activity during October to February, but the activity levels did not change drastically throughout the fruit development. The results substantiate the conclusion that, in all the planting seasons, acid invertase is a principal enzyme in the process of tomato fruit ripening and during early stage of tomato fruit development, sucrose synthase is the dominant enzyme, which, in turn, plays a part in regulating the translocation of sucrose into the fruit.

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Lipid Peroxidation Products in Tomato Fruit (*Lycopersicon esculentum*) during Storage after Exposure to Hormic Doses of UV Light

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Fresh fruit and vegetables are highly perishable because of their active metabolism during the postharvest phase. Previous studies showed that hormic dose of UV cause a delay in the senescence of tomato fruit by about 7 days. The objective of this study was to elucidate whether UV acts on the cell membrane in producing the phenomenon of delayed senescence, since it is known that UV radiation can provoke photooxidation of membrane lipids. Membrane lipid peroxidation was studied in tomato fruit (*Lycopersicon esculentum* Mill cv. Trust) treated by hormic UV dose, and was followed by assaying products of lipid oxidation during the storage period. We observed the production of lipofuscin-like compounds, malondialdehyde, aldehydes, pentane, ethane, and hydrogen peroxide within few days of the treatment. An increase in the efflux of electrolytes (total, potassium, and calcium) was also observed. An immediate increase in the level of these products of oxidation supports the hypothesis that UV radiation induces membrane lipid peroxidation. However, beyond 5 to 7 days after treatment, the production of oxidation products and electrolyte leakage were lower than the control fruits. Thereafter, the level of products of lipid oxidation associated with senescence was higher in control fruits than in treated ones. Results suggest that the initial oxidation stress by the exposure to UV led to biochemical reactions inducing the production of stress compounds, such as polyamines, which are non specific antioxidants. Consequently, a delay in the senescence was observed.

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Use of Electrolyzed Water to Reduce Bacteria on Fresh-cut Vegetables

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Effect of electrolyzed water on total microbial count of several fresh-cut vegetables was evaluated. Electrolyzed water (pH 6.5), containing 20 ppm available chlorine, was produced by electrolysis of salt solution using an electrolyzed neutral water generator, Ameni Clean (Matsushita Seiko Co. Ltd., Osaka, Japan). Fresh-cut vegetables, including carrot slices, chopped bell peppers, trimmed spinach leaves, shredded Japanese radish, and diced potatoes, were treated with electrolyzed water by dipping, rinsing, or bubbling (immersion and flush with air at 25 L/min) for 3 min and then rinsed with running tap water for 1 min. These treatments reduced the total microbial count by about 1 to 2 log units on tissue surface and inside of all vegetables relative to nontreated samples. Since rinsing with tap water also reduced the microbial count by about 1 log unit, the bubbling treatment was the only effective treatment in reducing bacteria on the surface of fresh-cut Japanese radish and potatoes when compared with water-rinsed controls. When samples were not rinsed with tap water after treatment, the microbicidal effect of electrolyzed water was noted on tissue surface of all vegetables even if relative to water-rinsed controls. Electrolyzed water did not affect the tissue pH ranging from 5.7 to 6.1, surface color, and taste of any fresh-cut.

148 POSTER SESSION 5G (Abstr. 304–315) Greenhouse Management—Cross-commodity

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Greenhouse Screens and Their Efficacy Against Whiteflies and Thrips

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Twenty-eight greenhouse screening materials, with predetermined airflow resistance values, were evaluated for exclusion of silverleaf whitefly (*Bemisia argentifolii* Perring & Bellows) and thrips from a mixed-species population. Screens differed in exclusion efficacy, as a percentage of the fiberglass window screen control and at an approach velocity of at 92 m/min, from -35 to 94% for silverleaf whitefly and from -13 to 95% for thrips. Seventeen screens excluded more silverleaf whitefly, whereas seven excluded more thrips than the window screen control. One material differentially excluded whitefly over thrips; many more differentially excluded thrips over whitefly. Airflow resistance, indicative of mesh hole size, did not necessarily correspond with degree of exclusion. Though two high-resistance screens, No-Thrips and Econet S, excluded both pests, not all materials characterized as highly resistant to airflow provided significant exclusion. Exclusion of both pests was also attained with three moderate resistance screens, BugBed 123, BugBed 85, Pak 44x44, and one low-resistance screen, BugBed 110UV.

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Effects of Temperature on the Development of Asiatic Lilies

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Temperature effects the rate of development of *Lilium* (Asiatic hybrid). The long-term objective is to evaluate thermal units as a tool for crop timing. The objective of this work was to determine *Lilium* base temperature (T_b). One-hundred-ninety plants of two cultivars ('Butter Pixie' and 'Horizon') were used. Phenological observations were made on plants during six plantings over a 2-year period. Developmental stages observed were: shoot visible out of the soil (SV), visible flower bud (BV), and open flower (OF). The two cultivars were grown in four different greenhouse compartments with settings at 13, 18, 24 and 27°C, respectively. During periods of extreme outdoor temperatures, actual temperature deviated from the settings. Actual temperatures were constantly monitored with copper-constantan thermocouples and stored in a datalogger. Rates of development were calculated as the inverse of the numbers of days to complete a given phenological phase. T_b values were obtained by calculating the x-interception of the linear regression describing rate of development as a function of mean air temperatures. T_b for 'Butter Pixie' and 'Horizon' for the entire growth cycle (SV through OF) were 0.4°C and 2.0°C respectively. The production cycle can be divided into two phases: SV-BV and BV-OF. For 'Horizon', T_b for these phases were 1.4 and 1.9°C respectively. For 'Butter Pixie', these T_b were 2.4 and -1.0, respectively. More observations of development at mean temperatures higher than 27°C and lower than 13°C are necessary in order to increase confidence on the obtained T_b s.

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Comparison of Container Placement Patterns for Maximizing Greenhouse Space Use

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A model was developed that will calculate the maximum number of containers that can be placed in a specified area. There are basically three patterns of container placement. First, "square" placement involves placing pots in parallel rows in both directions so that any four pots form a square. The other two methods involve staggered patterns in which any three containers form a triangle. In the "long staggered" pattern, the long rows are parallel to the long dimension of the bench or floor space, while in the "short staggered" pattern, long rows are parallel to the short dimension of the bench. Comparisons of spacing patterns were made using a range of

greenhouse/bench dimensions and container sizes. In most cases, a staggered arrangement allowed a significant increase in the number of containers fitting on a bench as compared to square placement. For example, when 6-inch pots are placed pot-to-pot in an 8 x 50-foot greenhouse section or bench, "short staggered" or "long staggered" arrangement of containers permitted 10.4% to 11.9% more containers over that allowed by a square pattern. In general, the larger the bench or greenhouse section, the greater the benefit of staggered spacing. The difference between short and long staggered was usually less than 3%, and depended on the specific space dimensions. This model can be easily entered into a spreadsheet for growers to perform their own calculations.

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Leaf Wetness Data Logger Use In Greenhouse Applications

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The Leaf Wetness Data Logger (LWL) and accompanying Logbook software were designed by Spectrum Technologies Inc. as a low-maintenance tool to aid in disease prediction and spray scheduling for outdoor field-grown crops. The LWL mimics leaf surface moisture represented as a value between 0 (dry) and 15 (wet). We explored an expanded use of the LWL to large-scale commercial greenhouses for the purpose of humidity control and disease prevention. Data were collected over 15 days in a commercial hydroponic tomato production greenhouse and repeated. Results indicated that leaf wetness, as determined by the LWL, increased during irrigation periods, with cumulative effects dependent on daily irrigation requirements and climate. Irrigation was controlled by the climate control computer in response to cumulative radiation intensity. By analyzing leaf wetness in correlation with climatic conditions, more adequate irrigation scheduling may be implemented, reducing the risk of disease spread and infection.

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The Simulation and Optimization of Greenhouse Microclimate for Energy-efficient Production

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Greenhouse crop production involves high rates of energy input to implement a greenhouse microclimate that results in high productivity levels, correct crop timing, and desired product specifications. Producing quality crops while maintaining low energy consumption is achievable through improved crop management and environment control strategies. In this study, greenhouse crops and their microclimate were treated as an integrated system that was driven by solar radiation and external energy input. A set of simulation models were developed to describe the greenhouse climate, the crop, and their dynamic interactions. The temperature and light regimes were simulated using the greenhouse energy budget under typical weather patterns. The crop model simulated growth and development of several ornamental greenhouse crops. Coupling the crop model with the greenhouse energy model resulted in a system that allows determination of optimal strategies for crop management and environmental control. This greenhouse/crop system can be used to assist growers with formulating strategies of greenhouse production management.

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Enhanced Control of Powdery Mildew of Greenhouse Roses using Piperalin Tank-mixed with Quaternary Benzophenanthridine Alkaloids

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A formulation of quaternary benzophenanthridine alkaloids (QBA) was combined with piperalin as a tank mix. The QBA was applied at 150 mg/L and piperalin, at the labeled rate, was applied as a spray application to greenhouse roses infected with *Sphaerotheca pannosa* var. *rosae* (powdery mildew). Copper sulfate pentahydrate and fenarimol were also applied to mildew-infected plants within the same greenhouse at their respective label rates for comparison. Initial infection for the QBA/piperalin combination spray was 45% of the leaflet surface area, 3 days after application the infection was reduced to 10%, 6 days after application infection was reduced to 5%, and 14 days after application the infection remained at 5%. Initial infection for a QBA application without piperalin was 25% of the leaflet surface area. Three days after application, the infection was reduced to 15%; 6 days

after application the infection remained at 15%; and 14 days after application, the infection was reduced to 10%. The data reveals that the QBA/piperalin combination gives a short-term as well as a long-term fungicidal and fungistatic activity.

310

Effect of Coir and Sphagnum Peat-based Substrates on Fungus Gnat Populations

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Fifteen-centimeter (1700-ml) containers were prepared for this experiment by sealing the drainage holes with insect screen (Hummert International, Earth City, Mo.) that had openings of 0.026 cm x 0.0805 cm. Containers were filled with substrates composed of either a 80% sphagnum peat or 80% coir. The remainder of the substrates was composed of perlite. Rooted cuttings of *Euphorbia pulcherrima* 'Freedom' were planted into the containers and the containers were sealed with the insect screen and plants were allowed to grow and the substrate to age for 2 weeks. Fungus gnat (*Bradysia* spp.) larvae were collected using potato disks placed on the surface of infested substrates. After 3 days, larvae were collected from the disks, and 10 larvae were added per container. Uninoculated controls were included. After a period of 6 weeks, the adult population was sampled by placing 2.5 x 5.0-cm yellow sticky cards in each container. The larval population was sampled by placing a 4-cm-diameter potato disk on the substrate surface of each container. Fungus gnat larvae and adults were recovered from both sphagnum peat and coir-based substrates. Neither the number of adults nor the number of larvae recovered were significantly different between sphagnum peat and coir-based substrates.

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Response of Poinsettias to Paclobutrazol in Paint Applications

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The effectiveness of a paclobutrazol/paint mix in controlling growth of poinsettia plants (*Euphorbia pulcherrima*) cultivars Freedom Red and Angelica Red was evaluated. Plants were grown in containers whose interior walls were coated with a flat latex impregnated with varying concentrations of paclobutrazol: 0, 5, 20, 80, 100, 150, 200, and 300 mg·L⁻¹ (0, 0.032, 0.128, 0.512, 0.64, 0.96, 1.28, and 1.92 mg a.i. per container, respectively). As a comparison, one treatment consisted of plants drenched with 118 ml/container of a paclobutrazol solution at 3 mg·L⁻¹. Plants grown in containers with the paint-paclobutrazol mix were shorter than the control plants. Treatments involving concentrations of 100 mg·L⁻¹ or more (even as much as doubled or tripled) did not produce proportionately shorter plants. Root dry weights of plants in all treatments were not significantly different. However, the length of roots touching the internal surface of the container decreased with increasing growth regulator concentrations. This may help explain why doubling concentrations of growth regulator-in-paint does not produce proportionately shorter plants: roots start absorbing the growth regulator as soon as they touch the wall of the container. As a consequence, all root elongation is reduced, resulting in less root-growth regulator contact and less growth regulator uptake. More measurements of root length and root area are required in order to proof this hypothesis. When paclobutrazol concentrations were higher than 100 mg·L⁻¹, some bracts showed evidence of "crinkling."

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Effects of Supplemental Light on Growth, Photosynthesis, and Carbohydrates Synthesis in the Leaves of Tomato (*Lycopersicon esculentum* L.) Grown under Different Greenhouse Covering Materials

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Most experiments on the effects of cover materials on greenhouse crops have provided no real statistical replication for the cover materials. This study was conducted in Winter 1996 at the Harrow Research Centre (Ontario) in nine mini-houses covered with glass (single-glass), D-poly (double inflated polyethylene film), and acrylic (rigid twin acrylic panel) offering a 3 x 3 latin square experimental design. Tomato plants (*Lycopersicon esculentum* L.) were grown in CO₂-enriched

atmosphere (1000 ppm) under three covering materials, and two light treatments (natural light, and supplemental light at $65 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) in order to determine the effects of supplemental light on growth, photosynthesis, reproductive carbon allocation, and evolution of carbohydrates synthesis in the diurnal cycles. Overall, the application of supplemental light increased photosynthesis rate, yields, harvest index, total chlorophyll content, and starch accumulation in all treatments, regardless of the type of cover materials. Early marketable yield in acrylic and D-poly houses was higher than in glasshouses. Plants grown under enhanced light intensity flowered earlier and produced 12% more marketable fruits than those grown under natural light. The photosynthetic rate of plants grown in acrylic houses was higher than that of plants grown in glasshouses and those grown in D-poly. The leaves of plants grown in acrylic and D-poly houses had higher dry mass contents and much higher specific leaf weight (>10%) than plants in glasshouses. The net photosynthesis dropped after 3 months of treatment, accompanied by a high accumulation of carbohydrates in the leaves. These results indicate that a photosynthetic acclimation occurs earlier during the growth period suggesting a limitations in carbon metabolism.

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Postharvest Treatment of Easter Lily Bulbs Prior to Shipping

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Easter lily bulbs are harvested in fields in northern California and southern Oregon, packed in cases, and shipped to distributors and growers. The greenhouse forcer then cools the bulbs at 40–45°F for 6 weeks. This cold period is needed to vernalize the bulbs and to assure that the plants will later flower uniformly. Bulbs that have been cooled for longer or shorter lengths of time respond differently. The objective of this study was to determine the optimal storage temperature regime for the bulbs dug during the early part of the 3-week bulb-harvest period. Twelve groups of bulbs at various storage temperature regimes were evaluated as to their performance during greenhouse forcing. The variables that were considered were: 1) bud count, 2) variability of flowering date, 3) earliness of flowering date, 4) variability of Visible Bud date, and 5) variability of final plant height. An index was developed to evaluate the degree to which each variable impacted the production during the forcing phase. We found that the best protocol for bulb growers is to dig the bulbs and then hold them at cool (>45°F) ambient temperatures for a week. Temperatures higher than the high 65°F should be avoided. If the bulbs will be stored just 1 more week, then they can stay at this temperature; otherwise, the bulbs should be cooled down to, and held at, 42 to 45°F.

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Rapid Production of Sweetpotato Cuttings under Controlled Environment: CO₂ Enrichment and Cutting Preparation Affected the Growth and Production Rates

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Sweetpotato [*Ipomoea batatas* (L.) Lam.] has been cultivated and recognized as an important crop in many countries, including Japan. Leafy node cuttings originated from virus-free, micropropagated mother plants are widely used for propagation of sweetpotato. In the present study, plant growth and cutting propagation rates as affected by atmospheric CO₂ concentration and cutting preparation (single- or multi-node cutting) were investigated. Cuttings of 'Beniazuma' sweetpotato were hydroponically cultured with or without carbon dioxide enrichment (CDE) under controlled greenhouse environment. Carbon dioxide concentration inside the greenhouse was either 1000 $\mu\text{mol}\cdot\text{mol}^{-1}$ with CDE or 300 $\mu\text{mol}\cdot\text{mol}^{-1}$ without CDE. Air temperature and relative humidity were maintained at $30 \pm 1^\circ\text{C}$ and $80 \pm 10\%$, respectively. Growth and development rates of the cuttings were analyzed on 20th day after start of the experiment. CDE enhanced fresh and dry weights per cutting. Propagation parameters (fresh and dry weights per single mother vine, leaf development rate, and cutting propagation rate) were greater when started from single-node cuttings than from multi-node cuttings, either with or without CDE. Shoot tip removal reduced leaf development and cutting propagation rates, but it did not affect the fresh and dry weights.

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Transplant Quality as Affected by Temperature, Light Intensity, and Photoperiod during Storage

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Storage techniques to hold the seedlings for several weeks prior to shipping/transplanting have been required for the successful management in plug seedling production. During storage, it is required to suppress growth and development of the seedlings as well as to preserve their transplant quality. Illumination during storage has been shown to be important for storage of high-quality transplants. In the present experiments, eggplant (*Solanum melongena* L.) plug seedlings, which were ready for transplanting after 3 weeks of growth under 28/20C photo-/dark period temperature, 330 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ photosynthetic photon flux (PPF), and 16-hr photoperiod per day, were stored for 3 to 4 weeks under combinations of different temperatures, PPF, and photoperiods. Storage air temperature affected elongation of the seedlings during 3 weeks of storage. Continuous illumination at a PPF close to the light compensation point maintained dry weight of the seedlings unchanged during storage and kept the high percent survival after storage. Storage in darkness reduced the dry weight during storage and, thus, the percent survival after storage. PPF and photoperiod were shown to be important factors in the preservation of transplant quality and suppression of growth of the seedlings during storage.

149 POSTER SESSION 6A (Abstr. 316–328) Breeding & Genetics—Cross-commodity

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New Cultivars of Korean Mountain Ash (*Sorbus alnifolia*) and Its Mass Propagation in Vitro

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New cultivars, 'SKK 1' and 'SKK 2', of Korean mountain ash (*Sorbus alnifolia*) that had superior morphological features as woody landscape plants were selected from 5000 seedlings of *Sorbus alnifolia*. Two clones with genetic variation were selected from 1983 to 1994 as landscape plants with large leaf and unique tree form: 'SKK 1', which had large leaf and flower, and 'SKK 2', with semi-weeping tree form. New selected cultivars of *S. alnifolia* were successfully grafted and inherited their mother characteristics. *Sorbus alnifolia* was difficult to propagate by cutting. Therefore, in vitro propagation methods might be used to propagate the superior cultivars. Shoots with apical and axillary buds were excised from 1-year-old seedlings. The explants were cultured on WPM supplemented with 0.5 mg/L BA. Shoots formed from initial cultures were subcultured at ≈ 4 -week intervals onto the same media. To know the best hormone concentration in shoot multiplication, 0.1–3.0 mg/L of BA and 0.1–1.0 mg/L of zeatin were added to each WPM and MS media. The best shoot proliferation and elongation were obtained on MS medium with 1.0 mg/L BA from the whole shoot with the callus-like tissue, whereas the worst results were obtained from shoot tip. A 13-fold proliferation rate was achieved every 4 weeks.

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Expression of "Rooting" Genes *iaaM* and *roIB* Under Regulatory Promoters in Tobacco

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Hybrid aspen is a major source of fiber in the north-central United States. One major problem for utilizing genetically improved aspen, and a variety of other woody species, is the difficulty in rooting hardwood cuttings. The objective of this project was to construct and confirm the function of genetic transformation vectors with two rooting genes (*iaaM* from *Agrobacterium tumefaciens* and *roIB* from *A. rhizogenes*) using three promoters (CaMV35S, soybean heat shock-inducible and poplar wound-inducible promoters). The gene constructs can be used to transform aspen for improvement of rooting hardwood cuttings and to elucidate rooting mechanisms. Each of these six gene constructs was inserted contiguously upstream from the promoter-less-glucuronidase (GUS) gene in the plasmid pBI 101. The engineered plasmids were transformed into *A. tumefaciens* strain LBA 4404 by electroporation. The functions of the genes were confirmed by transforming *Nicotiana tabacum* with these constructs. In plants transformed with *iaaM* and *roIB* under the CaMV35S promoter, the GUS gene expressed constitutively. These plants were also morphologically abnormal, with callus (and sometimes root) formation on stem tissue. The plants transformed with heat shock and Win6 constructs had no root formation and little or no GUS expression, without induction. After induction with heat shock (42°C for 1 hr per day for 7 days) or

wounding (wounding the plants daily for 7 days), root formation occurred and GUS expression increased significantly with each gene, respectively. No roots developed in the non-transformed control shoots. The transformed plants with the regulatory promoters appeared morphologically normal. These constructs are currently being tested in hybrid aspen.

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Interspecific Hybridizations in the Family Hamamelidaceae

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Interspecific hybridizations among members of the genus *Hamamelis* (the witchhazels) and *Corylopsis* were carried out in 1993, 1994, 1995, and 1996 at the U.S. National Arboretum. Specifically, crosses involving the native witchhazel (*H. vernalis* and *H. virginiana*) and the Asian taxa (*H. mollis*, *H. japonica*, and *H. x intermedia*) were attempted in order to combine the ornamental qualities of the Asian species with the adaptability and fall blooming characteristics of the native species. Additionally, *C. platypetala*, a hardy species with small inflorescences, was crossed with *C. himalaica*, which has large showy inflorescences but is less hardy. Approximately 50 seedlings resulting from these crosses have been analyzed using randomly amplified polymorphic DNA (RAPD) markers to verify interspecific hybridization. Based on these assays, we report the first incidence of controlled interspecific hybridization between the Asian and native witchhazel taxa.

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Field Evaluation of Azalea Species and Cultivars for Resistance to Azalea Lace Bug and Cranberry Rootworm

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Azalea lace bug (*Stephanitis pyrioides*) is the most serious pest on azalea. Both evergreen and deciduous azaleas are susceptible, though more resistance has been observed in the deciduous. To identify genes for resistance, fourteen deciduous azalea species, three deciduous azalea cultivars derived from complex hybrids, and one evergreen cultivar were planted in a randomized complete-block design under mixed deciduous trees in the fall of 1994. Each block was replicated 12 times. In the spring and summer of 1995, azalea lace bugs were introduced onto branches of six plants of each of the taxa. One month later, and again in the fall of 1996, the percentage of infected shoots per plant was measured. Very little damage from azalea lace bug was observed on the *R. canescens*, *R. periclymenoides*, and *R. prunifolium* plants, while 'Buttercup', 'My Mary', *R. japonicum*, and *R. oblongifolium* had the greatest damage. The cranberry rootworm, *Rhadopteris picipes*, damages many woody ornamentals, including some azalea species. The injury appears as elongated cuts on the leaves, and is most severe on plants growing under dense canopies. The cranberry rootworm has been observed in this azalea field plot. Plants were evaluated for damage in June 1995 and 1996. Cranberry rootworm damage was most severe on 'Buttercup', *R. japonicum*, *R. prinophyllum*, and *R. calendulaceum*, while the evergreen azalea 'Delaware Valley White' was the most resistant.

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Are the "Dentatum" Complex of *Viburnum* Species Genetically Distinct?

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Viburnum bracteatum Rehd. is a member of the "dentatum" complex represented by at least three types: *V. bracteatum*, *V. dentatum* L., and *V. rafinesquianum* Schult. *V. bracteatum* is an endangered species in Georgia and at the federal level is a candidate as an endangered species. Two populations were located in northwestern Georgia; however, there is some concern as to whether they are in fact *V. bracteatum*. To determine if it is possible to distinguish between the three *Viburnum* species, cellulose acetate electrophoresis to detect isozyme variation was done. Polymorphic enzymes resolved were alcohol dehydrogenase, malic dehydrogenase, glucose-6-phosphate dehydrogenase, malic enzyme, 6-phosphogluconate dehydrogenase, phosphoglucomutase, and phosphoglucose isomerase. Fresh bud tissue was used, and tissue samples were electrophoresed three times for each enzyme assayed. A review of 100 phylogeny trees created with Dollop analysis was done. *V. rafinesquianum*, the known sample of *V. bracteatum*, and the 12 samples of possible *V. bracteatum* were all equally parsimonious. *V. dentatum* was consistently an outgroup. In conclusion, isozyme variation can assist in *Viburnum* species distinction.

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Influence of the *roIC* Gene on Proteins Associated with Stroma and Thylakoid Membranes of Chloroplasts in Transgenic Plants of Kentucky Bluegrass

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The effects of the expression of the *roIC* gene on protein accumulation in the chloroplasts of transgenic Kentucky bluegrass (*Poa pratensis* L.) were investigated. Coleoptile tissues excised from 3-day dark-grown seedlings were bombarded with tungsten particles coated with DNA of the engineered plasmid, pGA-GUSGF, containing the *nptII*, *gus*, and *roIC* genes. The tissues were cultured on callus induction medium, which consists of MS salts supplemented with 0.2 mg/L picloram, 0.01 mg/L naphthaleneacetic acid (NAA) 250 mg/L kanamycin, and 100 mM acetosyringone. The putative transformants were either albinos or variegated plants composed of white and green sections. These albino plants had little or no stroma-based 56-kDa and 14-kDa subunits of the suspected Rubisco proteins, which are expressed in response to genes in the nucleus and plastid, respectively. The albino plants also lacked the 110-kDa and 57–58-kDa, and 43, 47-kDa polypeptides in PS I, coupling factor, and PS II in thylakoid membranes, respectively. These proteins involved in photosynthesis are translated from plastid-based genes. No light-harvesting complex proteins (LHC) were observed in these albino plants. LHC genes are encoded in the nucleus. The thylakoid membrane proteins in the chloroplasts of the *roIC* transgenic variegated plants contained these proteins. Our data suggest that the nucleus and plastid gene products for plastid development are concomitantly impaired by expression of genes in the transgenic plants.

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Comparative Studies on *Hanabusaya asiatica* and Its Allied Groups Based on Randomly Amplified Polymorphic DNA (RAPD) Analysis

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The phylogenetic relationships between Korean endemic, *Hanabusaya asiatica*, and its allied groups, including four genera and nine species, were investigated at the DNA level using randomly amplified polymorphic DNA (RAPD) method. Ten primers out of 80 primers (10-mer) screened gave rise to very high polymorphism (99%) in all of the tested plants, producing 153 randomly amplified DNA fragments. *H. asiatica* was differentiated from its allied groups at the 0.62 of similarity index of RAPDs. This results were in accordance with previous classification based on palynological studies. It was confirmed that *H. asiatica* could be placed into Korean endemic and suggested that RAPD technique be used as an additional method of phylogenetic relationship for plant systematics.

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Characterization of *Alstroemeria* Species using Random Amplified Polymorphic DNA (RAPD) Analysis

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In this study, 11 species, hybrids, and color variants were characterized using randomly amplified polymorphic DNA (RAPD) analysis. Total genomic DNA was extracted using a 2% CTAB extraction buffer using fresh or frozen leaf material. The DNA was amplified using standard RAPD-PCR protocols utilizing 10-mer primers. All primers utilized exhibited a high degree of polymorphism in their banding patterns among the species and hybrids studied. The primers used produced ≈40 reproducible bands. It was possible to identify and uniquely distinguish all species and hybrids investigated using these bands.

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Water Loss Changes of *Antirrhinum majus* L. Cut Flowers as Influenced by Genotype

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Cut flowers of a short- (S) lived (3 days) inbred, a long- (L) lived (15 days) inbred and their hybrid (F₁, 7.3 days) of *Antirrhinum majus* L. were evaluated for water loss when held in deionized water under continuous fluorescent light at 25°C. Flowering stems for water loss evaluation were harvested when the basal five to six florets expanded. Cut stems were placed in narrowed-necked bottles

with the open area between the stem and bottle sealed with Parafilm. Stem weight and water weight in the bottle were taken every 24 h. Water loss evaluation was continued until 50% of the open florets on the flowering stem wilted or turned brown. Overall, water loss from all accessions was highest 24 h postharvest, declined rapidly between 24 to 96 h, and remained unchanged throughout the remainder of postharvest life. Between 24 to 96 h, the slope of the line for water loss was greatest for L, least for S, and intermediate for the F₁. It appears that longest postharvest life of *A. majus* is associated with the most rapid decline of water loss immediately postharvest to a level, which remains constant.

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Inheritance of Male Sterility in *Impatiens wallerana*

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Most seed produced impatiens today are F₁ hybrids. The seed of F₁ hybrids is produced by hand-emasculating the seed parent or the use of some types of male sterility system. The male sterility systems used in impatiens breeding have never been reported, and is proprietary information of seed companies. The objective of this study was to investigate the types of male sterility involved in impatiens. Eighteen inbreds and 14 hybrids were investigated. One sterile inbred line was selected and crossed with several inbred fertile lines for inheritance analysis. The F₁ progenies were all fertile, and backcrossed to the sterile parent. The F₂ and backcross populations indicate that the inheritance is controlled by a single recessive *ms* gene. Information concerning with a possibility of cytoplasmic-nuclear gene interaction will be discussed.

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Procedures for the Determination of Lipase Activity and Percent Trivernolin in *Vernonia galamensis* spp. *galamensis* using Gas Chromatography

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Vernonia galamensis spp. *galamensis* is a short-season oilseed plant naturally producing an epoxy fatty acid, vernolic (*cis*-12, 13-epoxy-*cis*-9, 10-octadecenoic) acid. Trivernolin, a triglyceride with three vernolic acid moieties, is the highest-quality oil produced by vernonia. Industrial interest in vernonia oil includes use for metal coating and as a non-volatile oil in paint. Seed lipase causes production of free fatty acids (FFA) from triglycerides (TG) in pre- and post-crushed seeds, thereby decreasing the quality of vernonia oil. Consequently, production of FFA can be used as a measure of lipase activity. Our research has developed a technique for detecting the production of FFA and the accompanying di- and monoglycerides. We are able to quantify FFA in relation to total seed lipid. FFA were measured at time of crushing and at selected time intervals thereafter. This allowed us to assess FFA in intact seeds and in seeds that have been crushed with the lipase able to hydrolyze the TG. Significant differences were found between accessions for all times tested. This procedure was developed to enable us to screen plants in our breeding program for seed lipase activity. We are also screening our germplasm for triglyceride composition to select those plants producing the highest percentage of trivernolin. We will use this data to describe the genetics of both traits.

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Inheritance of Male Sterility in *Lesquerella fendleri*

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Lesquerella fendleri (Gray) Wats., Brassicaceae, is a potential oilseed crop native to the southwestern U.S. The seed oil contains hydroxy fatty acids, similar to castor. Unique properties of the oil, along with coproducts, allow additional applications that would not be in competition with castor. Plants with vestigial anthers were discovered in a bulk population growing in the greenhouse in 1993. The inheritance of the trait was investigated the following three crop seasons. Crosses were made among sterile and fertile plants and reciprocals among fertile plants. Chi-square results indicate the male sterility trait is expressed by a recessive nuclear gene with cytoplasmic influence restoring fertility. Cytoplasmic male sterile lines can be utilized for development of hybrids. Development of lines without male sterility should lead to higher yields than current bulk populations of *lesquerella*. Hybrid plants and higher yields will enhance the commercialization potential of this new, alternative crop.

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Response of *Arabidopsis hy* Mutants Grown in Lower Day/Higher Night Temperatures (-DIF)

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It is theorized that photomorphogenic reductions in stem elongation are similar to thermomorphogenic plant response, i.e. increased red:far-red light response is similar to -DIF (day temperature < night temperature). The long hypocotyl (*hy*) mutants of *Arabidopsis thaliana* Landsberg are phytochrome mutants that are less responsive to light quality than wild type. These include mutants of phytochrome chromophore biosynthesis (*hy* 1, *hy*2, *hy*6), phytochrome B (*hy*3), blue-light receptor (*hy*4), and signal transduction (*hy*5). These mutants were grown in growth chambers with temperatures of 18C day/24C night (-DIF) and 24°C day/18°C night with a 14-h photoperiod. Lighting consisted of both incandescent and fluorescent lamps. Growth measurements of five of the mutants were consistent with reported effects of DIF. The height of these plants were significantly greater in the +DIF regime when compared to -DIF. The *hy*5 mutant showed little difference in the height measurements of plants grown in either -DIF or +DIF. This mutant has a phytochrome signal transduction deficiency. This result indicates that a functional photoreceptor is required, even in reduced quantities as in the phytochrome chromophore biosynthesis mutants, to signal perception of DIF temperature conditions.

149 POSTER SESSION 6B (Abstr. 329–342) Culture & Management–Floriculture/Foliage

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Influence of Fertility on Plant Growth and Postharvest Quality of Pot Sunflowers

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Pot sunflowers (*Helianthus annuus* cv. 'Pacino') were fertigated on ebb-and-flow benches with 100 or 200 mg·liter⁻¹ of N to determine the influence of fertility level on plant growth and postharvest quality in interior conditions. The fertilization rates were held constant from potting until day 45, then the fertilization rates were continued, decreased, or ceased on day 45 and day 55, giving a combination of nine fertilization subtreatments. At bloom, the number of days from potting to flowering, plant height, plant diameter, flower diameter were recorded, and the root medium of five replicates per treatment were analyzed to determine the nutrient status. Five replicates of each treatments also were moved into interior conditions with artificial lighting and were graded 5, 10, and 15 days after moving to evaluate the postharvest quality. There was no significant difference among fertilizer treatments for the number of days to flower, plant height, or flower diameter. Plants fertilized with 100 mg·liter⁻¹ N from potting until day 45, in combination with a ceasing of fertilization on day 55, had significantly better plant grades when compared to plants grown with 200 mg·liter⁻¹ N. Plants fertigated with 100 mg·liter⁻¹ N also had a longer postharvest life and the number of days before the flowers wilted were significantly longer. Good-quality plants with longer postharvest life were produced with 100 mg·liter⁻¹ N and by terminating fertilization 55 days after potting.

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Growth of Poinsettia in Potting Media Amended with Ground Kenaf Stem Core

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Euphorbia pulcherrima Willd. 'V-14 Glory Red', 'V-17 Marble', and 'Jingle Bells 3' were grown in various peat-based potting media amended with ground, non-composted woody stem core of kenaf (*Hibiscus cannabinus* L.) and fertilized at every irrigation with a 17N–2.2P–13.8K fertilizer at 300 ppm N. Kenaf is an annual tropical species grown in several Gulf Coast states as a fiber crop. Growth and overall quality of all cultivars was best in media containing 50% to 70% coarse grind of kenaf (by volume) and was similar to a commercial soilless control medium (Sunshine #1, SunGro Horticulture, Inc.). Media containing greater than 70% fine grind kenaf resulted in significantly smaller plants with chlorosis of both lower and upper leaves, and also resulted in undesirable shrinkage of media in

the containers. Addition of 19N–2.6P–10K Osmocote to kenaf-amended media at a rate of 3.5 kg·m⁻³ resulted in significantly better plants with less chlorosis than similar media without Osmocote. Media containing kenaf also resulted in significantly less water-holding capacity than Sunshine #1 and required more-frequent irrigation to sustain the growth of plants.

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Poinsettia Stem Strength

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Lateral branches of poinsettia tend to break from the main stem as plants reach maturity. The cause of poor stem strength is not known; however, suggested factors implicated in poor stem strength are: rate of nitrogen fertilizer used, type of plant growth regulator used, crowding of plants, or stem diameter of the cutting. Four different experiments were conducted to determine if these factors affected stem strength of poinsettia. Experiment 1: 'Freedom Red', 'Success', 'V-17 Angelika Red', 'Red Sails', 'Nutcracker Red', 'Cortez', 'Maren', and 'Red Splendor' poinsettia were fertilized with 20N–1P0–20K at 75, 75/125, 125/200, or 200 ppm N drip fertigation with zero leachate. Experiment 2: Three plant growth regulators were applied to 'Pearl' and 'Jolly Red' poinsettias. Experiment 3: 'Freedom Red' plants were grown in a 625, 900, 1225, or 1600 cm² area. Experiment 4: Rooted 'Freedom Red' cuttings with stem diameters of 4.5, 5.5, 6.5, or 7.5 mm were used. A force meter was used to determine the strength of each lateral on the main stem of the six replications in each experiment. The lower laterals had the least stem strength and the top lateral had the highest stem strength for all treatments in all experiments. The stem strengths of some cultivars in experiment 1 were stronger at the lower fertilizer rates. Type of plant growth regulator had no significant affect on most poinsettia cultivars. The stem strengths of poinsettias in experiments 3 and 4 varied according to which lateral was measured.

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Response of Three Poinsettia Cultivars to Root Media Containing Coal Bottom Ash

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Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotsch) cultivars 'Dynasty Red', 'Nutcracker Pink', and 'Annette Hegg Topwhite' were planted in 15-cm azalea pots containing peat : vermiculite (1:1, v:v) in which coal bottom ash sieved through 6-mm mesh was mixed in proportions of 0%, 25%, or 50% by volume. Planting date was 23 July 1996, and pinch date was 25 Aug. Harvest date at anthesis was 16 Dec. Plant heights of all cultivars were increased in the ash media. L, a, and b, values measured with a Minolta CR-200 chroma meter differed very slightly among ash levels within cultivars. Mean per plant bract cluster count was very similar among ash levels and cultivars. Mean diameter of largest bract cluster was increased above that of 0% coal ash plants for 'Topwhite' plants in 50% coal ash media. Mean per plant dry weights of all three cultivars were increased over those of control plants in both 25% and 50% coal ash media. Media pH increased with increase in ash, while EC tended to decrease. Media available Ca increased with ash increase, while Mg decreased and the same pattern was noted for leaf tissue Ca and Mg. This was probably due to release of Ca from the ash, which contains about 10% Ca oxides. Tissue levels of Ca and Mg were within acceptable ranges; however, K levels also declined in plant tissue to suboptimal levels with plants in ash media.

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High Soluble Salts Affects Water Loss and Bract Necrosis of Poinsettia

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'Angelika White' poinsettias (*Euphorbia pulcherrima* Willd. ex. Klotsch) were grown hydroponically with modified Hoagland's solution concentrations of 2 or 8 mS·cm⁻¹. The 8-mS·cm⁻¹ rate was imposed by proportionate increases in Ca(NO₃)₂, KNO₃, and MgSO₄. Water use, whole plant fresh mass, and pan evaporation were measured gravimetrically twice weekly over a 2-week period beginning 12 Oct. 1995. Poinsettia leaf water loss (g H₂O/dm² of estimated leaf area per day) was 0.30 and 0.22 times pan evaporation (g H₂O/dm² of pan area per day) for the plants in the 2 and 8 mS·cm⁻¹ solutions, respectively (a 25% reduction in water loss for plants in the 8 mS·cm⁻¹ solution), as compared to

plants in the 2 mS·cm⁻¹ solution. At initial anthesis, a reciprocal transfer of plants between the 2 and 8 mS·cm⁻¹ solutions was used to investigate the time when plants were sensitive to high soluble salts for bract necrosis. Other plants were maintained throughout the experiment in the 2 and 8 mS·cm⁻¹ solutions. On 15 Jan. 1996, plants were harvested and total lamina surface of leaves and bracts, number of necrotic bracts, and dry mass of leaves, bracts, stems, and roots were recorded. The results indicated that exposure to high soluble salts (8 mS·cm⁻¹) prior to anthesis significantly increased the percent incidence of bract necrosis and decreased root growth. The smaller the root dry mass as a percent of total plant dry mass the greater the incidence of bract necrosis ($Y = 0.0972X^2 - 3.78X + 38.7$, $r^2 = 0.69$).

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The Response of Long-day Herbaceous Perennials to a Night-interruption at Low Night Temperatures

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A 4-hr night interruption (NI) is an effective way to promote flowering in many long-day herbaceous perennials. Some perennials are grown outdoors in the early spring and often are exposed to low night temperatures. Long days delivered by NI lighting ineffectively promote flowering under low-temperature conditions in some long-day species. The objective of this experiment was to determine the effectiveness of NI long-day lighting treatments delivered at different night temperatures in promoting flowering of several herbaceous perennials. Ten herbaceous perennial species were grown under natural short days augmented with a 4-hr NI. Night temperatures were 2.5, 5, 10, 15, 20, and 25°C with day temperature of 25°C for all treatments. Plants were transferred to 9-hr days at a constant 20°C after 7 weeks of treatment. Results on flowering percentage, date of visible bud and flowering, node count, flower bud count, and plant height at flowering will be presented.

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Plant and Pinch Number for Alternative Hanging Basket Crops Affect Quality and Scheduling

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The objective was to determine the optimum number of plants and the number of pinches required to market a basket for hanging basket production using alternative floriculture species. The number of plants per pot varied from one to four, and the number of manual pinches per basket ranged from 0 to 2. Several species were evaluated in spring of 1996 and heat tolerance was assessed throughout the summer. Plugs (50–95 plugs per flat) were transplanted into 25-cm hanging baskets in a 22/18°C (venting/night temperature set points) glasshouse. Three to four plants were necessary for *Scaevola aemula* 'Fancy Fan Falls' and *Evolvulus glomeratus* 'Blue Daze' to produce a marketable basket. One plant per pot was sufficient for *Abutilon hybrid* 'Apricot', *Portulaca oleraceae* 'Apricot', and *Tibouchina* 'Spanish Shaw' without sacrificing quality; however, an additional 1 to 3 weeks production time was needed in comparison to the four plants per pot treatment. *Abutilon* and *Portulaca* required one pinch, while *Tibouchina* did not require pinching. All plants x pinch combinations produced quality baskets with *Sutera cordata* 'Mauve Mist' and *Diascia hybrid* 'Ruby Fields'; therefore, production methods should be based on growers' scheduling and cost analysis. *Abutilon*, *Evolvulus*, *Portulaca*, *Scaevola*, and *Tibouchina* performed well in hanging baskets throughout the summer. Two species in the trial, *Orthosiphon stamineus* 'Lavender' and *Tabernaemontana coronaria*, displayed upright growth habits and would be best for uses other than hanging basket production.

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Pruning Method Influences Stem Length and Number of Four Woody Cut Species

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Rooted cuttings of four woody cut species, *Buddleia davidii* 'Black Knight' (butterfly bush), *Forsythia x intermedia* 'Lynwood Gold', *Salix chaenomeloides* (Japanese pussywillow), and *Salix matsudana* 'Tortuosa' (corkscrew willow) were planted outdoors in 23 Apr. 1992. During the next year, forsythia, pussywillow, and corkscrew willow plants were either unpruned or pruned to 30–45 cm above

the ground: 1) during dormancy or immediately after harvest (winter); 2) 3 to 4 weeks after start of shoot growth (spring); or 3) in early June (summer), and number and length of stems harvested was recorded for three years. Butterfly bush was either unpruned or pruned to 8 cm above the ground during: 1) winter or 2) spring, and number and length of stems recorded for 2 years. Stem length and number increased each year for all four species, and all species produced harvestable stems within 1 year after planting. For forsythia, no differences due to treatment were found, although year by treatment interactions were noted. The unpruned control produced the longest and greatest number of stems for pussy willow. Winter or spring pruning produced the longest and greatest number of stems for corkscrew willow. For butterfly bush, spring or no pruning produced the greatest number of stems, and year by treatment interactions were noted.

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Unblended or Co-blended Composts for Production of Potted Chrysanthemum

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Blending compost from various feedstocks may increase the beneficial effects of compost as potting substrate. A factorial treatment combinations included 10 compost combinations, Sunshine Mix and Pro Gro 300S as controls, three compost levels, and three chrysanthemum cultivars. The compost combinations were Compro (CP), poultry litter (PL), PSG polymer dewatered biosolids (PSG), yard trimmings (YT), CP:PL, CP:PSG, CP:YT, PL:PSG, PL:YT, and PSG:YT; all blends were on a 1:1 ratio (v/v). The compost levels were 50%, 75%, 100%; and chrysanthemum cultivars included 'Boaldi', 'Cherry Davis', and 'Yellow Favor'. All treatments were replicated six times. Plants were fertilized with 100 mg/L N from 20N-8.8P-16.6K twice weekly. All compost substrates, except PSG blends produced plants that were shorter than the controls. All compost blends produced similar or greater number of flower than the controls. Plants grown in substrates containing PSG and/or CP produced dark green or green foliage, and other substrates produced plants with pale green leaves. The PSG:PL and PSG:YT blends produced premium-quality plants. All other compost blends produced good-quality plants that were similar to the controls.

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Zinc Uptake by *Pelargonium x hortorum* Grown in Shredded Tire Rubber-amended Media

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On 2 Feb. 1996, rooted cuttings of *Pelargonium x hortorum* L. H. Bailey cvs. Tango and Blues were planted in 750-cm³ (14 cm in diameter) pots containing peatmoss mixed with shredded tire rubber (2-6.0 mm particle size) at 0%, 20%, 40%, 60%, or 80%. Plants were irrigated by hand, drip, or ebb-and-flood, and were arranged in a split-plot experimental design. A wetting agent (Aqua Gro 2000 L, Aquatrols Corporation, Cherry Hill, N.J.) was mixed at the rate of 6 ml per 3750 ml of water and 120 ml of solution was applied to each plant. Greenhouse studies indicated that geraniums could be grown successfully in media containing up to 20% shredded tire rubber by volume when irrigated by hand. Plants grown in media containing more than 20% rubber were observed to be slow-growing and chlorotic. Tissue analysis of the plants indicated significantly increased levels of zinc in plants grown in media containing high percentages of rubber. Geraniums grown in media containing 80% rubber and irrigated using ebb-and-flood benches had the significantly highest levels of foliar zinc. Media porosity, percent air space, and bulk density increased, while water holding capacity decreased with increasing amounts of shredded tire rubber added to the media.

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Geranium and Marigold Response to Fish Waste Compost as a Container Growth Medium and Nitrogen Source

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A fish waste/hemlock-fir sawdust compost (FWC) was evaluated as a container growth medium and N source for the greenhouse production of marigold (*Tagetes patula* 'Queen Sophia') and geranium (*Pelargonium x hortorum* 'Sprinter Scarlet') in 10-cm containers. Treatments were a factorial set of three Douglas-fir bark (B)/three FWC mixtures (100% FWC; 50% FWC/50% B; 100% B) and three rates of N fertilizer (0, 300 and 600 ppm N) applied every 2 weeks. After the initial irrigation, plants were drip-irrigated to negate leaching from the containers.

Weekly measurements of leachate conductivity, pH, and inorganic N were made on additional replications of the 0-ppm N plants in all growing media. Plant height and width were measured at 2-week intervals and, at the end of the production cycle, flower number, shoot fresh and dry weight, visual quality, and root dry weight were measured. The growing medium by N interaction was significant for all variables. Results indicated that plants receiving 0 ppm N in 100% FWC were larger and of higher quality than plants in 100% B receiving 600 ppm N. In 100% FWC, marigold shoot growth, dry weight, and quality were not influenced by N rate. The observed geranium and marigold growth response indicated that FWC was an effective N source and growing medium when leaching was minimized with drip irrigation.

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Cell-pack Size and Spacing Requirements for the Transplanted Floral Meadow

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The Transplanted Floral Meadow is a culture technique designed to provide an herbaceous planting of continuous seasonal bloom beginning about 1 month after transplanting to the landscape. The technique requires little or no maintenance once the plants have become established. The meadow consists of a seed mix of annual flowers that are started in the greenhouse in mixed plugs and transplanted to the landscape. In this study, plugs of the annual transplanted floral meadow seed mix were started by broadcasting the seed mix over flats of standard nursery cell-packs filled with a commercial growing medium. The plugs were grown in the greenhouse and transplanted to plots 4 weeks after sowing at 30 x 30-, 30 x 45-, or 30 x 60-cm spacing. The plug sizes used were 801, 1801, 804, or 1804 cell-packs. The plugs were transplanted to 2.25-m² plots with three replications, each plot being a replication. Plug size and spacing were evaluated based on the rate of canopy closure measured biweekly as the amount of photosynthetically active radiation penetrating the canopy. Close transplant spacing with large plug sizes provided the quickest site coverage. The 1801 and 801 plug sizes provided the greatest species diversity. The 1804 plug size reduced the number of seedlings present at the time of transplanting and did not cover the site until late in the season. The 801 and 1801 plug sizes at 30 x 30- or 30 x 45-cm spacing resulted in the best floral display. The results of this research will be used to standardize the transplanted floral meadow technique for use as a new product in the nursery trade.

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Assessment and Evaluation Program for the Australian Native Flower, *Ixodia achillaeoides*

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A research program is being conducted to support the development of superior varieties of *Ixodia achillaeoides* for cut flower production. This species is an everlasting daisy in the Asteraceae, which is produced on a woody perennial bush and is currently both harvested from the wild and cultivated in Southeastern and Western Australia. *Ixodia* shows a high degree of variation in plant form, flower characteristics, and flowering dates throughout its geographic distribution. In our assessment program, seedlings are screened for a range of morphological and flowering characteristics, and clonal selections are established under cultivation to assess suitability to row culture. The goal is the development of selections with known flowering characteristics and disease tolerance for fresh and dried flower markets and for flowering pot plants. Description is given of assessment criteria for selection of varieties for dried and fresh markets. Seventy selected varieties are currently being assessed in randomized block plantings at two sites in South Australia. Preliminary results and descriptions are presented for superior selections made for dried flower markets. The postharvest performance of selections for fresh markets will be discussed. Research on control of flowering will be presented.

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Late-season Establishment of Annuals

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Maintaining annual color throughout the long summer season in warm temperate regions has become an interest to landscapers and nursery operators. Some colorscape companies have begun implementing a second summer planting

season. There is little information available concerning suitable cultivars and species of bedding plants for establishment in late summer. This study examined plant establishment in two container sizes and three dates of transplanting to determine late season establishment in Starkville, Miss. (33°27' latitude, 88°49' longitude). Seeds of 27 different cultivars were grown in plug flats in the greenhouse and transplanted into jumbo 606 or 10-cm square containers. The plants were grown in the greenhouse until transplanting on 16 Aug., 30 Aug., or 13 Sept. 1996. The plants were transplanted into plots containing nine plants with three replications per planting date. The plants were spaced on 20-cm centers among and between plots. The earliest two plantings resulted in better plant establishment and floral display. Some of the cultivars and species were more tolerant of the late season temperature and humidity establishing and providing a good color display from 6 weeks after transplanting until frost, 2 Nov. 1996. Cultivars that performed well included: *Impatiens wallerana* 'Deco Crystal', 'Expo Lavender Blush', 'Dazzler Salmon', *Begonia semperflorens* 'Varsity Bronze Scarlet', *Zinnia* 'White Pinwheel', *Tagetes erecta* 'Marvel Gold', and *Tagetes patula* 'Bonanza Harmony'. Cultivars that did not establish well under these conditions included: *Verbena hybrida* 'Romance Pink' and *Salvia splendens* 'Salsa Salmon'. The container size did not significantly affect plant establishment.

149 POSTER SESSION 6C (Abstr. 343–353) Nutrition—Fruits/Small Fruits/Nuts

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Effect of Rootstock on Nitrogen and Water Use in Apple Trees

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One-year-old 'Fuji' apple trees on six rootstocks (Mark, M.9, M.26, M.7A, MM.106, and MM.111) were compared for N and water uptake and utilization. The trees were potted in sand and subjected to a 75-day N-deprivation period (supplied with modified Hoagland's solution lacking N) to deplete their N reserves. Thereafter, they were supplied with a complete modified Hoagland's solution. Uptake of water and N differed by rootstock. Water and N uptake were positively related to tree dry weight ($r = +0.97$, $P = 0.001$). Trees that had the highest N concentrations at planting were the last to set bud during the N-deprivation-phase. Tree size after one growing season depended largely on rootstock girth and whole-tree-N-concentration at planting ($r^2 = 0.80$, $P = 0.0001$) regardless of rootstock. Water and N uptake efficiency (liter of water or mg N absorbed per g root dry weight, respectively) differed among the rootstocks, being highest for trees on MM.111 and lowest for trees on M.7A rootstock. Nitrogen and water utilization efficiency (g dry weight gained per mg N or per liter of water absorbed, respectively) were not influenced by the rootstock.

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Uptake Patterns of 11 Elements of Orange Trees in Solution Culture

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Three trees each of 'Valencia' orange (*Citrus sinensis* L. Osbeck) on rough lemon (*C. limon* L. Burm. f.) rootstocks that had been grown in solution culture since July 1989 were grown in two solutions from Oct. 1995 to Sept. 1996. Solution 1 was a soil extract made by boiling field soil (1:2 soil:water) for 20 min and filtering. Solution 2 was a complete nutrient solution. The solutions were analyzed every 7 days and changed every 28 days. At each solution change, the newly prepared solutions were analyzed for 11 elements and their depletion was determined by weekly analysis. Nearly all the N, K, and Mn in Solution 1 was absorbed in the first 7 days after each solution change; in Solution 2, N and Mn were also absorbed in 7 days, but K absorption was variable; single trees sometimes needed 4 weeks to absorb all the potassium. Calcium and Mg were never completely absorbed and in contrast to Mn, traces of Fe, Zn, and Cu remained in both solutions after 4 weeks.

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Yield and Quality of 'Anna' Apple Trees (*Malus domestica* L.) in Response to Foliar Application of Ascobine and Citrine Fertilizers

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The beneficial effect on yield and quality of 'Anna' apple fruits for the application of ascobine at 0.1% and citrine at 0.6% was studied during 1995 and 1996. Results showed that two citrine sprays at start of growth and 30 days later of ascobine at 0.1% or citrine at 0.6% were of material promotion effect on yield, fruit weight, total soluble solids, and total sugars, while reducing the total acidity. Both fertilizers were equally very effective in all the studied characters. The most striking and promising treatment was the application of ascobine at 0.1% or citrine at 0.6% twice during the growing season; i.e., growth start at 30 days later.

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The Effects of Differing Potassium Status (K) On English Walnut Tree Growth, Yield, And Nut Quality

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Six years of previous research in a 12-year-old English walnut orchard, with a history of potassium deficiency, created a large number of trees with different potassium status. This provided the opportunity to study the long-term effects different potassium status has on English walnut trees growth, productivity, and nut quality. Walnut trees with a history of potassium deficiency, adequacy or luxury continued in this mode during this evaluation. Positive correlations existed between July leaf potassium levels and tree trunk sectional area (TCSA), visual potassium status, percent husk potassium, yield per tree, and tree yield per TCSA. These positive correlations suggest July leaf potassium levels of 1.4% to 1.5% as being adequate. This is higher than the 1.2% leaf potassium level currently recommended as being adequate for a July sample. Poor or no correlations existed between July leaf potassium levels and percent shell potassium, shell weight, shell breaking force, percent broken shell, nut size, nut weight, percent kernel potassium, percent light-colored kernels, percent edible kernel, percent kernel yield, or percent shriveled kernel. Trees with leaf potassium levels at or above 1.5% July leaf potassium produced 80 pounds per tree more yield than trees with leaf potassium levels at or below 1.0% July leaf potassium levels. These data indicate that good tree potassium status influences tree size and tree productivity. Also the walnut husk is an important sink for the accumulation of potassium. Currently recommended adequate potassium levels for walnut appear to be lower than what this study indicates.

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Solution pH and Papaya Seed Germination and Seedling Emergence

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Two studies were conducted to determine the influence of pH on papaya seed germination and seedling emergence. The germination test was conducted with 'Waimanalo' and 'Tainung 1' seeds, using a double layer of filter paper disks in plastic petri dishes placed within a growth chamber. Each dish received 40 seeds, and germination was defined as when the radicle was visible. Disks were wetted daily with nutrient solution adjusted to pH of 3, 4, 5, 6, 7, 8, or 9. Germination began on day 5, and the study was terminated on day 23. Solution pH did not influence germination rate or ultimate germination percentage. 'Waimanalo' exhibited 58% germination and 'Tainung 1' exhibited 64% germination in this test. The seedling emergence study was conducted with 'Waimanalo' seeds using sand culture within a growth chamber. Thirty seeds were planted in 10-cm containers, and the sand was irrigated daily with the solutions from the first study. Emergence was defined as when the hypocotyl hook was visible above the sand. Emergence began on day 10, and the study was terminated on day 30. Solution pH did not influence seedling emergence, and mean emergence was 69% in this study. The results indicate that the seed germination and seedling emergence stages of papaya seedling growth are adapted to a wide range of substrate pH.

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Mineral Relations and Growth of *Annona muricata* Seedlings as Influenced by Substrate pH

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Container-grown *Annona muricata* seedlings were bare-rooted and re-potted in sand. Containers were irrigated daily with a complete nutrient solution ad-

justed to a pH of 3, 4, 5, 6, 7, or 8, and the seedlings were grown for ≈5 months. Numerous growth variables were measured, including canopy volume, increase in mass, and trunk diameter. There were no differences in growth measurements among the pH levels. Moreover, leaf tissue was analyzed for mineral content. Leaf tissue concentration of various minerals did not differ among the pH levels. *Annona muricata* is known for growing well in a range of soil conditions. These data verify that the species is adapted to a wide range of substrate pH.

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The Effect of Aluminum and Media on the Growth of Mycorrhizal and Nonmycorrhizal Highbush Blueberry Plantlets

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A factorial experiment was conducted to determine the effect of aluminum (0 and 600 μM) and media (sand, and 1:1 sand:soil) on mycorrhizal (M) and non-mycorrhizal (NM) highbush blueberry plantlets. There were no differences in nutrient uptake and total plant dry weight between M and NM plantlets. However, more root growth, as determined by dry weight, was observed in M than NM plantlets. The plantlets growing in sand had more dry weight than did those in the soil medium. Although the root growth and shoot growth were reduced by the 600-μM Al treatment, the direct effect of Al on plantlet growth was not clear due to Al and P interactions. Plant nutrient uptake was reduced by high concentrations of Al, suggesting that high Al concentration limited the ability of roots to acquire most of the nutrients. Mycorrhizal epidermal cell infection levels of 15% to 20% were maintained in the roots in soil medium but decreased to about 5% over the 6 weeks of the experiment in the sand medium. Although M plantlets accumulated more Al in their roots, Al was readily transported to the leaf tissues of M and NM plantlets.

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Nitrogen Partitioning of Field-grown 'Arapaho' Thornless Blackberry

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A spring application of 19 g CO(¹⁵NH₂)₂/plant at 2.49% atom percent enrichment was made in Mar. 1995 on 2-year old, field-grown 'Arapaho' blackberry plants. Individual plants were harvested during the study at preharvest (late May), postharvest (mid-July), and early dormancy (late October). The following plant parts were separated for analysis: roots, primocanes, floricanes, primocane leaves, floricanes leaves, fruits. Soil samples were also taken from within the drip line of the plants at each sample date. Plant tissues were washed, dry weights measured and ground for acid digestion, total N determination and ¹⁵N analysis. Samples were measured for ¹⁵N atom percent abundance by a isotope ratio spectrometer. The whole-plant dry matter increased during the season from 53 g in May to 153 g in October. Plants sampled in October had a greater amount of dry matter in roots than in any other tissue. There was a decreased total N content in all vegetative tissues (leaves and canes) from May to October. The maximum fertilizer ¹⁵N percent recovery was 43% (October) and the minimum was 12% (May) from the total plant tissues. Compared to other plant tissues, floricanes leaves and primocanes recovered significantly more fertilizer ¹⁵N in May, while roots and primocane leaves recovered more in October. Floricanes and fruits did not increase in ¹⁵N levels during the sampling period. Fertilizer ¹⁵N recovered in the soil amounted to 35.5% of the applied with 4.5% found in the inorganic fraction, 31% in the organic fraction. There were no statistical differences in percent recovery of the fertilizer ¹⁵N among sample dates in the topsoil. October ¹⁵N percent recovery was much lower than May in the subsoil, indicating a downward movement of N by leaching. Averaging all sample dates, 59.5% of the labeled fertilizer was accounted for in the plant and soil, with the remaining portion probably lost via volatilization, leaching, and/or denitrification.

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The Beneficial Effects of Biofertilizers for 'Red Roomy' Grapevines (*Vitis vinifera* L.): 1. The Effect of Growth and Nutritional Status

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Four biofertilizers (active dry yeast, phosphorene, rhizobacterium, and nitro-

bein) were used to fertilize 'Red Roomy' grapevines. Growth and nutritional status of the vines as affected by such fertilizers during 1995 and 1996 were studied. Results showed that fertilizing the vine with all biofertilizers caused a material improvement in shoot length, leaf area, and cane thickness, and effectively enhance the nutritional status of the vines. The favorable effects of such fertilizers were in the following descending order: phosphorene, rhizobacterium, nitrobein, and active dry yeast. A great increase on growth and nutritional status of 'Red Roomy' grapevines occurred as a result of supplying the vines with phosphorene or rhizobacterium as good, new biofertilizers.

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The Beneficial Effects of Biofertilizers for 'Red Roomy' Grapevines (*Vitis vinifera* L.): 2. The Effect of Berry Set, Yield, and Quality of Berries

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The positive influence of fertilizing 'Red Roomy' grapevines with four biofertilizers (active dry yeast, phosphorene, rhizobacterium, and nitrobein) on berry set and productivity was investigated during 1995 and 1996. The improvement occurred in berry set and yield, as well as physical and chemical properties in vines treated with the four biofertilizers in the following ascending order: active dry yeast, nitrobein, rhizobacterium, and phosphorene. Highly significant differences in characters were observed between treated and untreated vines. The best results with regard to yield and quality of berries was obtained in 'Red Roomy' vines biofertilized with phosphorene or rhizobacterium.

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Broiler Litter and Inorganic Nitrogen Fertilizer Influence on Yield and Earliness of June-bearing Strawberry

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Short-term soil application of broiler litter (B) has had variable results when compared to inorganic nitrogen fertilizers (Ni). We grew 'Oso Grande' strawberry on raised beds in the greenhouse and treated it with a preplant soil incorporation of B (N = 44, P = 15.3, H₂O = 170 g·kg⁻¹) at a N rate of 100 (B1) or 200 (B2) kg·ha⁻¹, and Ni from ammonium nitrate (34.5N-0P-0K) [A] or fluid nitrogen with 10 g·kg⁻¹ micro elements (30N-0P-0K) [F] applied in six equal monthly applications. Results show that fruit yield was increased under B-treated plots (*P* < 0.05), with B2 yielding the highest. Yield ranged between 172 to 324 g/plant. Fruit number per plant ranged from 14 to 24, with B2 yielding the highest (*P* < 0.05). Early flowering was enhanced by B2 (*P* < 0.05), which reflected in higher early yields under B2 (*P* < 0.05). Leaf tissue NO₃-N, PO₄-P and Fe were comparable among all treatments during the growing season. Soil NO₃-N, available P, CaCO₃, and pH at the end of the season were comparable among the treatments (*P* > 0.05), whereas EC was reduced by B1 and F treatments (*P* < 0.05). We recommend B at 200 kg N/ha as a fertilizer for June-bearing strawberry, and as a good alternative to inorganic N fertilizers.

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Relationship between Static Headspace and Vapor Concentration Above Dilute Liquid Solution Methods In the Measurement of Volatile Compounds

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The generation of dilute vapor phase standards using the static headspace method can be challenging, requiring the construction of specialized chambers or use special methods for adding minute amounts of the compound of interest. The vapor concentration above a dilute water solution can be effective and accurate and has been used to create standards to measure the concentration for a wide range of volatile and semivolatile organic compounds. Such systems are highly temperature-sensitive, however. The goal of this work is to mathematically describe the relationship between vapor concentration above a dilute water mixture for compounds important

to postharvest physiology, such as ethanol, acetaldehyde, ethyl acetate, and hexanol. The experiments were carried out in the range of 0 to 40°C and concentration of 0 to 1000 ppm for each compound. Three replications were used for each data point. The concentration was measured after thermal and chemical equilibration by gas chromatography containing a HAYESSEP-N column, by injecting 1 cc of the vapor headspace, using a 8-cm-long needle Hamilton syringe. Relationships for each of the compounds noted were successfully described employing multiple-order equations. For example, the relationship for ethanol vapor concentration was: $Y = 12.12356 + 0.9461594 * X + 0.5761110e-01 * X^2 + 0.6565694E-03 * X^3 + 0.23499598E-04 * X^4$ ($R^2 = 1.000$), with X being the temperature in °C. The relationships described for those compounds provides an useful tool that allows us to dilute liquid standards across a range of temperatures.

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Nuclear Magnetic Resonance Imaging Detects Internal Defects in Potatoes

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Potatoes with hollow heart or brown center are considered to be of poor quality for both fresh and processing markets. A reliable nondestructive method, which can distinguish affected and normal potatoes, is described here. A Varian 4.7 Tesla, 33-cm horizontal-bore spectroscopy/imaging system was used to obtain nuclear magnetic resonance (NMR) images of potatoes. A two-dimensional multi-slice spin-echo imaging technique was used to acquire the cross-sectional images along the longitudinal direction. The echo time was 35 msec and the repetition time was 1.2 sec. A total of 13 slice images were taken for each potato. A one-dimensional projection technique was also performed to evaluate the possibility of using fast-scan method. The brown center showed high intensity in long echo scans due to its longer T_2 relaxation time. A suberin-like layer resembling the periderm developed on the cavity wall of hollow heart causing a tan or dark brown coloration. This cavity wall also appeared in high intensity on the image. The affected potatoes can easily be sorted out using this nondestructive NMR imaging technique.

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The Evolution of Capsaicinoids during Fruit Development of Three Varieties of Hot Peppers

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Hot chile peppers are the main element that characterizes the Mexican cuisine and culture for at least the past 8 centuries. The components responsible for chile hot flavor, capsaicinoids, are synthesized through the shikimic acid pathway. Their degradation is thought to be aided by the action of peroxidases. This work describes the evolution of capsaicinoids during the development of the fruit in three varieties of hot chile widely used in Mexico: 'Habanero', 'Arbol', and 'Piquin', and its relation with the activity of peroxidases in these fruits. Plants were seeded and transplanted in a greenhouse and fruit were harvested after 10, 20, 30, 40, 50, and 60 days from fruit set. At 60 days from fruit set fruit were completely red and senescent. Total capsaicinoids, capsaicin, and dihydrocapsaicin were detected and quantified using HPLC. The activity of peroxidases was followed using spectrophotometry. Capsaicinoids were higher in the fruit of 'Habanero', followed by 'Arbol', and then by 'Piquin'. Capsaicin was higher than dihydrocapsaicin in the three varieties. Capsaicinoids, capsaicin, and dihydrocapsaicin increased continuously and reached a peak at 50 days after fruit set in the varieties 'Habanero' and 'Arbol' and after 40 days in 'Piquin', and then started to decline. Peroxidases had a maximum activity at pH 6.0, ≈ 1.0 mM of capsaicin, and 1.0–1.5 mM of H_2O_2 . The activity of peroxidases was slightly high after 10 days from fruit set, decreased, and started to increase again after 50 days from fruit set, which might be related to the evolution of the capsaicinoids.

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Lactic Fermentation of Carrot Root Shred under Low Oxygen

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Glycolysis has been shown to accelerate in many plant species, and the glycolytic pathway was considered to replace the Krebs cycle as the main source of energy when O_2 becomes limiting. The increase in glycolytic flux is accompanied

by the accumulation of glycolytic end products, including ethanol and lactate. Lactate dehydrogenase (LDH) has been isolated from several plant sources; however, there is very little work reported on LDH induction during anaerobiosis and no information is available on the long-term effect of low O_2 atmosphere on lactic fermentation in carrot (*Daucus carota* L.) roots. To understand the regulation of metabolism of lactic fermentation, carrot root shreds were stored under a continuous flow of 0.5% and 2% O_2 (balance N_2), or air at 5°C and 15°C. The concentration of lactate and the activity of LDH increased rapidly, reached peaks after 2 days, and then gradually decreased. The maximum increase level of LDH was 2.8-, 2.1-, 2.0-, and 1.6-fold; that of lactate was 5.6-, 3.8-, 2.9-, and 2.6-fold for 0.5% O_2 at 15°C and 5°C, and 2% O_2 at 15°C and 5°C, respectively, compared with corresponding air control. These results indicate that the lactic fermentation was more accelerated in 0.5% O_2 than 2% O_2 atmosphere, and more accelerated at the higher storage temperature than the lower one. However, ethanol accumulation, which was found in the carrots under the same low- O_2 atmosphere, was much more than lactate accumulation. Thus, carrot roots possess LDH, which appears under low- O_2 atmosphere, but lactic fermentation may be a minor carbon flux compared to ethanolic fermentation.

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Replacement of Postharvest Moisture Loss by Recharging and Its Effect on Subsequent Moisture Loss during Short-term Storage of Carrots (*Daucus carota* L.)

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The replacement of postharvest moisture loss in carrots (cv. Caro-choice) by single and repeated recharging (i.e., rehydration in water) treatments, interaction between the duration of recharging and temperature during recharging, and the effects of these treatments on moisture loss during subsequent short-term storage were studied. Carrot weight gain increased with increase in the duration of single recharging treatments. Carrots that had lost 2.96% of their weight, during storage at 13°C and 35% relative humidity, regained as much as 2.45% of the weight during recharging for 12 h. Longer rechargings had little additional effect. Recharging at 13°C and 26°C was more effective at replacing water than at 0°C. The rate of moisture loss (%/day) during subsequent storage was not affected by recharging duration and the temperature. With repeated recharging (every 3.5 d), increase in recharging duration up to 9 h increased carrot weight gain. Most of the weight gain occurred following 0 to 7 d of storage. These treatments, however, did not affect the rate of moisture loss during subsequent storage. These results suggest that the beneficial effect of recharging on carrot quality is due to replacement of the lost moisture and not to a decrease in moisture loss during storage following recharging. It is suggested that recharging be explored as an option to improve the shelf life of carrots.

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The Relationship between Ca Uptake and Firmness in Cucurbit Fruit

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During nutrient solution culture of cucumber, paclobutrazol (PBZ) promoted the Ca uptake and accumulation of cucumber fruit, but significantly inhibited the shoot growth. In the medium and stem parts of the smaller cucumber fruits treated by PBZ, Ca uptake and accumulation were vigorous but in the blossom part did not do so. PBZ was effective in the maintenance of firmness in the smaller fruits. PBZ was an effective growth regulating chemical for Ca uptake of cucumber plant and storability of cucumber fruit. This Ca accumulated in cucumber fruit reduced loss of firmness during postharvest ripening, but led to the decrease of marketable fruit per plant, as well as productivity. To solve this problem, the direct application of Ca was conducted after anthesis. Foliar treatment of Ca on leaf area around fruit was ineffective in Ca uptake, but its direct application on fruit itself increased the concentration of Ca in fruit. The cucumber fruit that Ca was accumulated by direct application maintained the firmness longer after harvest.

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Purification and Characterization of a Prominent Polygalacturonase Isozyme Produced by *Phomopsis cucurbitae* in Decayed Muskmelon Fruit

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Phomopsis cucurbitae is a latent infecting pathogen that infects unripe muskmelon fruit, but causes decay after harvest. This fungus causes severe losses during muskmelon fruit storage and marketing in the U.S., Japan, and some Central American countries. Previous studies showed that the fungus produced the cell wall-degrading enzyme polygalacturonase (PG) in both culture and muskmelon fruit tissue. The role of *P. cucurbitae* PG in the fruit decay process and its relation to latent infection is not well-understood. A prominent PG isozyme produced by the fungus in decayed fruit was purified to homogeneity by a sequence of extraction, ultrafiltration, preparative isoelectric focusing, anion exchange, and gel filtration chromatography. This isozyme exhibited endo-activity, a molecular weight of 54 kDa according to SDS-PAGE, and a pI of 4.2 based on IEF-PAGE. Isozyme activity was optimal at 40–45°C and pH 5.0. It had a K_m of 44.7 g/ml and a V_{max} of 0.313. The purified isozyme also effectively macerated mature muskmelon fruit tissues. This isozyme was the most prominent of the PG isozymes produced by *P. cucurbitae* in decaying fruit, and may play an important role in postharvest decay.

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Evaluation of the Organic and Mineral Fertilization on Postharvest Quality of Cantaloupe (*Cucumis melo* L.)

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Several postharvest quality parameters of cantaloupe fruit were grown under different organic and mineral fertilization schemes. We evaluated a Laguna hybrid (Asgrow) cantaloupe grown under a design of blocks completely randomized, with three fertilizer treatments corresponding to: T1, goat manure; T2, simple fertilization; T3 mixed fertilization, with six replications each. The fruits were mature-harvested and stored in a room with an average temperature of 18°C for posterior laboratory analysis. The results showed different effects of the treatments on the following parameters: total soluble solids, diameter of the fruits, and thickness of the pulp, and showed no effects on consistency of fruits, cavity, dry matter, and fresh weight. All these parameters decreased during the period of storage. The organic manure treatments showed the best values of most of the evaluated parameters.

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Volatile Profiles of Microorganisms on Various Substrates, Including Fruits and Vegetables

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Minimally processed fruits and vegetables, by virtue of cell disruption resulting from processing and handling, can encourage the growth of microorganisms. There is potential for identification of microorganisms and characterization of microbial products and constituents in food, based on volatile profile analysis. We have prepared a flow-through system to grow several bacteria including *E. coli* 25922-ATCC and *E. coli* 0157:H7 and monitored the volatile profiles under conditions similar to those experienced by minimally processed fruits and vegetables during marketing conditions. Specific volatiles have been identified that may have potential to serve as signature-type volatiles in accurate automated quality control systems. For example, indole and a number of short-chain fatty acids are produced in copious amount by *E. coli* 25922-ATCC, but are not constituent of broccoli or carrot aroma profiles. The data suggest that specific volatiles may serve as "markers" for bacterial presence.

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Phosphogypsum (CaSO₄·2H₂O) Effects on Cantaloupe Postharvest Quality (*Cucumis melo* L.)

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The response of different doses of calcium sulfate or phosphogypsum (PG) on several postharvest quality parameters of 'Laguna' cantaloupe hybrid were

analyzed in the semi-arid San Francisco experiment station (UCLA), located in the Lara state, Venezuela. The experimental design was a completely randomized block with four treatments (0, 300, 600, and 1200 kg/ha, PG) with five replications. The PG was surface-spread on the irrigation furrows, 1 day before sowing. The fruits were harvested at maturity and stored under an average temperature of 28°C for posterior quality analysis. The PG treatments did not have any effect on the studied parameters: total soluble solids (°Brix), consistency (kg/cm²), diameter, and cavity of the fruit, pulp thickness, and dry and fresh matter. All of the parameters evaluated decreased during the 6 days of storage. These results could be because of the low doses of PG used or because the supply of calcium was not a limitation in these soils.

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Physicochemical Characterization of Hybrid Honeydew Muskmelon Fruit (*Cucumis melo* L. var. *inodorus* Naud.) Following Maturation, Abscission, and Postharvest Storage

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Hybrid, non-netted, green-flesh, honeydew muskmelon fruit physiological maturity occurred by 40 days after anthesis (DAA). Fruit maturity was determined by major increases in quality attributes: moisture content, firmness, soluble solids concentration, weight, volume, and qualitative and quantitative changes in glucose, fructose, and sucrose content. Fruit ripening occurred between 40 and 50 DAA as determined by maximized changes in the aforementioned quality attributes, and by fruit abscission at 50 DAA. Fruit senescence begins with decreases in: quality attributes, hypodermal-mesocarp plasma membrane H⁺-ATPase (E.C. 3.6.1.3) activity, and protein content, and by increases in: the total free sterol: total phospholipid ratio, and hypodermal-mesocarp lipoxygenase (E.C. 1.13.11.12) activity. Delineated growth and maturation physicochemical data of hybrid honeydew muskmelon fruit should be beneficial to the commercial harvest of mature fruits, which is necessary for maximizing honeydew fruit quality, extending shelf-life, and enhancing consumer satisfaction.

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Surface Energies of Tomato and Bell Pepper Cultivars

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Fruit processing treatments, such as osmotic dehydration, washing, aqueous dips and coatings applications, and even microbial adhesion, depend critically on the surface energy of surfaces. Knowledge of these values can be used as reference targets for treatment formulations when complete wetting is necessary. Unripened and ripened tomato cultivars, 'Ace' and 'Castlemar', and bell pepper cultivars 'California Wonder' and 'Garden Sunshine' were characterized by color, firmness, and soluble solids, and evaluated for their surface energy. Calculated surface energy was obtained using Fowkes' equation by measuring contact angles of a series of pure surfactants of different HLB values on the fruit surface and by comparing with a reference paraffin surface of 25.5 dynes/cm. Results indicated that surface energies were similar between both types of fruits, while there were differences between maturity stages for tomato fruits. Surface energy in all cases was lower than 30 dynes/cm, indicating the hydrophobic nature of the epicuticular surface of the fruits tested.

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Vitalization of Spinach

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Vitalization is a process whereby senescence is retarded and refrigerated storage can be extended. The process involves hyperhydration of plant materials with selected aqueous solution, thereby flooding interstitial spaces and vascular tissues. Microscopic examination revealed increased size of interstitial spaces and expansion and increased roundness to cells. No disruption of tissues was detected. Turgidity was measured with an Instron Universal Testing Machine equipped with a Kramer Shear Cell. Color was measured with a Minolta color difference meter. Leaves were evaluated for color and turgidity changes during storage. Vitalized leaves did not change significantly in color or turgidity during a 10-week storage period. Untreated leaves lost turgidity and yellowed in storage.

Bacteriostatic Effect of Fresh-cut Spinach on *Listeria* spp.

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Fresh-cut spinach has been shown to have a bacteriostatic effect on *Listeria monocytogenes* ATCC 19111 (Babic et al., 1997). A study was undertaken to determine if this effect is noted on other species of *Listeria* and to determine if the spinach or the natural microorganisms on the spinach was the cause of the bacteriostatic effect. Six species of *Listeria* was cultivated in pure tryptic soy broth, tryptic soy broth containing freeze-dried spinach powder, or broth containing mesophilic aerobic microorganisms (MAM) isolated from spinach powder. The cultures were incubated at 10°C for 6 days and growth measured daily. Growth data were analyzed as four factor general linear repeated measures mixed model with species, treatment, and day as the fixed effects. The fixed effects showed a significant interaction between treatment x day and day x species. Results indicated that both the spinach and MAM had an inhibitory effect on *Listeria* as noted by the maximum population at 6 days, which was 8.8 Log¹⁰ cfu/ml in control, 6.4 in spinach powder cultures, and 7.4 in mixed cultures ($P < 0.05$). Of the six *Listeria* species, three *L. monocytogenes* were affected similarly whereas the remaining three, particularly *L. innocua*, were affected differently. In conclusion, the bacteriostatic effect of fresh-cut spinach differs with *Listeria* species and the native microorganisms play a major role as competitors.

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High-temperature Short-time Thermal Processing of Bean Flour to Remove Raw Bean Flavor

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Dry edible beans (*Phaseolus vulgaris*) represent an inexpensive way to incorporate protein into the diet as a food ingredient, but beans contain unpleasant flavors and several anti-nutritional factors that limit their use without first processing with long heat treatments. 'Great Northern' bean flour was processed using either static or specially designed dynamic (continuous) processing methods. The dynamic process treated flour slurries at temperatures up to 124° for 20 sec. The slurries were quick-frozen and freeze-dried after frozen storage periods of 0, 8, 24, 120, or 504 hr. The flours were analyzed for sensory properties, emulsifying activity, foaming properties, and trypsin inhibition. The heat treatments improved sensory attributes of the flour. The foam capacity and foam stability decreased in heat-treated flours. Trypsin inhibitor activity was at a minimum level immediately following thermal processing, but increased with time in frozen storage prior to drying. Minimal thermal processes cannot be relied upon to inactivate trypsin inhibitors.

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Production of Cowpea Green Pods for Processing

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A study was conducted to evaluate the possibility of producing and processing immature cowpea (*Vigna unguiculata*) green pods by using the same technology used for green beans (*Phaseolus vulgaris*). The cowpea cultivar Bettersnap developed for green pod production and the green bean cultivars Benton and OSU-5402 were produced under the same cultural conditions. 'Bettersnap' yielded less than 0.5 ton/ha, while 'Benton' and 'OSU-5402' produced about 2.5 ton/ha in once-over simulated mechanical harvest. 'Bettersnap' had long vines and dense foliage, which resulted in plants with more width and less erectness than 'Benton', the predominant green bean cultivar. Uneven pod setting and long pods (23.8 cm) in 'Bettersnap' constitute potential problem for mechanical harvest. Canned cowpea pods of sieves 2 and 3 had darker green color, smaller seeds, and higher shear value, fiber content, and sloughing than green bean pods. Our study indicates that there is a need to develop cultivars with high yield potential and concentrated pod setting adapted to mechanical harvest with pods containing less fiber and less tendency to sloughing.

370

The Alternative Oxidase Limits Superoxide Production by Plant Mitochondria

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Mitochondria isolated from the pericarp tissue of green bell pepper (*Capsi-*

cum annum L.) fruit and purified on a Percoll gradient produced superoxide in buffers aerated with oxygen. ADP and uncouplers of the electron transport chain reduced superoxide production. Disulfiram, an inhibitor of the alternative oxidase, enhanced superoxide production. Inhibitors of the ubiquinone-cytochrome bc1 complex had little effect on superoxide production by mitochondria which were insensitive to cyanide. Less superoxide was produced when DTT was used to reduce the sulfhydryl groups of the alternative oxidase protein and the enzyme was activated with pyruvate than when the sulfhydryl groups were oxidized with diamide. A role for the alternative oxidase in limiting the level of reactive oxygen species produced in stressed and senescing plant tissues is suggested.

149 POSTER SESSION 6E (Abstr. 371–378) Photosynthesis & Partitioning–Cross-commodity

371

Light Duration Alters Carbon Partitioning into Sorbitol in Leaves, Stems, and Roots of Apple

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Light duration alters carbon partitioning among carbohydrates (CHOs) in source leaves. The current experiments were designed to determine how light duration affected the metabolism of newly fixed and reserve CHOs in various organs of apple and whether longer durations favored sorbitol (sor) synthesis. One-year-old 'Gala' apple plants that experienced a 1-, 4-, 7-, 10-, or 14-h photoperiod for 7 d were exposed to ¹⁴C₂ for 15 min. Individual CHO concentrations and the activity of newly-fixed [¹⁴C]CHOs in leaves, stems, and roots were analyzed during different intervals after labeling. In source leaves, sor increased significantly, whereas sucrose (suc) did not change as light duration increased from 1 to 10 h, resulting in increased sor/suc ratios from 2.6 in the 1-h to 4.3 in the 10-h light duration. The increased sor/suc ratios may be due primarily to the preferential carbon partitioning into sor in longer light durations. Longer light durations enhanced the sor export rate from source leaves, resulting in higher sor in stems and sink tissues. In roots, starch increased significantly over increasing light durations. A major portion of starch in roots may be converted from newly fixed CHO. Our results suggest that light duration alters the metabolism of sor and other CHOs in source and sink tissues of apple and that the changes in CHO concentrations result from different rates of carbon synthesis, partitioning, and export.

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Evaluation of a Rapid Method for Screening the Capacity of Leaves to Export Photosynthate

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A method was developed to rapidly screen genotypes for capacity of leaves to export photosynthate, with the expectation that rapid export should promote growth. Vegetative plants of 13 cultivars of *Pisum sativum* L. (pea) were screened based on changes in specific leaf weight (SLW) at dawn before and after exposing plants to CO₂-enriched air (1200 ppm) for one diurnal cycle. Three cultivars (Nofila, Little Marvel, Sugar Daddy) had relatively little increase in SLW and were designated rapid exporters; based on this criterion 'Alaska', 'Oregon Sugar Pod II', and 'Manoa' were slow exporters. The increase in SLW was due to starch and sugars. Neither single leaf net photosynthetic nor dark respiration rates consistently differed among cultivars when measured at 1200 or 350 ppm CO₂ (normal air). The difference between rapid and slow exporters persisted after plants were grown for 2 weeks at 1200 vs. 350 ppm CO₂. However, the relative growth rate (RGR) of whole-plant dry mass did not differ consistently among cultivars at either CO₂ level, except it was high for 'Alaska', a slow exporter. The high RGR for 'Alaska' was due in part to a high ratio of whole plant leaf area to dry mass early in the growth period. Thus, although the rapid exporters accumulated relatively low levels of starch and sugars, this trait did not dominate other growth determining traits.

Phytochrome Regulation of Photosynthate Partitioning in Watermelon Plants Exposed to End-of-day Light Treatments

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End-of-day (EOD) light treatments were used to study phytochrome involvement in photosynthesis and photosynthate partitioning in watermelon plants. Two-week-old plants were treated with brief low-intensity red (R) or far-red (FR) light for 9 days at the end of daily light period. Petiole elongation in the first two leaves was the first significant growth change in FR-treated plants compared to other plants after 3 days of treatments. This petiole elongation was accompanied by significantly higher photosynthate partitioning to petioles, even without increase in above-ground dry weight of plants. Net CO₂ assimilation rate in the second leaf was significantly higher in FR treated plants on a weight basis after 3 days of treatments. Far-red-treated plants had lower chlorophyll content per leaf area and higher stem specific weight compared to R-treated plants after 3 and 6 days of treatments, respectively. Transpiration and stomatal conduction were higher in FR-treated plants compared to other treatments after 3 days of treatments. The EOD FR regulated growth and photosynthate partitioning patterns were reversible when FR treated plants were immediately followed by R. This implies EOD R:FR ratio acting through the phytochrome regulates the growth and development processes in watermelon plants.

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Gas Exchange Behavior of Male and Female Parwal Plants

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Parwal [*Trichosanthus dioica* (Roxb.)] is a tropical perennial vine producing small fleshy fruits used as a vegetable. It bears male and female flowers on separate plants. During the summer of 1996, a field study was conducted to determine if male and female plants differed in their gas exchange behavior. Three leaves per plant replicated six times for each sex were tagged randomly at initiation of gas exchange measurements. Transpiration (E), stomatal conductance (g_s), CO₂ exchange rate (CER), and internal leaf CO₂ concentration (C_i) were measured when the leaves were 6, 18, 36, 47, 71, and 81 days old. In general, the gas exchange values for both sexes were similar. The leaves of male plants attained highest E, g_s, and CER at 18 days of age. In female plants, CER peaked at an early leaf age of 6 days, while the peaks for E and g_s were reached 30 days later. The highest C_i for both sexes were observed in 47-day-old leaves. Eighty-four-day-old leaves were no longer actively exchanging gases.

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Seasonal Variation of Photosynthetic Efficiency of Greenhouse Tomato Plants

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Yield of greenhouse tomatoes has greatly increased during the past decade due to the development of more-productive cultivars and to the use of new technologies, such as supplemental lighting and CO₂ enrichment. Under high PPF and p[CO₂], however, the capacity of tomato plants to use supplemental energy and CO₂ decreases. Our project aimed at determining the limits of photosynthetic capacity of tomato plants under supplemental lighting (HPS lamps, 100 μmol·m⁻²·s⁻¹, photoperiod of 14 to 17 h) and high p[CO₂] (900 ppm). The following measurements were made on the 5th and the 10th leaves of tomato plants at regular intervals from November to May: diurnal changes in net (P_n) and maximum (P_{n,max}) photosynthetic rate, Chl a fluorescence of dark-adapted and no dark-adapted leaves, and the soluble sugars and starch contents of the 5th and 10th leaves. Changes in global radiation from 250 W/m² in winter to about 850 W/m² in spring resulted in P_n increases of 45% and 42% in the 5th and 10th leaves, respectively. During the winter period, P_{n,max} was higher than P_n, suggesting that leaves were not at maximum photosynthetic capacity. In the spring, no difference was found between P_{n,max} and P_n. Sucrose concentration in leaves increased progressively up to a maximum of 12-h photoperiod, while hexoses remained constant. The Fv/Fm ratio did not vary during winter, but significantly decreased during spring due to photoinhibition. Increases in global radiation during spring resulted in lower photosynthetic rates, higher fluorescence, and starch accumula-

tion in leaves. Data will be discussed in terms of crop efficiency and yield.

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Interactive Effects of Light and CO₂ on Photosynthesis and Growth of *Brassica* spp.

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Long- and short-term physiological responses of pak choi (Chinese cabbage, *Brassica campestris* cv. 'Hypro') to elevated CO₂ and light environments were evaluated in the series of growth chamber experiments. Plants were grown hydroponically (Nutrient Film Technique) at 25/18°C (day/night) temperature, a 16-h photoperiod, and at three CO₂ levels (350, 700, 1400 ppm) and two light levels (200 and 400 μmol·m⁻²·s⁻¹PPFD). Relative to 350-ppm CO₂ treatment, the final total plant dry mass in low light increased by 37% and 38% at 700 and 1400 ppm CO₂, respectively. In high light the increase was 7% and 13% at 700 and 1400 ppm CO₂, respectively. Light response curves showed a positive CO₂ effect on light compensation point, a slight increase in quantum yield and increase in maximum P_n rates at elevated CO₂. Carbon dioxide response curves (measured at saturating PPFD of 1600 μmol·m⁻²·s⁻¹) showed no effect of growth light treatment on the CO₂ compensation point, but a 20% to 30% higher maximum P_n rate at saturating CO₂ in plants grown at the higher light level. Overall, the highest P_n rates and the highest plant dry mass at final harvest were found in plants grown at the 400 μmol·m⁻²·s⁻¹ PPFD and 1400 ppm CO₂. Relative beneficial CO₂ effects, however, were the most pronounced in low light conditions.

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Sucrose Metabolism and Purification and Characterization of Sucrose Synthase from *Lycopersicon esculentum* var. *cerasiforme* Fruit

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Sucrose metabolism was followed in developing fruit of domesticated cherry tomato (*Lycopersicon esculentum* var. *cerasiforme* Alef.). The high amounts of reducing sugars were consistently linked to high soluble acid invertase (EC 3.2.1.26), whereas sucrose synthase (EC 2.4.1.13) followed the same pattern of sucrose levels and reached a peak of activity during early stage of maturation and then decreased to near nil. In comparison, sucrose phosphate synthase (EC 2.4.1.14) activity remain relatively constant throughout development. Thus, sucrose synthase and acid invertase, rather than sucrose phosphate synthase, are the critical enzymes regulating sucrose accumulation in tomatoes. Cultivated cherry tomato sucrose synthase (UDP-glucose: D-fructose 2-glycosyltransferase) was purified to homogeneity by ammonium sulfate precipitation, anion exchange chromatography on DEAE-Toyopreal 650, and gel filtration on Sephadex G-200. Further purification to homogeneity resulted from a single band from SDS-PAGE. The enzyme was identified as a homotetramer with a total molecular mass of 370 kDa and subunits of 92 kDa. The enzyme showed maximum activity for the cleavage and synthesis of sucrose was at pH 7.0 and 8.0, respectively, and the optimum temperature was 40°C in both directions for HEPES-KOH buffer. The enzymatic reaction followed typical Michaelis-Menten kinetics, with the following parameters: K_m (fructose), 7.4; K_m (UDP-glucose), 0.2612; K_m (sucrose), 33.24; K_m (UDP), 0.0946. The enzyme was very sensitive to inhibition by heavy metals.

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The Effects of Development and Salinity Stress on Mannitol Biosynthesis in Celery Leaves

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In celery (*Apium graveolens* L.), up to 50% of newly assimilated carbon may be partitioned into mannitol in mature leaves. Mannitol biosynthesis involves three unique enzymatic steps, and mannose 6-phosphate reductase (M6PR) is the critical regulatory step in the pathway. We measured M6PR enzyme activities, M6PR protein levels (using an immunological method) and M6PR transcript levels (by Northern blotting) to assess effects of leaf development on mannitol biosynthesis. M6PR was limited to green tissues and was under tight transcriptional regulation during leaf initiation, expansion, and maturation. M6PR expression was also closely correlated with the capacity of leaves to partition newly fixed carbon into mannitol (measured by ¹⁴C pulse/chase on intact leaves). Previous studies

have also shown salt stress to lead to mannitol accumulation in celery. Using the methods outlined above we also investigated the combined effects of salt stress and leaf development on M6PR expression and the capacity of leaves to partition C to mannitol. Under salt stress M6PR expression and the capacity to synthesize mannitol occurred in younger leaves than in control plants. Thus, the increase in mannitol pool size in salt-stressed celery plants is due, in part, to enhanced *de novo* synthesis in young leaves. The data also confirmed the relationship between development of photosynthetic capacity, mannitol synthesis and M6PR activity. Supported by USDA-NRI grant # 940-1439.

149 POSTER SESSION 6F (Abstr. 379–386) Children and Community Education

379

Horticulture Intergenerational Learning as Therapy, a New Project Publication for 4H Clubs and Local Geriatric Programs

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The population of senior citizens in our society (65 and older) are growing at a faster rate than any other segment of the population. Loss of decision-making capabilities coupled with controlled retirement home environments can lead to stress and depression in our elderly. At the same time, our nations youth no longer enjoy a family nucleus that includes elders who help guide youth away from risky activities. The publication "HILT: Horticulture Intergenerational Learning as Therapy" (Cornell Media Services, Ithaca, N.Y., in press) was used as a guidebook for combining senior citizens and gradeschoolers at three local settings in 1995 and 1996. The project encourages elders to take charge and mentor youth while leading youth in an indoor and outdoor gardening program. The pilot projects included a public gradeschool site, a mental day-care facility, and a local retirement home. Youth benefited by learning about their elders and about horticulture. The subject of horticulture provides a comfortable and valuable learning environment as well as a focal point for the participants. The project provides three evaluation methods that include survey, interview, and leader observation tools. In our study, senior participation increased by 75% during two 8-week projects and 40% during a 7-month project. Surveys reveal that senior citizens were nervous and concerned about behavior of young people before the project, yet renewed and excited about future projects after participation. Youth enjoyed hearing stories, learning about planting, and getting dirty. Use of self concept and morale scales will be presented. A copy of the project publication as well as ideas about using the publication will be provided in the discussion.

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Abstract withdrawn

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University–Elementary School Partnerships: Using Landscape Design and Construction Classes to Create School Teaching Gardens

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Bring together a university landscape horticulture professor who believes in school gardens, a landscape design class, a landscape construction class, enthusiastic elementary school teachers and a willing principal, and you can create wonderful teaching gardens. The interactions among university students, elementary teachers, and students were a true learning experience for everyone. University students were involved in a true problem-solving project, being forced to look at problems and solutions through the eyes of elementary school children. Their expertise was valued as they were asked to explain horticulture to first and second graders. For some, this was the first time they really understood some of the concepts. Teachers and students were active participants throughout the process. Sharing thoughts and ideas was dynamic throughout the design and construction. Ways to initiate and maintain university–school partnerships will be presented.

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Master Gardener–Water Stewards: Advanced Training to Enhance Community Volunteerism

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Virginia Cooperative Extension's (VCE) Master Gardener–Water Steward program (MGWS) provides advanced training in leadership development and water quality management to Master Gardener (MG) volunteer educators so that they may expand the influence of Extension through leadership in community water quality management. Typically, agents cite limited staff and volunteer resources as the primary factor in restricting program expansion. The MGWS program simultaneously answers the desire of MGs to expand their role in the community landscape and the need of VCE to expand its outreach with increasingly limited resources. MGWS training, guided by a 10-unit resource book, integrates technical and program management expertise to foster volunteer pride and self-sufficiency. This allows MGWS to coordinate much of their own training and recruit and manage large numbers of non-MG volunteers to whom they can provide limited training for specific projects, thus allowing program expansion without additional staff. The Advanced Master Gardener–Water Steward Handbook allows for appropriate training of Master Gardeners so that Extension education is able to reach a larger audience than just that reachable by an agent alone. Eight slide sets on water-quality related topics are available as part of this program. They come complete with legible, easy-to-read scripts. Updated slide sets include Calibrating Your Lawn Spreader (40 slides), Minimum Chemical Vegetable Gardening (62 slides), Backyard Composting (56 slides), Reading and Understanding the Pesticide Label for Lawn and Garden (41 slides), Landscape Tree and Shrub Fertilization (43 slides), Applying Pesticides Safely for the Environment (47 slides), Water Quality and Landscaping Slide Set (48 slides), and Proper Management of Fertilizers on Home Lawns (40 slides).

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Edina Goes Green: A Community Education Project in Low-Input Lawn Care

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The objectives of the project were to design and implement an educational campaign on low-input lawn care, measure its effectiveness, and use the information gained to develop a model education plan that other communities could use. Residents of Edina, Minn., a suburb of Minneapolis, initiated the project by expressing an interest in reducing the amounts of chemical inputs (fertilizers and pesticides) used on residential lawns. The program's educational goal focused on teaching Edina's residents about proper timing and rate of application of all lawn inputs, as well as cultural techniques for producing a healthy lawn. The educational campaign consisted of informational articles published in Edina's quarterly community magazine; the establishment of 19 demonstration sites in which volunteer homeowners worked with Master Gardener mentors learning low-input lawn care techniques; a WWW page where information about lawn care and the project itself was posted; and a public seminar conducted by a turf specialist. Two surveys (May 1996 and April 1997) were distributed, each to a random sample of 800 Edina residents. The surveys measured lawn care knowledge and current practices, attitudes concerning pesticide use and the environment, as well as the effectiveness of this educational program. Recommendations for other community educational programs will be presented.

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Partnering of U.K. and Kentucky Division of Forestry in Woody Plant Education

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America the Beautiful and Urban and Community Forestry grant programs, part of the expanded Forestry Title of the 1990 Farm Bill, authorized funding to encourage citizen involvement in creating and supporting long-term and sustained urban and community forestry programs. U.K. Woody Ornamental scientists and the KY Division of Forestry Urban Forestry Coordinator planned and implemented the following educational programs to this end: 1) comprehensive training manual on Managing Trees in the Urban Environment, including a guide for the

care and protection of trees, grant application, and managing of volunteers; 2) three publications on small, medium-sized, and large trees for urban spaces; 3) interactive hypertext version of tree selector publications; 4) statewide workshops on Trees in Communities; 5) annual statewide Urban Forestry Short Course; 5) Plant Health Care and Hazard Trees workshops for arborists. The comprehensive program brings city planners, government personnel, public works personnel, arborists, builders and developers, horticulturists and landscape architects, tree board members, homeowners' associations, Master Gardeners, and other community volunteers together to support quality programming for preservation and enhancement of valuable natural resource of trees.

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Using Native Plants

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Using Native Plants is a 120-min videotape that was developed as a result of a Cooperative Extension Partnership Programming Grant between the Univ. of Minnesota, Minnesota Extension Service and the Cooperative Extension—Univ. of Wisconsin—Extension. The content covers woodland wildflowers, prairie establishment and maintenance, landscaping lakeshores, and using native plants in traditional gardens settings. Video segments include: Eloise Butler Wildflower garden, Minneapolis, Minn.; Curtis Prairie, Madison, Wis.; Big Sandy Lake, Minn.; and the Minnesota Landscape Arboretum, Chanhassen. Developed originally as advanced Master Gardener training, the program was a national satellite broadcast on 29 Feb. 1996. It was viewed by at least nine states and more than 500 participants. Video production costs, including a 20-page participant's handout with extensive references and plant lists, were just under \$13,000. A cost analysis, evaluation, sample of the participant's packet, pictures from the videotape and an order form will be presented. Copies of the tape and print packet may be obtained for \$50 from Minnesota Extension Service, 1.800.876.8636, or Univ. of Wisconsin—Extension, at 1.608.262.3346.

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Fungi in Landscape Mulches—Are They a Problem?

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Homeowners are often troubled by the presence of slime molds, stinkhorns, and mushrooms growing in their landscape mulches; but, they are not harmful to landscape plants, and no known health hazards are associated with them unless they are eaten. They can be discarded or ignored and they will quickly decompose. The fruiting bodies of the artillery fungus are barely visible (tiny cream or orange-brown cups approximately 1/10 of an inch in diameter), but they are the source of serious problems, many of which have resulted in insurance claims and lawsuits. They are phototropic and orient themselves toward bright surfaces, such as light-colored siding on homes and automobiles. They "shoot" their black, sticky spore masses, which can be windblown to the second story of a house. The masses stick to the side of buildings and automobiles, resembling small specks of tar. Once in place, the spore masses are very difficult to remove without damaging the surface to which they are attached. When removed, a stain remains. A few of the spots are barely noticeable, but, as they accumulate, they may become very unsightly. To date, there are no known controls for this fungus, but a research program studying possible solutions has been initiated. We ask that anyone who has information or experience with the artillery fungus contact us to exchange information. A brochure describing the four common types of fungi growing in landscape mulches in the eastern United States—mushrooms, slime molds, bird's nest fungus, and the artillery fungus—has also been prepared to educate consumers.

32 ORAL SESSION 1 (Abstr. 387–391) Crop Protection & Weed Control—Woody Ornamentals/Landscape/Turf

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1996 Ornamental Research Program of IR-4

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More than 14,000 ornamental research trials have been conducted in this program since 1977. This extensive research program has led to more than 4900 label registrations for fungicides, herbicides, insecticides, nematocides, and plant growth regulators. During 1996 alone, 890 ornamental label registrations were obtained. This cooperative program is conducted by federal and state workers in cooperation with the green industry, including growers of floral, forestry, nursery, and turf crops. Registrations are also developed for the commercial landscape and the interior plantscape.

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Natural Landscapes in Urban Settings: A Regulatory Jungle

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Thousands of property owners annually attempt to develop a natural landscape on their property. Annually, thousands of people are cited for violation of "weed laws," nuisance laws, subdivision covenants, and other local ordinances. Often, these regulations allow the city to mow the "weeds" first and follow up with fines, bills, and other legal actions. How reasonable are these requirements? What is the basis of the regulations? How do they vary by state and locality? Is every property required to have a smooth, unbroken bluegrass lawn? A variety of case studies across the midwest shows much local variation in both the wording of the ordinances and local tolerance for diversity of landscaping goals. The most successful responses require considerable planning and effort, and the least successful attempts are simplistic "no more mowing" declarations.

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Using Soybean Oil as a Pesticide on Nursery Stock

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Our research has previously shown that soybean oil can substitute for petroleum oil for controlling insects on fruit trees. Soybean oil may also be a safe, environmentally friendly pesticide to use on nursery stock. The objectives of these experiments were to evaluate phytotoxicity of soybean oil to nursery stock and efficacy for mite control. Four replications of container-grown plants of 'Alberta' spruce, 'Emerald' arborvitae, 'Leyland' cypress, Canadian hemlock, and 'Andorra' juniper were sprayed on 26 Mar. with 0%, 1.0%, 2.0%, or 3.0% soybean oil; or 2.0% petroleum oil. None of the oil treatments caused phytotoxicity. The same plants were sprayed on 1 Aug. with 0%, 1.0%, 2.0%, or 3.0% soybean oil. Application of 1% or 2% soybean oil appeared to be non-phytotoxic to spruce, but 3% soybean oil caused slight terminal necrosis. Arborvitae, cypress, hemlock, and juniper were not injured by spraying 1% to 3% soybean oil in the summer. Container-grown burning bush plants with mite infestations were sprayed on 20 Sept. with 0%, 1.0%, 2.0%, or 3.0% soybean oil; or with 1.0% SunSpray petroleum oil. Container-grown mite-infested 'Andorra' juniper plants received the same treatments, except for the 3% soybean oil. Application of 1% or 2% soybean oil to burning bush or to juniper shrubs resulted in >97% and 87% control of mites 7 and 14 days, respectively, after treatment.

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The Effect of Weed Control Methods upon Soil Physical Properties and Plant Growth

Pual H. Henry* and She-Kong Chong, Dept. of Plant and Soil Science, Southern Illinois Univ., Carbondale, IL 62901

There has been recent speculation in trade journals that landscape fabrics, while doing an excellent job of weed control, may have a detrimental effect upon ornamental plant growth. 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 identified as composted or non-composted areas. Within each main plot, the design is a randomized complete block with four blocks and three treatments per block (control, organic mulch, landscape fabric + organic

mulch). Each plot has been planted with herbaceous perennials so as to allow analysis of treatment effects upon plant growth. Redox potential is measured on a weekly and infiltration rate is measured on a biweekly basis. Soil temperature within plots is monitored on a continuous basis. Preliminary results suggest that landscape fabrics have a detrimental effect on soil aeration and that this likely has an adverse effect upon plant growth. An attempt will be made in this study to contrast any adverse effects of landscape fabric use with the obvious benefits offered by increased weed control.

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An Evaluation of Four Glyphosate Formulations on Dormant Conifers

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In 1995, Monsanto Chemical Co. announced that they would replace Roundup herbicide with Roundup Pro for use in the ornamentals and turf markets. Both products contain 4 lb a.i./gal glyphosate, but Roundup Pro contains a more-active surfactant. Though Roundup was labeled as a nonselective herbicide, dormant conifers were found to have varying degrees of resistance to it. Directed sprays that hit the lower two-thirds of many dormant conifers became common practice in the industry. Because the surfactant in Roundup Pro increases the activity of the glyphosate, a series of trials were initiated in 1996 in Connecticut, Pennsylvania, and Vermont in which four glyphosate formulations were applied to a variety of dormant conifers. Roundup, Roundup Pro, Glyfos, and Accord (with and without surfactant) were applied either over-the-top or as directed sprays to the lower 18 inches of the plants at rates between 0.5 and 3 lb a.i./acre. Plants treated included globe arborvitae; upright yew; Canadian hemlock; Colorado, Norway and white spruce; Douglas fir; eastern white pine; and balsam, Canaan, and Fraser fir. In a preliminary study, injury to the spruces in the form of dwarfed and chlorotic new growth was primarily associated with fresh pruning wounds. Accord plus surfactant and Roundup Pro injured more spruces than Roundup, but injury was slight. No injury was observed in upright yew with any formulation at rates up to 0.75 lb a.i./acre. Injury to arborvitae was greatest with Accord plus surfactant, intermediate with Roundup Pro, and least with Roundup. Results are inconclusive at this time, but the results of additional studies available early in the next growing season will be presented.

33 ORAL SESSION 2 (Abstr. 392–396) Breeding & Genetics—Fruits/Nuts

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Pistachio Breeding in California: 1989 to 1997

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A pistachio breeding program was initiated in 1989 to develop new cultivars for the California industry. The program was begun with an initial set of 1940 progeny from 78 crosses. In 1990, an additional 5470 seedlings were produced from 176 controlled crosses. Progeny were planted at Winters, Calif., Kearney Agr. Center, and a plot near Bakersfield in a randomized block design with crosses as treatments. Fifty-three, 962, and 2943 genotypes flowered in 1994, 1995, and 1996, respectively. Data on flowering, flowering date, sex, tree size as measured by trunk cross-section area, and disease status were collected on all trees in the breeding program at the three field locations. Nuts were collected and evaluated for number of nuts/tree, % splits, % blanks, wet and dry weight, kernel weight, and volume. Heritability estimates for nut characters, tree size, and *Alternaria* resistance were ranged from 0.30 to 0.76. Several parents were identified that apparently provide a high level of resistance to *Alternaria*. Relationships among various nut parameters and the relationship of tree size to flowering and parentage were also investigated and evaluated statistically. Replicated advanced selection trials will be established in 1997.

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Inheritance of *Alternaria* Late Blight Resistance in Pistachio

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Alternaria late blight of pistachio caused by *Alternaria alternata*, has become a serious problem in pistachio orchards in California. As part of the California pistachio improvement program, we evaluated the resistance/susceptibility of the breeding progenies to *Alternaria* late blight at two locations. The heritability of resistance ranged from 0.35 to 0.38 based on half-sib progenies analysis. Open-pollinated (OP) progenies from three cultivars showed moderate to high resistance. Greenhouse inoculation confirmed that OP progenies of cultivars Bronte and Trabonella had the greatest resistance. OP progenies of cultivar Red Aleppo were highly susceptible in greenhouse inoculations compared to moderate resistance found in field evaluations. OP progenies of the only commercial cultivar Kerman in California were susceptible in both field and greenhouse evaluation. The results show the potential for development of resistant cultivars is available in the breeding population of the California pistachio improvement program.

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Variance Components and Estimates of Broad-sense Heritability of Nut and Kernel Traits in Hazelnut

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Seventy-seven trees representing 41 hazelnut (*Corylus avellana* L.) genotypes were to evaluate variance components and broad-sense heritability for 10 nut and kernel traits from 1994 to 1996. All effects in the models were assumed to be random. All traits had extremely high heritability. This indicated that nearly all of the phenotypic variation had a genetic basis. Knowledge of variance components may help us efficiently allocate resources. Broad-sense heritability estimates were larger than those in narrow sense, suggesting the presence of nonadditive genetic variation in the population.

395

Greenhouse and Field Resistance to Yellow Aphids in the 'Pawnee' Pecan

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Putative resistance to the yellow aphid complex (*Monellia caryella* (Fitch) and *Monelliopsis pecanis* Bissell) in the 'Pawnee' pecan [*Carya illinoensis* (Wangenh.) K. Koch] cultivar was first noted in greenhouse tests by rating cultivars for relative amounts of honeydew on adaxial leaf surfaces. This resistance was confirmed in two field tests monitored from mid-June to mid-Oct. 'Pawnee' supported significantly lower aphid populations during every rating period when relatively large numbers of these insects were present. 'Navaho' also showed resistance, with 'Desirable' having intermediate resistance and 'Stuart' being very susceptible. Insect populations were also monitored on the four quadrants of each tree, with this quadrant effect being significant in only one test. This test had the highest populations on the West and lowest populations on the East.

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Abstract withdrawn

34 ORAL SESSION 3 (Abstr. 397–403) Breeding & Genetics—Vegetables

397

Evaluation of Squash Cultigens in North Carolina

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Yellow and zucchini squash (*Cucurbita pepo* L.) cultivars/elite lines (cultigens) were evaluated over two seasons (fall 1995 and spring 1996) in North Carolina. Different cultigens were tested over the 2-year period for both yellow and zucchini squash, although some cultigens were tested both years. Cultigen recommendations are based on yield, quality, disease resistance, and season grown. Yellow squash cultigens that yielded well include: Destiny III, Freedom III, Multipik, TW 941141, Liberator III (fall 1995); and HMX 4716, Superpik, PSX 391, Monet,

Dixie, Picasso, and XPH 1780 (spring 1996). Superior-yielding zucchini squash cultigens were: TW 940981, Tigress, TW 940982, ZS 19, Elite, and Noblesse (fall 1995); and Leonardo, Hurricane, Elite, HMX 4715, Noblesse, and Tigress (spring 1996). Virus ratings for fall 1995 indicated that some transgenic plants with virus resistance withstood virus infection better than those without resistance. These were Freedom III, Destead III, Freedom II, Liberator III, Prelude II, and TW 941121 (yellow), and Tigress, TW 940982, TW 940981, TW 940866 (zucchini). Virus-infected plants were assayed and viruses were determined to be zucchini yellow mosaic, watermelon mosaic II, and papaya ringspot.

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Development of a Simulation Model to Predict Growth and Yield of Pickling Cucumber

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Production of pickling cucumber (*Cucumis sativus* L.) requires a significant expenditure of labor and money. Those resources could be better managed if both yield and harvest date could be predicted for a given planting date and production area. The objective of this experiment was to develop a model to simulate growth and yield of pickling cucumbers under field conditions in North Carolina. Detailed measurements of leaf area, branching habit, flowering, fruiting, and dry weight distribution were obtained for the cultigens 'Calypso', M 21, 'Wis. SMR 18', and WI 2757 for 10 planting dates. Light interception, air temperature, and rainfall were also recorded. There were differences among cultigens and planting dates for time needed to reach certain growth stages. Number of days to reach a given stage generally decreased with later planting dates. Addition of nodes over time to the main stem was linear and the interaction of planting date by cultigen was significant. Number of staminate and pistillate flowers was affected by both cultigen and planting date.

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Early Flowering Pollenizers for Improved Yield and Quality of Gynoecious Pickling Cucumbers

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Most gynoecious hybrid cucumbers (*Cucumis sativus* L.) grown in the U.S. require pollination for proper fruit set. Early flowering pollenizers may help yield, earliness, or quality. Two experiments were run to measure the value of early pollenizers using fields isolated from other cucumbers by at least 1 km. The first experiment used 'Armstrong Early Cluster' and 'Sumter' as the early and normal pollenizer, with 30 and 35 days to flower, respectively. Gy 2, Gy 3, Gy 4, and Gy 14 were used as the gynoecious pickling cucumbers. The experiment was run in 2 years (1994, 1995) and seven locations in North Carolina with two pollenizers and the four gynoecious inbreds. There were four replications of plots within each whole plot to help control variability inherent in an experiment where treatments are in separate fields. The second experiment had only 1 year (1996), but the same seven locations, four replications, and four gynoecious inbreds, but only one pollenizer ('Sumter') planted at the same time, or 2 weeks earlier than the gynoecious lines. Plots were harvested once when 30% of the fruits were >50 mm diameter. None of the differences in either experiment were significant (F-ratio test, 10% level). Therefore, it does not appear that use of early flowering pollenizers in blends with gynoecious pickling cucumbers will have a large effect on the yield, earliness, or internal quality of the crop.

400

Genetic Analysis of Cucumber Collections Made in India in 1992

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Genetic variation in cucumber (*Cucumis sativus* L.) accessions from India was assessed by examining variation at 21 polymorphic isozyme loci. Forty-six accessions acquired by the U.S. National Plant Germplasm System (NPGS) before 1972 were compared with 146 accessions collected during a 1992 U.S.-India expedition to the states of Rajasthan, Madhya Pradesh, and Uttar Pradesh, India. Two distinct groups (Group 1 and Group 2) were identified within accessions collected in 1992 (0.025 < P < 0.01). Variation at *Ak-2*, *Fdp-2*, *Gr*, *Mdh-2*, *Mpi-1*, *Per*, *Pgm*, and *Skdh* was important in the detection of this difference. Group 1

contained 37 (27 Madhya Pradesh + 10 Uttar Pradesh) accessions and Group 2 contains 102 (84 Rajasthan + 18 Madhya Pradesh) accessions. Seven accessions (5 Madhya Pradesh + 2 Rajasthan) were not associated with either group. Isozymic variation in U.S. NPGS accessions acquired before 1972 differed significantly (P < 0.005) from those collected during 1992. When Indian accessions taken collectively (collected before 1972 and in 1992) were compared with an array of 707 *C. sativus* U.S. NPGS accessions examined previously, relationships differed between accessions grouped by country or subcontinent.

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Germplasm Expedition to Collect Wild Cucurbits in the Republic of South Africa

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A germplasm expedition was organized to collect seeds in the Republic of South Africa. There was an abundance of wild cucurbits there in 1996 because of an unusually rainy summer. Southern Africa is a major center of diversity for melons of *Cucumis* and *Citrullus*, and there were many plants with mature fruits along roadsides, and in other areas that had been recently disturbed. The team met in Johannesburg on 25 Apr. 1996, and covered 4213 km (passing through 35 cities and towns) located in four provinces in the northern half of the country. The expedition passed through Pretoria, Potgietersrus, Elisras, Zeerust, Bray, Van Zylsrus, Kalahari Gemsbok Nat. Park, Upington, Postmasburg, Vryburg, and Derdepoort, and visited areas bordering Zimbabwe, Botswana, and Namibia. In 9 days, 112 accessions were collected belonging to 10 species of six genera (*Acanthosicyos*, *Citrullus*, *Coccinia*, *Cucumis*, *Momordica*, and *Zehneria*). Plant, soil and geographic data were recorded for each accession. Data and seeds for the 112 accessions were added to the germplasm collections of the two countries, and can be obtained free from the USDA by interested researchers.

402

Barriers to Gene Transfer in an Interspecific *Cucurbita* Cross

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Cucurbita ecuadorensis is a valuable source of multiple virus resistance. It is resistant to zucchini yellow mosaic virus (ZYMV), papaya ringspot virus (PRSV), watermelon mosaic virus, tobacco ringspot virus, squash mosaic virus, and cucumber mosaic virus (CMV). Its virus resistance can be transferred to squash and pumpkin, but sterility barriers must be overcome. The cross *Cucurbita maxima* x *C. ecuadorensis* can readily be made, and there is no need for embryo culture. Pollen fertility of the hybrid is somewhat reduced, but sufficient for producing F₂ seed. Segregation for sterility occurs in the F₂, but selection can be made for fertile plants that are homozygous for virus resistance. *Cucurbita ecuadorensis* is much more distantly related to *C. pepo* than to *C. maxima*, and there are more formidable barriers in this interspecific cross. The cross is very difficult to make with some *C. pepo* cultivars, but other cultivars are more compatible. Viable seed were not produced, but hybrid plants were obtained by embryo culture. Although both parents were monoecious, the hybrid was gynoecious. Male flower formation was induced by treating the hybrid with Ag or GA, but they were male-sterile. F₂ seed was not obtained, but backcross seed was easily produced by using the interspecific hybrid as the maternal parent in crosses with *C. pepo*. The most refractory barrier was achieving homozygosity for ZYMV resistance. Disturbed segregation occurred in succeeding generations and the progeny of most resistant plants segregated and were not uniform for resistance. This and other barriers to interspecific gene exchange were overcome and a summer squash variety homozygous for resistance to ZYMV, PRSV, and CMV is being released this year.

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Current Status of Cucurbit Anthracnose

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Anthracnose is a destructive foliage and fruit disease of cucurbits worldwide, particularly on cucumber, watermelon, and cantaloupe. Three fungal taxa have been implicated in the cucurbit anthracnose complex [*Colletotrichum orbiculare* (CO), *C. magna* (CM), and the putative teleomorph *Glomerella cingulata* var. *orbiculare* (GC)]. In the past 7 years we have assembled a large geographically diverse collection of cucurbit isolates that have been characterized for virulence,

vegetative (heterokaryon) compatibility, and mitochondrial and nuclear DNA RFLPs. All isolates that are pathogenic on cucurbit foliage are CO, belong to one of the four VCGs, and belong to a single mtDNA RFLP haplotype. Three races of CO (1, 2, and 2B) can be distinguished by their disease reactions on cucumber ('Marketer' and 'H19') and watermelon ('Black Diamond' and 'Charleston Gray') differentials. Race 1 (cucumber pathogen) and race 2 (watermelon pathogen) were the most common. Examination of virulence on cucurbit fruit indicates that CM and GC are more aggressive than CO, indicating that they could primarily be fruit-rot pathogens. Race 1 and 2 have been used effectively for screening disease resistance in cucumber and watermelon. Isolates of CM, GC, and *Colletotrichum* spp. recovered from fruit lesions were not pathogenic or were weakly virulent on cucurbit foliage and were diverse with regard to VCGs, nuDNA, and mtDNA RFLPs. However, CM and GC were more virulent on cucurbit fruit than CO.

35 ORAL SESSION 4 (Abstr. 404–410) Postharvest Physiology—Fruits/Nuts

404

Quality of Valencia Oranges in Response to Fruit Fly Disinfestation Treatments

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Valencia orange (*C. sinensis* L. Osbeck) fruit quality was evaluated following exposure to either a cold treatment or a high-temperature forced-air treatment (HTFA: fruit center end point, 47.2°C). These treatments are approved as disinfestation measures against selected fruit flies (APHIS, 1996). Fruits were stored at either 5°C 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 orange season (three grower lots/time). Valencia oranges exposed to HTFA had significantly lower appearance ratings, total soluble solids, titratable acidity, and also had significantly higher rind firmness and weight loss as compared to control or cold-treated fruits. Cold-treated fruits had significantly higher L and hue⁰ values. Fruits were also presented to an untrained sensory evaluation panel. Cold and HTFA treated fruits were rated significantly inferior in taste. Although statistically significant, these differences were slight. The potential for HTFA treatments for CA citrus, in light of these results, will be discussed.

405

The Morphology of Postharvest Pitting of White Grapefruit

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Postharvest pitting of citrus fruit is a recently defined peel disorder that is caused by high-temperature storage (>10°C) of waxed fruit. We examined the anatomy of pitted white grapefruit peel to improve our understanding of this disorder and assist in its diagnosis. Scanning, light, and transmission micrographs showed that postharvest pitting is characterized by the collapse of oil glands. Cells enveloping the oil glands are the cells of primary damage. Oil gland rupture may occur anywhere around the oil gland, but often occurs in regions farthest from the epidermal cells. Adjacent parenchyma cells are damaged as the oil spreads. Epidermal and hypodermal cells are often damaged during severe oil gland collapse. In contrast, chilling injury is characterized by the collapse of epidermal and hypodermal cells. Oil glands are affected only in severe cases of chilling injury. Oleocellosis (oil spotting) is often characterized by the collapse of epidermal and hypodermal cells, but cells enveloping the oil gland are typically not damaged. Physical damage is characterized by damage of epidermal cells, a wound periderm, and presence of secondary pathogens.

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Wax Effects on Postharvest Storage of 'Fallglo' Tangerines

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'Fallglo' is an early season variety of tangerine that has become known among citrus packers for its susceptibility to postharvest peel disorders. Among these disorders is postharvest pitting, a disorder characterized by the collapse of the peel during the storage of waxed fruit at room temperature. In this study, the effects of wax application on selected postharvest storage characteristics were evaluated.

Fruit were either not waxed or waxed with carnauba-, polyethylene-, or shellac-based waxes obtained from four suppliers of commercial citrus coatings and were stored at 21°C. In general, waxing reduced weight loss and improved shine. Waxing with shellac-based waxes significantly decreased internal O₂ levels (5% vs. 19% for non-waxed fruit) and increased internal CO₂ (6% vs. 2% for non-waxed fruit) and ethanol levels. Waxing with shellac-based waxes also significantly reduced post-packing degreening and stimulated pitting. Waxing with more gas-permeable coatings (carnauba- and polyethylene-based waxes) resulted in less internal gas modification than that of the shellac-based treatments, and low incidences of pitting. Controlled atmosphere studies showed that low (4%) O₂, rather than high (8%) CO₂, inhibited post-packing degreening and stimulated pitting.

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Effects of Elevated CO₂, Liquid Coating, and Ethylene Inhibitors on Postharvest Storage and Quality of Mango

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Mango fruits (*Mangifera indica* L. cv. Tommy Atkins) were harvested at early physiological maturity to study the effects of postharvest treatments on storage and fruit shelf-life. The fruits were subjected to control atmosphere (20 CO₂ + 3% O₂, and 30% CO₂ + 3% O₂), liquid coating (NatureSeal and Polyamine), and ethanol vapor. The fruits were kept for 4 weeks at 50 + 3°F then removed from the cold storage and maintained at room temperature. Mango fruits stored at high level of CO₂ or dipped in NatureSeal had better shelf-life than fruits stored at a low level of CO₂ or with ethanol vapor.

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The Temporal Relationship between Volatile Biosynthesis and Other Ripening Parameters in Banana Fruit

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Banana [*Musa* sp.9AAA group0, Cavendish] fruit are climacteric in nature, undergoing a rapid rise in ethylene production and respiration. Ethylene production can peak within 8 h of a detectable rise in production and respiration peaks within 24 h. These rapid changes permit precise timing for events related to or dependent on ethylene presence. Using rapid analytical methodology, we investigated the dynamic changes in volatile biosynthesis and its relation to other ripening parameters. Ungassed, mature-green banana fruit were placed individually at 23°C in flow through glass chambers. Ethylene production, respiration, chlorophyll fluorescence, skin color (hue angle) and volatile production were monitored. The climacteric rise and subsequent fall in ethylene production was found to be complete within 20 h. The respiratory rise peaked 20 h after the initial rise in ethylene production. The onset of the decline in chlorophyll fluorescence, skin color (hue angle) were coincident with the rise of ethylene and respiration, which indicated that the chlorophyll fluorescence may be used to monitor the banana fruit ripening. Volatile production was found to begin ≈60 h after the onset of the ethylene climacteric, peaking 3 to 4 days later. The ester precursors butyric acid and 3-methylbutanol were used in feeding experiments at different developmental stages for pulp and peel. Full ester-forming capacity was found to exist well before the onset of volatile biosynthesis. There were also different biosynthetic capacities for pulp and peel. Low aroma production in pre-climacteric fruit is apparently limited by the supply of precursors, which may be derived from the ethylene-induced enhancement of fruit respiratory metabolism.

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Changes in Anthocyanin Concentration, Phenylalanine Ammonia Lyase, and Glucosyltransferase in the Arils of Pomegranates Stored in Elevated Carbon Dioxide Atmospheres

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The influence of CO₂ on color and anthocyanin concentration in the arils of 'Wonderful' pomegranate (*Punica granatum* L.) was investigated. Pomegranates were placed in jars ventilated continuously with air or air enriched with 10% or 20% CO₂ at 10°C for 6 weeks. Samples were taken initially, and after 1, 2, 4, and 6 weeks and anthocyanin concentration was measured by HPLC. The arils of the pomegranates stored in air were deeper red than those stored in CO₂-enriched atmospheres. This increase in red color resulted from an increase

in anthocyanin concentration. Arils from fruit stored in air+10% CO₂ had a lower anthocyanin concentration than air-stored fruit, and atmospheres enriched with 20% CO₂ suppressed anthocyanin biosynthesis. Anthocyanin concentration was well-correlated to the activity of phenylalanine ammonia lyase (PAL), but not to glucosyltransferase (GT) activity. Moderate CO₂ atmospheres (10%) prolong the storage life and maintain the quality of pomegranates, including an adequate red color of the arils.

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Response of Mamey Sapote (*Pouteria sapota*) Fruits to Post-harvest Exogenous Ethylene Applications

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There are very few postharvest studies about the mamey sapote fruits. The lack of appropriate harvest indexes for this crop result in fruits having a wide variability in maturity after harvest. Fruit skin shows no apparent changes in color as maturity progresses. Another complication results from harvesting the fruit with long poles, which restricts the harvester from touching the fruit to evaluate fruit softening. The objective of this study was to evaluate the effect of exogenous ethylene applications to fruits on increasing the uniformity of fruit maturity. Fruits were harvested every 2 weeks over a 4-month period. Fruit harvest was initiated 8 weeks before the estimated ripening day. Fruits were treated by immersion for 1 min in an ethephon solution at 0, 500, or 1000 mg·liter⁻¹ and stored at 20°C (65% RH) for 4 or 8 days. After the storage period, fruits were analyzed for fruit firmness, color (external and internal), pH, titratable acidity, soluble solids content, ascorbic acid, and starch. Postharvest exogenous applications of ethylene stimulated postharvest ripening of the mamey sapote fruits. Ripening was associated to fruit softening, a change in pulp color from a pale pink to an intense pink color, and an increase in SSC. Fruit response to exogenous ethylene applications was small in immature fruits and increased as fruits approached the ripe stage, and decreased again in over-ripe fruits. In conclusion, postharvest applications of ethylene increased both fruit earliness and maturity uniformity in fruits.

36 ORAL SESSION 5 (Abstr. 411–417) Culture & Management—Fruits/Nuts

411

Minimal Pruning during Orchard Development Improves Yield of Late-season 'Fairtime' Peaches

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Minimal dormant pruning after the first and second growing seasons, followed by standard pruning thereafter, improved total tree yield in the 3rd, 4th, and 5th years after planting. Trees that were pruned in accordance with standard local practice had ≈50% yield compared to minimally pruned trees in years 3 through 5. Fruit from minimally pruned trees was significantly smaller, but mathematical adjustment of crop load indicated that overall yield efficiency was improved in the 3rd and 4th years for trees receiving minimal pruning.

412

Peach Rootstock Performance of BY-520-9 and Lovell in a Peach Tree Short Life Replant Site

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A study was initiated in 1994 to evaluate the performance of the recently released peach rootstock Guardian TM (BY-5209-9), compared to Lovell, the commercial standard in North Carolina. 'Redhaven' was the scion for both rootstocks. Guardian™ is reported to be tolerant to root-knot nematodes and not affected by ring nematodes, which contribute to the incidence of peach tree short life (PTSL). The site of this study has a history of poor peach tree survival. Six-year-old trees were removed because of tree mortality from PTSL in Spring 1993. After tree removal, one-half of each existing row was pre-plant fumigated and trees were

replanted over the rows of the previous orchard in Feb. 1994. In Spring 1996, tree mortality for the trees planted on Lovell was 30%, compared to 10% for the trees planted on Guardian™. Trunk cross-sectional area for trees grown in the fumigated soil was approximately double that of trees grown in the unfumigated soil for both Guardian™ and Lovell. The 1996 fruit crop was eliminated from frost/freeze conditions and 1997 yields will be discussed. In Fall 1996, one-half of the trees were treated with a post-plant nematicide to determine if such treatments are necessary or beneficial with the Guardian™ rootstock.

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Effective Cutting Methods and Media for Hardwood Cuttings in 'Sunaga Wase' Peaches

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This experiment was carried out to investigate the effective cutting methods and media for hardwood cuttings in 'Sunaga Wase' peach (*Prunus persica* L.). Using 1-year-old peach stems out of winter pruning, the cutting stems were procured through several steps on 16 Feb. 1995 and 1996. i) Cut 30 cm in length by pruning scissors and bundled to 10 stems; ii) 1-cm bottom part of cutting stem dipped into IBA (1000 ppm solution) for 5 s and then powdering with Captan WP; iii) upper part of cutting stem coated with Topsin paste; iv) standing the bundled cutting stems in the cutting bench filled with cutting media; v) the temperature maintained at 20 ± 1°C under the level of cutting media by bottom heating and at 5 to 10°C above the media level. Among the cutting media, vermiculite showed the highest rooting percentage, as much as 93.2%, followed by Jiffy pot and rockwool cube. High transplanting survival percentage under field conditions was obtained by the treatment of vermiculite of media + cutting duration for 35 days. Although the treatment of cutting duration for 55 days showed very high percentage of rooting, such as 96.4% in vermiculite, 78.3% in Jiffy pots, and 83.3% of rockwool cube, their percentage of nursery survival after transplanting were reduced remarkably less than 10% in nursery fields covered with black polyethylene film. The nursery trees obtained from each treatment were characteristically 136 to 146 cm in tree height and 22.9 to 26.8 cm in trunk diameter.

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Advancing Fruit Ripening in Stone Fruit Species

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Fresh fruits of stone fruit species are either lacking or in short supply in the months of March and April on the world market. This results from the absence of late-maturing cultivars in most of these species and from their poor storage capabilities. In March–April, supply from the Southern Hemisphere is dwindling or finished, while supply from the Northern Hemisphere has not started yet. A horticultural system was developed in Israel to get early fruit ripening of stone-fruit species. The system developed is based on early completion of dormancy requirements followed by greenhouse tree growing. The system uses the following elements: 1) Improve chilling accumulation in winter by using evaporative cooling, to prevent chilling negation by high day temperatures. 2) Monitor salt accumulation level to prevent damage to branches and buds. 3) Monitor bud temperature and evaluate dormancy development according to the dynamic model. 4) Use dormancy breaking chemicals to compensate for part of the chilling not applied. 5) Cover of the trees with polyethylene having the appropriate characteristics of light filtering. 6) Keep the temperature in the greenhouse lower than the maximal temperature allowed, at every specific stage of development by ventilation. By using this system, fruit ripening was advanced by 4 to 6 weeks in peaches and nectarines (harvested from late March) and by 4 weeks in sweet cherries (harvested from April 11). Yields of 20 to 30 tons/ha were obtained in both species with high fruit quality.

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Avoiding Internal Breakdown of Stone Fruit by an "Off" the Tree Pre-ripening Treatment

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During the past two seasons, the relationship between fruit ripening "ON" or "OFF" the tree and internal breakdown incidence was studied with 'Elegant Lady' and 'O'Henry' peach cultivars. Internal breakdown (IB) visual symptom development was delayed in fruit harvested at different physiological maturities

and exposed to different "OFF" the tree pre-ripening treatments. As a follow up, different pre-ripening treatments (controlled delayed cooling) were tested for several peach, nectarine, and plum cultivars susceptible to IB. This pre-ripening treatment delayed flesh browning, mealliness, and off-flavor development after a simulated shipment and retailer handling period for 'Flavorcrest', 'Elegant Lady', 'O'Henry', 'Parade', 'Fairtime', 'Carnival', 'Prima Gattie', 'Last Chance', 'Autumn Gem', 'Autumn Lady', and 'Autumn Rose' peaches; 'Summer Grand' and 'September Red' nectarines; and 'Fortune' plum. However, decay development may be a problem. Delayed cooling at 20°C must be carried out with fruit protected with fungicide and wax for the shortest possible, but still effective, length of time to limit IB. The temperature and the length of this pre-ripening treatment, and the presence or absence of ethylene during the delayed cooling is cultivar dependent. Thus, specific pre-ripening conditions must be developed for each cultivar.

416 Evaluation of the Influence of Packhard on 'Ross' Cling Peaches during Postharvest Storage

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The Packhard treatment included Packhard® Caenise at 3 qt/A rate applied at four equally spaced intervals beginning on 1 May 1996 and continuing until harvest on 29 July 1996. After harvest, treated and nontreated peaches were stored at 1°C, 95% RH. For up to 42 days, after which they were allowed to ripen for 6 days at 18°C. Fruit from 5-day storage intervals and 2-day ripening intervals were then evaluated for firmness, color, brown rot lesions, soluble solids, titratable acidity, starch, pectin, total Ca, and fruit epidermis thickness. Packhard protected the fruit in cold storage for 42 days from brown rot compared to the controls, which began to breakdown in 26 days. The ripening studies have given mixed results suggesting that there is no difference in the degree of brown rot contamination between Packhard-treated fruit and control fruit after removal from storage. Fruit firmness was increased by Packhard in the majority of the storage periods. Sucrose content seemed to have been reduced in the Packhard-treated fruit compared to the controls, possibly due to increased respiration. The Packhard-treated fruit retained more moisture than the control fruit, which indicates that Ca²⁺ from Packhard may have increased the integrity of the plasma membranes of treated fruit. In general, the Packhard-treated fruit held up much better in cold storage than the control fruit but was not different in brown rot infection during ripening. Packhard increased fruit firmness and allowed the fruit to retain more moisture than the control fruit. Sucrose content decreased in Packhard-treated fruit compared to the controls.

417 Peach Leaves Do Take Up Foliarly Applied Urea Nitrogen

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The ability of peach leaves to absorb and translocated foliarly applied ¹⁵N-urea in mature peach (*Prunus persica*) trees was determined. Urea uptake experiments were conducted in June, October, and November 1995. Peach leaves absorbed ≈80% of the urea within 48 hr of application in all three experiments based on urea rinsed from leaf surfaces. Similarly, leaf ¹⁵N content reached a peak 48 hr after application. Translocation of ¹⁵N out of leaves, however, was more rapid in October than November. In October, 24% of the ¹⁵N remained in the leaves 2 weeks after application, while, in November, 80% stayed in the leaves and fell to the orchard floor. Thus, applying urea in mid November did not allow enough time for the N to be transported out of the leaves before leaf abscission. Timing of foliar urea application is critical to maximize N transport into perennial tissues of peach trees. ¹⁵N- urea resorption out of leaves and into perennial tree parts (roots, trunk, current year wood, etc.) is discussed.

43 ORAL SESSION 6 (Abstr. 418–422) Breeding & Genetics—Vegetables

418 Agrobacterium-mediated Introduction of Athb-7, Water Stress Gene, into Solanum spp.

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A genetic transformation in *Solanum* spp. was performed using *Agrobacterium tumefaciens*: C58:pGV2260:*Athb-7*. *Athb-7* gene, known to be related to water stress and ABA level, one of *Arabidopsis thaliana* homeobox genes was inserted into pBin-Hyg-Tx. Explants were placed on callus induction medium for 14 days, and then transferred on shoot induction medium. Shoot primordium appeared on callus surface after 2 weeks of culture. About 6 weeks later, 100 putatively transgenic plants were obtained, and DNA was extracted from each plant for PCR analysis. Twenty out of 100 putatively transgenic plantlets turned to be positive, having a band of 800 bp in M.W. corresponding to the hygromycin gene. Both PCR and genomic Southern hybridizations using HPTII and *Athb-7* genes as probes showed that these genes were inserted into plant genome.

419 Application of Gene-specific mRNA Differential Display for Identification of cDNAs that Encode Small HSPs Correlated with the Heat-induced Chilling Tolerance of Tomato Fruit

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Heat-treatment of mature-green tomato fruit (*Lycopersicon esculentum*) for 48 h at 42°C has been shown to prevent chilling injury from developing after 2 or 3 weeks at 2°C. Using mRNA differential display, we recently cloned and characterized a cDNA that encodes a cytosolic class II small heat-shock protein (*Le* HSP17.6). The mRNA of *Le* HSP17.6 is up-regulated during heat shock and the level of transcription remains high during subsequent storage at chilling temperatures. We used mRNA differential display with gene-specific primers from the other small HSPs families and find that the transcription of the other small heat-shock proteins is up-regulated during heat shock and persists at elevated levels at 2°C for at least 2 weeks. When the fruits are returned to a permissive ripening temperature after the chilling period, the mRNA of the small HSPs declines slowly for 3 days. These results suggest that the persistence of the small heat-shock proteins at low temperatures may provide protection against chilling injury.

420 Identification of Heritable Resistance to Tomato Spotted Wilt Virus (TSWV) as Derived from *Lycopersicon chilense* Interspecific Hybrid Breeding Line LA 1938

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Nineteen interspecific hybrid breeding lines were tested for resistance to a TSWV isolate using enzyme-linked immunosorbent assay (ELISA) to check for presence of the virus after inoculation. These lines were all BC₁F₆ lines derived from *L. esculentum* crosses with seven *L. chilense* accessions. All of these lines had been selected for high tolerance/resistance to tomato mottle virus (ToMoV), a geminivirus [Scott et al., Bemisia 1995: Taxonomy, Biology, Damage Control and Management 30: 357–367 (1996)]. The initial TSWV screening indicated that eight of the 19 original lines had "possible" TSWV resistance. Seed from these selected eight lines were then planted and inoculated with TSWV ≈3 weeks after emergence. Three weeks later, ELISA results indicated that all plants from all lines were infected with TSWV. However, none of the plants from Y118 (derived from the LA 1938 cross) showed visual TSWV symptoms. The Y118-derived plants were allowed to grow for several months, and at no time developed significant visual symptoms of the virus. The consistent lack of TSWV symptoms prompted a second ELISA test on the Y118 plants, and the results indicated the plants were completely free of TSWV. Further tests were then initiated with F₂ (*L. esculentum* x Y118) seed, and results indicate a single dominant gene is responsible for TSWV resistance. Data from this segregating population, including a molecular marker study which screened 800 randomly amplified polymorphic DNA (RAPD) primers, will be presented. Approximately two to five RAPD primers are possibly linked to TSWV resistance.

421 Inheritance of Leptine Production in *Solanum chacoense*

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Colorado Potato Beetle (*Leptinotarsa decemlineata* Say., CPB) is a destruc-

tive pest of the cultivated potato, *Solanum tuberosum* L. Certain glycoalkaloids in potato leaves are effective deterrents to this insect; however, in tubers these compounds can be toxic to humans. Leptines are foliar-specific glycoalkaloids produced by the related species, *S. chacoense*. These compounds have been shown to confer resistance to CPB. We are studying the inheritance of leptine production in segregating F_1 and F_2 populations derived from two *S. chacoense* accessions, 55-1 and 55-3, which are (respectively) high and low leptine producers. The F_1 segregates 1:1 for high (>70% of total glycoalkaloids) and low (<20% of TGA) leptine content. Segregation data from the F_1 and F_2 populations suggest a two-gene model for leptine production: a dominant repressor and a recessive inducer. Using two bulked DNA samples composed of high- and low-leptine individuals from the F_1 population, we are using various types of molecular markers (RAPDs, SSRs, DS-PCR, and AFLPs) to search for markers linked to leptine production. We have identified a RAPD band that appears to be closely associated with low leptine content and supports the two-gene model. The use of such a marker in a breeding program will facilitate the development of CPB resistant potato varieties.

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Sweetpotato Weevil Resistance to Stem and Root Injury Sweetpotato Plant Introductions

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The sweetpotato weevil is the most-destructive worldwide pest of sweetpotato and only low to moderate levels of resistance to the insect are available in acceptable cultivars. No sources of high resistance levels have been identified; consequently, there is a need to identify additional sources of resistance genes to develop high resistance levels. To begin a search for sources of resistance, plant introductions were evaluated for injury levels. In 1993, 100 plant introductions were evaluated for sweetpotato weevil injury and 62 of the least injured were tested again in 1994. In 1995, 36 of the least injured in 1993 and 1994, plus 24 additional PIs were evaluated. Control cultivars included 'Regal', moderately resistant; 'Jewel', intermediate; and 'Beauregard' and 'Centennial', susceptible. Measurements of injury were percentage of roots injured, and, stem and root injury scores based on a 0–5 scale, with 0 being no injury. First year results indicated that a low level of resistance to stem injury is available in the PIs tested. Stem injury was more severe in the following year and no differences were found. Lower weevil populations will be required to screen for low levels of stem injury resistance. Percentage injured roots and root injury scores were lower over the 3 years for five PIs than for 'Regal'.

44 ORAL SESSION 7 (Abstr. 423–429) Breeding & Genetics—Floriculture/Foliage

423

Analysis of Heat Tolerance in New Guinea Impatiens (*Impatiens hawkeri*) Utilizing Diallel Analysis

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Four heat-tolerant ('Celebration Cherry Red', 'Celebration Rose', 'Lasting Impressions Shadow', and 'Paradise Moorea') and three non-heat-tolerant ('Lasting Impressions Twilight', 'Danziger Blues', and 'Pure Beauty Prepona') cultivars were identified using a Weighted Base Selection Index. These cultivars were used as parents in a full diallel crossing block with reciprocals and selfs. Progeny from five parents (25 crosses) were evaluated for heat tolerance. Four floral (flower number, flower diameter, flower bud number, and floral dry weight) and five vegetative characteristics (visual rating, leaf size rating, vegetative dry weight, branch number, and node number) were evaluated with emphasis placed on continued flowering under long-term heat stress. In addition, progeny from all seven parents (49 crosses) were evaluated for inheritance of adaxial leaf color, abaxial leaf color, vein color, and flower color. Significant differences were found in each data category ($P < 0.001$) with the exception of node number, which was not significant. Flower number varied from 0 to 2, flower diameter varied from 0 to 41 mm, floral dry weight varied from 14 to 105 mg, bud number varied from 0 to 12, branch number varied from 5 to 15, and vegetative dry weight varied from 220 to 607 mg. General and specific combining abilities of the parents were evaluated as was heritability. It was found

that the four heat-tolerant cultivars had higher general combining abilities. Heat tolerance has low heritability and is controlled by many genes.

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Inheritance Patterns of Morphological Traits Related to Drought Tolerance in New Guinea Impatiens

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Three drought-tolerant and four drought-susceptible breeding lines from the Univ. of Minnesota's New Guinea impatiens breeding program were crossed in all combinations (reciprocals and selfs) using a complete diallel crossing scheme. Progeny of each cross were grown using standard cultural practices and data was taken on the morphological traits shown to be related to drought tolerance in previous studies. Data was taken on leaf thickness, leaf width, leaf length, leaf area, and leaf dry weight. From these data the leaf length:width ratio and leaf dry weight/unit area ($\text{g}\cdot\text{cm}^{-2}$) were calculated. Mean squares for general and specific combining ability were estimated using Griffing's Model 1, Method 4. Differences between crosses were highly significant ($P < 0.001$) for all traits examined. Mean squares for specific (SCA) and general (GCA) combining ability were significant indicating that both additive and non-additive gene effects are important in the inheritance patterns of these characters. For all traits, GCA was greater than SCA indicating that the additive component had the greatest influence on gain from selection for these traits. These findings agree with other estimates of GCA and SCA for these characters in other crops species. The importance of non-additive effects (SCA) on inheritance of these traits explains why we were able to make rapid improvement in drought tolerance in New Guinea impatiens and the role of additive effects (GCA) on drought tolerance indicates that we can continue to make substantial progress improving drought tolerance in New Guinea impatiens. The impact of these findings on strategies to improve drought tolerance in New Guinea impatiens will be discussed in this presentation.

425

Abstract withdrawn

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Analysis of Horticultural Performance of Ethylene-insensitive Petunias and Tomatoes

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We are studying the horticultural performance of two model plant systems that carry a mutant gene that confers ethylene-insensitivity: *Never Ripe* tomatoes and petunia plants transformed with the mutant *etr1-1* gene isolated from *Arabidopsis thaliana*. Having two model systems to compare side-by-side allows us to determine with greater certainty ethylene's role at different developmental stages. Presence of the mutant *etr1-1* gene in transgenic petunias was determined using three techniques: PCR analysis, the seedling triple response assay (inhibition of stem elongation, radial swelling of stem and roots, and an exaggerated apical hook when grown in the dark and in the presence of ethylene), and the flower wilting response to pollination, which is known to be induced by ethylene. Flowers from ethylene-insensitive petunias took almost four times as long to wilt after pollination as wild-type plants. It is well known that fruit ripening in *Never Ripe* tomato is inhibited, and a similar delayed fruit ripening phenotype is observed in petunia plants transformed with *etr1-1*. In an effort to maintain ethylene-insensitive petunia plants by vegetative propagation, we observed that the rate of adventitious root formation was much lower with transgenic plants than in wild-type plants. In subsequent experiments on adventitious root formation in *Never Ripe* tomato, we observed the same result. Therefore, while ethylene-insensitive tomato and petunia plants appear phenotypically normal for many characters, other factors are altered by the presence of this mutation. The fact that these changes are present in two model systems helps to define the role of ethylene perception in plant growth and reproduction.

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Isolation and Characterization of Putative Ethylene Receptor Genes from Zonal Geranium

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In this study, the temporal and spatial regulation of putative ethylene recep-

tor genes was examined during ethylene and pollination-induced flower petal abscission of zonal geranium (*Pelargonium x hortorum* L.H. Bailey). We used the *Arabidopsis thaliana* ETR1 gene as a heterologous probe to isolate two full-length cDNA clones, GER1 and GER2, from an ethylene-treated geranium pistil cDNA library. Both cDNAs share a high degree of DNA sequence similarity to ETR1, and examinations of deduced amino acid sequences indicate that the proteins encoded by each gene have the conserved ethylene binding and response regulator domains found in ETR1. Experiments focused on determining the temporal regulation of these genes revealed that both genes are expressed in geranium florets much earlier than when the florets become responsive to ethylene treatment, which is sufficient to cause petal abscission in 1 hr. Both genes are expressed in pistils throughout floret development. Experiments focused on determining the spatial regulation of these genes revealed that both genes are expressed at moderate levels in leaves, pistils, anthers, and petals, and are expressed at very low levels in roots. Preliminary evidence suggests that GER2 is transcriptionally regulated by ethylene in pistils after exogenous ethylene treatment. Currently, the transcriptional regulation of these genes in pistils after pollination is unknown.

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Distinguishing Poinsettia Cultivars and Evaluating Their Genetic Relationships using DNA Fingerprinting

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The objective was to distinguish between cultivars and evaluate genetic relatedness of poinsettia (*Euphorbia pulcherrima*) using two methods of DNA fingerprinting—DNA Amplification Fingerprinting (DAF) and Arbitrary Signatures from Amplification Profiles (ASAP). Eleven red poinsettia cultivars were studied, including 'Celebrate 2', 'Darlyne', 'Freedom Red', 'Lilo', 'Nutcracker Red', 'Peterstar Red', 'Petoy', 'Red Sails', 'Supjibi', 'V-14 Glory', and 'V-17 Angelika'. Amplification was with 10 octamer primers. Gels were visually scored for presence or absence of bands. The 10 primers generated 336 bands. The average number of bands (≈ 1000 bp) per primer was 34 ranging from 19 to 43. Thirty-one percent of bands were polymorphic and distinguished between each cultivar. The number of unique profiles varied from two to nine. Genetic relationships were evaluated by SAHN cluster analysis based on the distance estimator of Jaccard using the NTSYS-pc program (Numerical taxonomy and multivariate analysis system, version 1.8). The resulting dendrogram closely agreed with known pedigree data. ASAP analysis was used to further assess cultivar identification of two cultivars that were genetically and morphologically similar. Markers were found that separated 'Nutcracker Red' and 'Peterstar Red'. ASAP analysis separated cultivars within the Freedom series that DAF failed to distinguish. Two cultivars in the Freedom series, 'Jingle Bells' and 'Marble', were characterized from other cultivars in the series with ASAP.

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Arbitrary Signatures from Amplification Profiles (ASAP) Distinguishes Somatic and Radiation-induced Mutations in the 'Charm' Series of Chrysanthemum

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Four chrysanthemum (*Dendranthema grandiflora*) spontaneous and radiation-induced sports from the cultivar 'Charm' and phenotypically differing only in flower color were individually characterized using arbitrary signatures from amplification profiles (ASAP). ASAP analysis is based on a two-step arbitrary primer amplification procedure that produces "fingerprints of fingerprints." In the first step, 'Charm', 'Dark Charm', 'Dark Bronze Charm', 'Salmon Charm', and 'Coral Charm' were fingerprinted by DNA amplification fingerprinting (DAF) with standard octamer arbitrary primers. Diluted products from three monomorphic fingerprints for each cultivar were subsequently reamplified using four minihairpin decamer primers. Each of the 12 ASAP profiles revealed polymorphic loci that were used to uniquely identify cultivars and estimate genetic relationships. The ASAP technique permits identification of previously genetically indistinguishable plant material and should facilitate marker assisted breeding and protection of ownership rights.

47 ORAL SESSION 8 (Abstr. 430–435) Modeling—Floriculture/Foliage

430

Validation of a Model for Simulating the Effect of Daminozide Application on Chrysanthemum

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Daminozide is a growth retardant used in potted plant production as a foliar spray to inhibit shoot elongation. It has its greatest inhibitory effect immediately after application, becoming less pronounced thereafter; continued retardation is accomplished by reapplication at 7- to 14-day intervals. A model for this retardation effect is useful in developing decision support tools, as well as in optimizing (perhaps minimizing) the use of this growth retardant. Such a model, as developed and described earlier, simulates the effect of a foliar spray application of daminozide at various concentrations on various days during the production cycle. The objective of this work was to validate this model for various varieties of chrysanthemum. Using the model to simulate the effect of one application of daminozide resulted in predicted plant heights very close to the observed heights for most of the varieties tested. Of four methods used to implement the multiple-application effect, two resulted in very good simulation of the observed plant heights. In summary, the model was shown to be valid for all the varieties of chrysanthemum tested.

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Predicting Variability in Flowering of Easter Lily Populations in Response to Temperature

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The objective was to predict the distribution (mean and variance) of flower opening for an Easter lily (*Lilium longiflorum* Thunb.) population based on the variability in an earlier phenological stage and the expected average temperature from that state until flowering. The thermal time from the visible bud stage until anthesis was calculated using published data. 'Nellie White' grade 8/9 Easter lilies were grown in five research and commercial greenhouse locations during 1995, 1996, and 1997 under a variety of temperature and bulb-cooling regimes. Distributions of visible bud and anthesis were normally distributed for a population growing in a greenhouse with spatially homogenous temperatures. The variance at anthesis was positively correlated with variance at visible bud. The mean and variance at visible bud could therefore be used to predict the distribution of the occurrence of anthesis in the crop. The relationship between bud elongation, harvest, and temperature was also incorporated into the model. After visible bud, flower bud length measurements from a random sample of plants could be used to predict the harvest distribution. A computer decision-support system was developed to package the model for grower use.

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A Heat Unit Model for Tracking the Development of Geranium

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A heat-unit model was established for tracking the development of geranium, based on experimental data collected at UC Davis and Rutgers Univ. The temperature thresholds for initiating development and heat-unit benchmarks needed to accomplish each phenostage are parameters in this model. The methods of estimating these parameters were proposed and tested with the observed data. The model worked well during either vegetative or reproductive stages, but failed to predict the initiation of flowers, suggesting that factors other than only temperature drive the flower initiation process. With this model crop development characterized by a series of specific morphological events can be tracked and predicted under various temperature regimes, so that crop timing can be more precise.

Modeling Poinsettia Plant Quality in Response to the Ratio of Radiant to Thermal Energy

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The objectives of this study were to quantify the effects of the radiant-to-thermal energy ratio (RRT) on poinsettia plant growth and development during the vegetative stage and develop a simple, mechanistic model for poinsettia quality control. Based on greenhouse experiments conducted with 27 treatment combinations; i.e., factorial combinations of three levels of constant temperature (19, 23, or 27°C), three levels of daily light integral (5, 10, or 20 mol/m² per day), and three plant spacings (15 x 15, 22 x 22, or 30 x 30 cm), from pinch to the onset of short-day flower induction, the relationship between plant growth/development and light/temperature has been established. A model for poinsettia quality control was constructed using the computer software program STELLA II. The *t*-test shows that there were no significant differences between model predictions and actual observations for all considered plant characteristics; i.e., total, leaf and stem dry weight, leaf unfolding number, leaf area index, and leaf area. The simulation results confirm that RRT is an important parameter to describe potential plant quality in floral crop production.

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Regulation of Greenhouse Night Temperature Based on Total Carbohydrate Concentration and Night Length

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The relationship between initial total non-structural carbohydrate concentration (TNC_i) in marigold seedlings, night temperature, and night length were evaluated. Seedlings containing an average of 7.2, 18.1, and 23.5 mg/100 mg dwt of non-structural carbohydrate (TNC) at sunset were treated with night temperatures of low (10°C), medium (17°C), and high (24°C). Starch and soluble sugars were determined at intervals during the night. TNC concentration at the end of the night is a function of the night temperature, TNC_i concentration at sunset, and the night length. A model describing the relationship of these variables and their interactions was derived to estimate TNC concentration at any time during the night. This model when solved for temperature (*t*) establishes a temperature that will regulate the metabolic rate so the TNC concentration is metabolized efficiently to some minimum concentration by the end of the dark period. $t = (-2.93 + 1.14 \text{ TNC}_i + 0.74 \text{ T} - 0.48 \text{ TNC}_i * \text{T}) / (-0.18 + 0.011 \text{ TNC}_i + 0.04 * \text{T})$, $R^2 = 0.88^{**}$. Thus, by knowing TNC_i (possibly by near-infrared spectroscopy), the length of the night, and, assuming some minimum concentration for TNC by the end of the dark period, the night temperature is established.

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Plastochron Index—A Valuable Method in Assessing Morphological Changes Induced by Light Levels

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Dracaena sanderana 'Ribbon' plants were grown under 47%, 63%, 80%, and 91% shade. After 15 weeks of growth, plants exhibited marked changes in various morphological features. In order to precisely compare leaves of plants grown under different light levels the Plastochron Index (PI) of Erickson and Mickelini (1957) was used. The plastochron was defined in terms of leaf length. Various leaf morphological characteristics were examined and correlated with 1) actual leaf numbers, and 2) with leaf developmental age. A comparison between the two methods 1) and 2) revealed that overall trends displayed by leaves with a Leaf Plastochron Index (LPI) from 12 to 2 were similar to the same trends linked to actual leaf numbers. However, leaves with LPIs lower than 2 showed that under 80% and 91% shade these leaves had higher values for all studied parameters. Comparable leaves of plants in 91% shade had consistently higher values of the leaf parameters compared to plants in other shade treatments. The use of the PI enabled us to accurately compare morphological differences between plants grown under diverse light conditions.

55 ORAL SESSION 9 (Abstr. 436–443) Growth & Development—Floriculture/ Foliage

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Vernalization and Growing Degree-day Requirements of *Thalictrum delavayi* 'Hewitt's Double'

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Vernalization and growing degree-day requirements of *Thalictrum delavayi* 'Hewitt's Double' were determined to improve the production scheduling of this cut flower crop. Two-year-old crowns of *T. delavayi* 'Hewitt's Double', lifted in the fall, were exposed to cold storage for 0, 3, 6, 9, 12, or 15 weeks at 8 ± 1°C. After storage, the containerized plants were grown at Massey Univ., Palmerston North (40°20'S) in a greenhouse heated at 15°C and vented at 20°C, under a natural photoperiod (11 h increasing to 13 h) plus a 4-h night interruption between 2200 and 0200 HR. As buds continued to develop during storage at 8°C, growing degree-days calculations were made over both storage and greenhouse forcing periods. All plants flowered, but *T. delavayi* 'Hewitt's Double' nevertheless showed a quantitative vernalization requirement, being fully saturated after 6 weeks of cold storage at 8°C. With a base temperature of 0°C, time to flowering reduced from 3338 degree-days without vernalization to an average 2804 degree-days subsequent to the saturation of the vernalization response (6 to 15 weeks of vernalization). Flower yield averaged between three and five stems per plant, with stem lengths ranging between 140 and 200 cm. Differences in flower yield and quality among storage durations were minor and not commercially significant.

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Effect of Stock Plant Photoperiod and Temperature on Cutting Production and Rooting of Herbaceous Perennials

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Previous research has shown that the photoperiod under which stock plants are grown has a significant effect on cutting production and rooting of several species of herbaceous perennials. Long-day (LD) treatment of stock plants promoted cutting production of certain LD perennials but reduced rooting. Cuttings from plants grown under short days rooted readily but few were produced. Stock plants were exposed to alternating photoperiods to determine if this treatment would yield many cuttings with high rooting potential. *Coreopsis verticillata* 'Moonbeam' and *Phlox paniculata* 'Eva Cullum' stock plants were given 4 weeks of 4-h night interruption (NI), while *Sedum* 'Autumn Joy' stock plants were grown under 14-h days. After 4 weeks plants were given 0, 2, or 4 weeks of 10-h days. Cuttings were harvested and propagated under mist and three different photoperiods (10-h, 14-h, NI) for 4 weeks, after which rooting percentage and the number and length of roots produced by each cutting were measured. The results will be presented.

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Effect of Forcing Temperature on Flowering of Four Herbaceous Perennial Species

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Four herbaceous perennial species, *Delphinium grandiflorum* 'Blue Mirror', *Hibiscus xhybrida* 'Disco Belle Mix', *Salvia xsuperba* 'Blue Queen', and *Veronica longifolia* 'Sunny Border Blue' were forced in a glass greenhouse at 15, 18, 21, 24, or 27°C under long days. Before being forced, all tested species except *H. xhybrida* were exposed to 5°C for 12 weeks. Increasing forcing temperature generally promoted visible bud and flowering. However, visible bud and flowering of *D. grandiflorum* 'Blue Mirror' and flowering of *V. longifolia* 'Sunny Border Blue' were delayed at 27°C. Although the tested species tended to have more flower buds, bigger flowers, and greater height at lower forcing temperatures, the effect of forcing temperature on those characteristics was species-dependent. Temperatures as low as 15°C decreased bud number and flower size of *H. xhybrida* 'Disco Belle Mix'. The base temperature (*T_b*) and cumulative thermal time (CTT) necessary to complete the indicated developmental stage were calculated from a linear regression: $1/f = a + bT$. Based this equation, days to flowering (or visible

bud) at certain temperatures or the temperature required for flowering within a certain number of days can be predicted.

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Photoperiod and Temperature Interact to Affect *Petunia x hybrida* Vilm. Development

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Petunia x hybrida Vilm. cvs. 'Purple Wave', 'Celebrity Burgundy', 'Fantasy Pink Morn', and 'Dreams Red' were treated with temperature and photoperiod treatments for different lengths of time at different stages of development during the first 6 weeks after germination. Plants were grown with ambient light (≈8–9 hr) at 16°C before and after treatments. Flowering was earliest and leaf number below the first flower was lowest when plants were grown under daylight plus 100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ continuous light (high-pressure sodium lamps). Flowering did not occur when plants were grown under short-day treatment (8-hr daylight). Plants grown with night interruption lighting from 2200–0200 HR (2 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from incandescent lamps) flowered earlier, and with a reduced leaf number compared to plants grown with daylight + a 3-hr day extension from 1700–2000 HR (100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ using high-pressure sodium lamps). Plant height and internode elongation were greatest and least in night interruption and continuous light treatments, respectively. 'Fantasy Pink Morn' and 'Purple Wave' were the earliest and latest cultivars to flower, respectively. Flowering was hastened as temperature increased from 12 to 20°C, but not as temperature was further increased from 20 to 24°C. Branching increased as temperature decreased from 24 to 12°C. Implications of data with respect to classification of petunia flower induction and pre-finishing seedlings are discussed.

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Photoperiod and Temperature Interact to Affect *Gomphrena globosa* L. and *Salvia farinacea* Benth. Development

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Gomphrena globosa L. 'Gnome Pink' and *Salvia farinacea* Benth. 'Victoria Blue' were grown under different photoperiod treatments with day and night temperatures ranging from 15 to 30°C ± 1°C air temperature for 14 weeks after germination or until anthesis. Days to anthesis and leaf number were lowest when plants were grown under 9 hr of daylight and daylight plus 4-hr day extension from 1700–2100 HR (100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from high-pressure sodium lamps) for *Gomphrena* and *Salvia*, respectively. Days to anthesis decreased as temperature increased from 15 to 25°C with *Gomphrena*. Further increasing night temperature from 25 to 30°C delayed flowering and increased leaf number below the first flower of *Gomphrena*, but hastened flowering of *Salvia*. Plant height and internode elongation were greatest and least in the night interruption (2 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from incandescent lamps from 2200–0200 HR) and continuous light (daylight plus 100 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ from high-pressure sodium lamps) treatments, respectively. Implications of these data with respect to classification of *Gomphrena* and *Salvia* flower induction are discussed and revised production schedules are presented.

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Photoperiodic Responses of Ten Alternative Hanging Basket Species

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The photoperiodic responses were determined for the following species: *Abutilon hybrid* 'Apricot', *Diascia hybrid* 'Ruby Fields', *Evolvulus glomeratus* 'Blue Daze', *Orthosiphon stamineus* 'Lavender', *Portulaca oleraceae* 'Apricot', *Scaevola aemula* 'Fancy Fan Falls', *Sutera cordata* 'Mauve Mist' and 'Snowflake', *Tabernamontana coronaria* 'Double', and *Tibouchina* 'Spanish Shaw'. Each plant species was grown at 8-, 10-, 12-, 14-, and 16-h photoperiods. Photoperiods were provided by delivering 8 h of sunlight, then pulling black cloth and providing daylength extension with incandescent bulbs. Air temperatures were monitored under each black cloth. Data collected included time to flower, number of flowers, and vegetative characteristics. *Diascia*, *Sutera* 'Mauve Mist' and 'Snowflake', *Tabernamontana*,

and *Tibouchina* were day neutral with regard to flowering; i.e., no difference in days to visible bud or days to anthesis in response to photoperiod was observed. *Portulaca* and *Scaevola* increased in bud and flower number as photoperiod increased from 8 to 16 h, performing similar to quantitative long-day plants. There was no difference in time to flower for *Portulaca*; however, 70% more flowers were produced under the 16-h photoperiod, compared to the 8-h photoperiod. *Scaevola* had 26% more flowers under the 16-h than 8-h photoperiod. *Abutilon*, *Evolvulus*, and *Orthosiphon* performed as quantitative short-day plants. Days to visible bud and days to anthesis increased as photoperiod increased for *Evolvulus* and *Orthosiphon*, and *Abutilon* had decreased flower number as photoperiod increased. Although *Abutilon* had no difference in time to flower, there was a 43% increase in flowers on plants under the 8-h photoperiod vs. 16-h photoperiod. *Evolvulus* set visible bud and reached anthesis 10 days earlier under 8-h photoperiod than 16-h. *Orthosiphon* reached visible bud 32 days earlier under an 8-h photoperiod than a 16-h photoperiod.

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Photoperiodic Responses of Garden Chrysanthemum

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The objective was to study the flowering response of garden cultivars of *Chrysanthemum x grandiflorum* (Ramat.) Kitamura to temperature and photoperiod. Fifteen garden mum cultivars were grown in ten temperature (18 and 24°C constant day and night greenhouse temperatures) and photoperiod (8, 10, 12, 14, and 16 h) combinations. Rooted cuttings were pinched above the fifth node and placed in the temperature/photoperiod treatments. When axillary shoots developed, all but one shoot was removed to produce a single stemmed plant. Photoperiods were provided by delivering 8 h sunlight, then pulling black cloth and providing daylength extension with incandescent bulbs. Days to visible bud, days to first bud color, days to flower, node number, and stem length were measured. By 11 weeks after the start of photoperiod treatments, no difference was measured in days to flower in the 8-, 10-, and 12-h photoperiods at 18°C. Days to flower increased as photoperiod increased from 12 to 14 h. At 18°C, five cultivars flowered in the 16-h photoperiod, while 10 cultivars developed crown buds, i.e., flower buds that initiated but had not developed. At 24°C, there was no difference in days to flower in the 8- and 10-h photoperiod, while days to flower increased as photoperiod increased from 10- to 12-h treatment. Cultivars formed crown buds but had not reached flowering in the 14- and 16-h photoperiods at 24°C. Regardless of temperature, stem length increased as photoperiod increased above 10 h.

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Red/Far Red Light and PAR Leaf Absorption Varies among Hanging Basket Crop Species

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Variation in red/far red leaf and photosynthetically active radiation (PAR) absorption by an individual leaf of various ornamental hanging basket species was measured. Red/far red ratios varied from 0.30 to 0.83 for *Syngonium podophyllum* Schott. and *Chlorophytum comosum* Thunb. 'vittatum', respectively. Reduction in PAR varied from 86% to 61% for those same species, respectively. Estimated state of phytochrome photoequilibria for understorey crops when grown under each species was calculated. *Cucumis sativus* L. seedling hypocotyl elongation was measured under different species to validate hypothesized differences in stem elongation associated with differences in red/far red filtering through individual leaves. Implications with respect to light quality effects on stem elongation and dry weight accumulation of plants grown under different species are discussed.

56 ORAL SESSION 10 (Abstr. 444–450) Culture & Management—Vegetables

444

Edamame Genotype Performance in Southwest Washington

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Commercial edamame (*Glycine max*) varieties and advanced edamame breeding lines from the Asian Vegetable Research Development Center (AVRDC) were tested for adaptability to southwest Washington. Edamame, or green vegetable soybeans, are specialty varieties of soybeans that are eaten at the green stage as a vegetable. For the vegetable market, 25 beans must weigh at least 20 g. Experimental procedure was a randomized complete block design with four replications. Recommendations from AVRDC for plant spacing and fertilizer application and timing were followed. In 1995, 13 commercial varieties and 10 AVRDC breeding lines were tested in an on-farm location in Chehalis. At the same location in 1996, 10 of these commercial varieties were again tested along with an additional six commercial varieties. Also in 1996, 12 new AVRDC breeding lines were tested along with the single line that was selected in 1995. Both years, all commercial varieties were harvested more than 40 days later than their advertised days to maturity. Three commercial varieties, White Lion, Shironomai, and Butterbeans, were high-yielding in both years. In 1995, one AVRDC breeding line was selected in Chehalis, and in 1996 five additional AVRDC breeding lines were selected. Earliness is a key factor affecting suitability of commercial varieties and breeding lines to the Chehalis area. In this region, irrigation also appears essential for production of large beans for the vegetable market. Pod weight was not a good indicator of bean weight. Seed was collected in Chehalis from AVRDC breeding lines for use in future trials.

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Dry Matter Allocation and Loss in Jerusalem Artichoke (*Helianthus tuberosus*, L.) during Growth and Field Storage

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Jerusalem artichokes are one of a small number of crops that store carbon predominately in the form of inulin, a straight chain fructosan. There has been a tremendous increase in interest in inulin due to its dietary health benefits for humans and calorie replacement potential in processed foods. We measured the allocation of dry matter within the crop (cv. Sunckoke) during an entire growth cycle by harvesting plants over a 40-week period (2-week intervals) from initial planting through field storage. Plant characters assessed were: no. of basal stems, leaves, branches, flowers, and tubers; the dry weight of leaves, branches, flowers, tubers, and fibrous roots; and date of flowering. Total dry weight of above-ground plant parts increased until 18 weeks after planting (22 Aug.) and then progressively decreased thereafter. Tuber dry weight began to increase rapidly \approx 4 weeks (19 Sept.) after the peak in above-ground dry weight, suggesting that dry matter within the aerial portion of the plant was being recycled into the storage organs. Tuber dry weight continued to increase during the latter part of the growing season, even after the first frost. Final tuber yield was 13.6 MT of dry matter/ha.

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Manual Onion Grading Equipment for Research and Commercial Applications in Developing Countries

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Obtaining equipment for research in developing countries can be difficult, but it is possible to build some simple equipment with local materials. Onion varietal testing for the export market from Central America has been a major emphasis for the Honduran Agricultural Research Foundation. They have been carrying out evaluations since their inception in 1985, but did not have a good way to consistently grade large quantities of onions. To evaluate the yields, simple low-cost, and easily transportable grading equipment was constructed from materials readily available in the domestic market. Grading equipment must give uniform and repeatable results. Two grading systems were designed to provide that consistency. The first was the use of PVC (polyvinylchloride) tubing to construct 3- and 4-inch grading rings. Yellow and sweet onions for export are divided into two classes—jumbo (3-4 inches with 65% 3-1/2 or larger in diameter) and colossal (larger than 4 inches in diameter). Rings were constructed by cutting 1-inch cross-sections of tubing and putting one inside the other until the desired diameter was reached. The rings were functional for small plots, but were not appropriate for large trials. A compact, collapsible grader, easily carried in the back of a small truck or van, was constructed for use on large trials. Local wood and steel bars were used for the section table and sizers. At the same time, growers were looking for a grading system that could be used in areas where there was no electricity. The grader was redesigned for commercial use, but was still

portable. The designs for and cost effectiveness of the grading equipment will be discussed.

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Development of a Cultural Production System for Gobo (Japanese Burdock)

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'Takinogawa Long' gobo was seeded with two, three, or four rows per 1.5-m bed at in-row spacings of 7.5, 15, 21.5, and 30 cm. Total and marketable increased with in-row spacing and marketable yield increased with row number with the greatest yields occurring at 15, regardless of row number. Average root weight and yield of forked roots was not affected by row number, but increased with in row spacing. Similarly, percentage of forked roots decreased with more rows per bed. The 15-cm in-row spacing had the greatest yield, but also the greatest weight of culled roots, but none of the populations affected the percentage culls. In another study, in-row subsoiling (SS) and in-row banded phosphorus (P) were evaluated. Marketable yield was increased by both SS and P, but they did not interact. P increased average root weight. Neither SS or P affected forked root yield or cull root yield, but SS decreased forked roots and increased cull production.

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Yield Mapping of Vegetable Crops

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Over the past few years, grain yield monitors have gained a significant hold in the market place. While the largest share of production agriculture acres are devoted to producing grain crops, high-value crops such as potatoes, tomatoes, sugarbeets, onions, and many others will benefit considerably by application of site-specific technology. Yield mapping is one of the tools that utilizes GPS technology and allows us to visualize our farms as an array of tiny parcels instead of one uniform aggregate. Yield mapping is simple, accurate measurement of yield at precise positions, the data from which is used to give us a visual report card of each parcel in that field. While yield mapping will not provide the entire basis of site-specific agriculture management, it begins to give a picture of how understanding spatial variation will revolutionize management of high-value crop production acres. The tools necessary to make yield measurements are now available. When combined with Differential GPS, the yield map becomes a powerful tool to identify atypical areas in the field. Without DGPS the process of identifying and treating areas within a field individually would be a nearly impossible task, and certainly cost-prohibitive. Identification of the spatial distribution of yield will contribute significantly to a grower's ability to make informed management decisions.

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Vegetable Variety Trial Programs: Opportunities and Challenges at Auburn University

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In 1996, more than 72,000 acres of vegetables were produced in Alabama. This number has been steadily increasing since the mid-1980s. Growers and county agents requested information on which vegetable varieties performed well in Alabama. To support a growing vegetable industry, Auburn Univ. committed itself to developing an extensive vegetable variety trial (VVT) program focusing on rapid dissemination of results. Presently, replicated trials are held at nine experiment stations, each representing a unique growing environment. The VVTs are divided into a spring and fall section. The spring trials evaluate spring/summer planted crops such as tomato, peppers, watermelon, sweetpotato, eggplant, southernpea, lettuce, melons, cucumber, summer squash, and others. Fall trials examine cole crops, winter squash, pumpkin, and other late-summer/fall-planted crops. Turn around time from final harvest of the final crop to placing the report in the county agent's or grower's hands is 2 to 3 months. Good support is received from industry through financial contributions and/or materials. More than 3000 copies of the spring and fall VVT reports are distributed annually at field days, statewide and county meetings, and in direct mailings. Other research projects, such as projects on nutritional composition of vegetables, postharvest quality, and consumer acceptance, have been supported by materials from the VVT program. Without overwhelming support and commitment from the State of Alabama, Auburn Univ.,

grower organizations, and industry, the VVT program would not be the success that it is today providing timely and needed information to strengthen the growing vegetable industry in Alabama.

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From Agronomy to Horticulture: The Diversification of Hawaii's Agriculture

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Sugar cane and pineapple have dominated agriculture in Hawaii for more than 100 years. The plantation system that produced these agronomic crops is now in sharp decline, and a search is underway for horticultural crops, such as macadamia nut, papaya, and potted foliage plants, with which to diversify island agriculture. This paper, using the case study of potatoes and melons, describes the constraints encountered in establishing a 1000-acre farm enterprise on lands made available by the closing of Oahu Sugar Plantation in 1994. The major constraints were 1) a short-term lease with a clause for immediate revocation, 2) the reallocation of irrigation water from agricultural to conservation use, 3) the available plantation work force was ill-prepared for the varied tasks of horticultural production, 4) an irrigation infrastructure not compatible with vegetable production, 5) difficulty in expanding pesticide labels for local use, and 6) the absence of an institution to provide policy and technical assistance in addressing the above constraints.

57 ORAL SESSION 11 (Abstr. 451–455) Human Issues in Horticulture—Children's Gardening

451

Factors that Affect Teachers' Use of School Gardening in the Elementary School Curriculum

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A national survey was conducted of teachers who use school gardening and horticulture as a teaching strategy to enhance student learning within a educational curriculum. The surveyed teachers are employed by schools that were recipients of a Youth Gardening Grant from the National Gardening Assn. in the 1994–95 and 1995–96 school years. The intent of this survey was to define the factors that are crucial to the successful implementation of school gardening into the elementary school curriculum as determined by educators who have already implemented such a program. The survey also described the characteristics of school gardening experiences at these elementary schools. Personal interviews with experienced school gardening educators in Virginia and Maryland verified survey results. Educators reported that the factors most responsible for school gardening success were a person responsible for school gardening activities, a growing site, and funding. Support of the principal and the availability of gardening equipment were also highly rated as success factors. Teachers indicated that, although these factors are important, they are not necessarily available at their individual schools. Responses also included an enormous listing of resources used by teachers to meet their school gardening needs. The survey overwhelmingly indicated that experienced educators view school gardening as a successful teaching strategy to enhance student learning. However, educators rely primarily on their personal knowledge of gardening to implement learning experiences with their students. Teachers feel that although their personal gardening knowledge is adequate, they are greatly interested in continued education in the use of school gardening and horticulture, either as in-service training, Master Gardener training, or for continuing education credit.

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Effect of School Gardens on Environmental Attitudes of Children

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Children develop their personalities and attitudes at an early age. With children spending a large portion of their waking hours in the classroom, schools are a major influence on many factors including environmental attitudes. Studies in human issues in horticulture have focused on how gardens and nature affect other variables in

children, but few have focused on environmental attitudes of children in mainstream school districts. The main goal of this study was to initiate and integrate an environmental education garden program into the curriculum of several schools in the midwest and Texas. One objective of the research project included evaluating whether the students participating in the garden program developed positive environmental attitudes as a result of participation in the garden program. The garden program, Project Green, was designed to provide third- through eighth-grade teachers some basic garden activities that could be infused into their classroom lessons and would serve to reinforce curriculum in various disciplines with hands-on activities. Eight schools, ≈1000 students, took part in the study. Students participating in the study were administered a pre-test prior to participation in the garden program and an identical post-test after its completion. Comparisons were made between children based on age, ethnic background, gender, and length of garden season. Results examine the relationship between the garden program, environmental attitudes of children and demographic variables.

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Project GREEN: The Effect of Gardening on Environmental Attitudes of Elementary School Students

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Project GREEN (Garden Resources for Environmental Education Now!) is an educational tool to assist in the teaching of environmental education at the elementary school level. Project GREEN is different from many current educational practices because its major goal is to provide an interdisciplinary approach to environmental education by infusing activities centered around a hands-on tool, "the garden." The main goal of this project included evaluating whether students participating in Project GREEN were developing positive environmental attitudes. Three schools throughout Texas participated in the study. Approximately 200 students were evaluated; 100 participants served as the experimental group and 100 non-participants served as the control group. Students were evaluated using the Children's Environmental Response Inventory (CERI), which measures students' attitudes about nature and human dominance over nature. This questionnaire also contained a section for biographical information. Comparisons were made between the experimental and control groups, as well as between gender, age, ethnicity, and time in the garden. Results examine the relationship between the garden program and environmental attitudes for both control and experimental groups.

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Impact of Environmental Education Classes at Missouri Botanical Garden on Attitude and Knowledge Change of Elementary School Children

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Two environmental education classes at Missouri Botanical Garden, "The Water Cycle: Making a Terrarium" and "The Tropical Rainforest," were evaluated to determine their effects upon attitude and knowledge change of elementary school children. A pre-test post-test design was used to compare experimental and control groups. Data indicated that The Water Cycle: Making a Terrarium class had a positive influence on attitudes toward learning about plants and the environment; The Tropical Rainforest class had no effect. Neither of the classes significantly affected the children's attitudes toward interacting with the environment. Both classes increased the knowledge base of participating children. There were no differences between male and female attitudes or knowledge in either class. Nonformal learning experiences of this type may be a more effective means of stimulating horticultural interest among younger children than traditional classroom settings. [Affiliation. The research was conducted at Southern Illinois Univ. in the Plant and Soil Science Dept.]

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The Effects of the Green Brigade Program on Horticultural Knowledge, Attitudes, and Behavioral Changes of Juvenile Offenders

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The Green Brigade, organized by the Bexar County Agricultural Extension Service in San Antonio, Texas, is a community-based horticultural program for juvenile offenders based on the earn while learning philosophy. This study determined if participation in the Green Brigade Program improved self-esteem, locus of control, interpersonal relationships, and attitudes toward school, toward gardening and

toward the environment as well as decreased recidivism of juvenile offenders. To measure psychological variables, a pre-test, post-test design was implemented using the Self-Report of Personality from The Behavior Assessment System for Children (BASC). A questionnaire, developed by the researchers, measured environmental attitudes as well as basic horticultural knowledge. Youths participating in the Green Brigade were pre-tested on the first day of the session and post-tested on the final day of the 6-month session. Comparisons were made between children based on age, ethnic background, gender, and session of the Green Brigade in which they participated. Results determined the relationship between participation in the Green Brigade and the dependent variables mentioned previously.

58 ORAL SESSION 12 (Abstr. 456–461) Culture & Management—Small Fruits/ Viticulture

456

Polyethylene Mulch, Diurnal and Seasonal Soil Temperatures, and Growth and Productivity of Strawberries in Southern California

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Southern California strawberry growers use clear polyethylene mulch to increase soil warming and promote plant growth and fruiting, but use of clear poly mulch is only feasible when effective preplant soil fumigation controls weeds. In the absence of methyl bromide fumigation, the use of wave-length selective (WLS) or black polyethylene bed mulches may be required for adequate weed suppression, but the influence of these materials on strawberry plant growth and productivity in southern California is not well-documented. We conducted experiments in 1994–95 and 1995–96 to determine the influence of various mulch formulations on soil temperature and growth and productivity of 'Chandler' strawberry in Irvine, Calif. Clear poly and a green WLS material (IRT76, AEP Plastics) were compared in both trials; in addition, the 1995–96 trial included a brown WLS material (ALOR, PolyWest, Inc.) and a black poly mulch. For both trials, freshly dug runner plants were established in pre-mulched beds in early October, and soil temperatures were continuously monitored at a 10-cm depth using thermocouples and a recording datalogger. Fruit harvest commenced in December and continued through June. In both years, clear poly mulch resulted in significantly greater soil temperatures, greater December plant diameters, and greater early and total fruit yields than other mulches. In both years, use of clear poly resulted in 12% greater fruit yields than the other three materials. No growth or productivity differences were observed among the WLS and black mulches, although differences were observed in mean soil temperatures.

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Comparing Solarization Soil Treatment with Methyl-bromide Soil Fumigation on Strawberries

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There is a great deal of interest in the possibility of developing suitable materials or procedures for use in strawberries and other crops in place of methyl-bromide as a soil fumigant. One such has been soil heating resulting from the bed application of transparent polyethylene. This requires high mid-summer soil temperatures with relatively high soil humidity. We present the results of a solarization experiment. Bed soil temperature were measured regularly at a depth of 12 cm through the 9 weeks of differential treatments. The soil temperature differences were highly significant, averaging $\approx 7^\circ\text{C}$ higher than the non-solarized treatments. Weed control is one of the results of high interest. The number of weeds were counted twice. The number in the solar plots were not significantly different from the number counted for the methyl-bromide-fumigated plots. Vegetative vigor (asexual response) was also an important measurement. This was measured in two ways: first, the number of runners, and second, the measurement of plant size. The results were identical. The solarized plots and fumigated plots were identical in plant size and identical in runner production, and both were significantly different from the non-solarized and non-fumigated plots. Similar results were obtained for the sexual responses, yield, and fruit size. Solarization should be tested sufficiently in detail as a possible procedure to replace some methyl-bromide fumigation.

The biggest problem may be difficulty getting the temperature high enough to be adequately effective.

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Transplant Container Shape and Strawberry Transplant Growth

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Bare-root strawberry transplants have been conventionally used for establishment of strawberry fruiting fields. These bare-root transplants have variability in vegetative vigor that results in irregular flowering patterns. We have been experimenting with a containerized transplant system to produce uniform transplants. Increasing transplant container volume by increasing perimeter, rather than depth, has resulted in increased plant size, but also increases transplant production costs. This study evaluated three container perimeters (17, 25, 32 cm) and three container shapes (circular, elliptical, and biconvex) such that different cell perimeters had the same greatest diameter. All containers had a depth of 3.5 cm. Root imaging analysis (MacRHIZOTM) was used to measure root growth in the container as well as root growth 3 and 6 weeks after transplanting. Increasing container perimeter led to increased plant growth before and after transplanting, but did not affect fruit production. Transplant container shape did not significantly alter plant growth or fruit production. Biconvex and elliptical containers required 25% and 15% less surface area, respectively. Therefore, a biconvex shaped container can be used to increase plant density during transplant propagation, decreasing surface area needed and reducing production costs.

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Cultivar Variation in Responses of Strawberry Fruit to High Carbon Dioxide Treatments

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The tolerances of strawberry fruit to postharvest CO₂ treatments is an important factor in assessing their potential for extended storage and marketing, but little information on variation among cultivars is available. We have assessed differences in responses of seven strawberry cultivars ('Annapolis', 'Earliglow', 'Kent', 'Honeoye', 'Cavendish', 'Jewel', and 'Governor Simcoe') to high-CO₂ atmospheres. Fruit were harvested at the orange or white tip stage of ripeness, kept in air, or 20% CO₂ (in air), and sampled after 1, 2, or 7 days for analysis of firmness, color, and volatile concentrations. Berries from each cultivar were collected on three separate harvest dates. Flesh firmness measurements of all cultivars tested were higher when treated with high CO₂, but the degree of firming was affected by cultivar and assessment time. For example, firmness of 'Annapolis', 'Earliglow', 'Honeoye', and 'Jewel' was consistently enhanced by CO₂, compared with air, during storage. In contrast, firmness of 'Kent' was not affected by treatment after 1 day of storage and benefits were relatively slight at each subsequent removal. Red color development of the fruits was affected by cultivar and treatment period, but not by CO₂ treatment. Volatile accumulation varied greatly among cultivars. 'Annapolis' for example, appears very tolerant of high-CO₂ treatment levels as indicated by low accumulations of ethanol, acetaldehyde, and ethyl acetate in the fruit. In contrast, 'Kent' and 'Governor Simcoe' accumulated large amounts of these compounds. This study indicates that differences in cultivar responses to CO₂ should be considered by growers planning to store fruit under these conditions to extend marketing options. Research supported in part by the North American Strawberry Growers Association.

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E-2-Hexenal Can Both Stimulate and Inhibit Botrytis Growth In Vitro and on Strawberry Fruit In Vivo

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Some plant-derived natural volatile compounds exhibit antifungal properties and may offer a tremendous opportunity to control the causes of postharvest spoilage without affecting fresh produce quality or leaving a residue on the produce. E-2-hexenal has shown significant potential for use as a fumigant for controlling *Botrytis cinerea* in prior studies. In vitro studies on the mode of action of E-2-hexenal, mycelial growth and percent spore germination were

inversely proportional to concentrations of the compound. Spore germination was found to be more susceptible to the compound than mycelial growth. Much higher concentrations of E-2-hexenal were required to inhibit mycelial growth than spore germination. Lower concentrations of the compound significantly stimulated mycelial growth, especially when the volatile was added 2 days following inoculation. Light microscopy analysis revealed that a high concentration of the volatile damaged fungal cell wall and membranes. Treatment with a high vapor phase level of E-2-hexenal during postharvest storage of strawberry fruit at 2°C prevented botrytis development in a subsequent storage period at 15°C. However, treatment with a low vapor phase level enhanced botrytis development. The implications of these results with respect to the practical use of E-2-hexenal and other natural volatile compounds will be discussed.

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Is Strawberry Clipper (*Anthonomus signatus*) an Economically Important Pest?

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Strawberry clipper is considered to be a major pest on matted-row strawberries in the northern U.S. and Canada. This pest is thought to be so threatening that even a single clipped bud indicates the potential for serious and rapid damage. Conventional wisdom states that fields should be treated for clipper during warm weather if they have a history of clipper damage—even if fields have not been scouted. Thresholds (five clipped buds per meter) are based on the assumption that one clipped bud is equivalent to the loss of one average-sized berry. However, our data show no correlation between clipper damage and yield in field surveys, and our artificial clipping studies have found that strawberry plants have the ability to compensate for flower bud loss by increasing allocation to other fruits. For example, in plots of cv. Jewel, no significant difference was found in total yields between plots with no flower bud removal and plots with all primary flower buds removed (an average of 100 clipped buds per meter)—so long as the clipping happened early in the season. An increase in the size of secondary and tertiary fruit balanced the reduced fruit numbers. Similar trends were found with Kent. The ability to compensate for early flower bud loss also was assessed in a separate study with 10 strawberry cultivars. These studies suggest that our current threshold for clipper may be nearly two orders of magnitude too low, and that clipper may not be a true economic pest of strawberry.

64 ORAL SESSION 13 (Abstr. 462–469) Culture & Management—Fruits/Nuts

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Cropping Effects on Flower Development of 'Royal Gala' Apple

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Spurs were collected periodically throughout three growing seasons from the 1-year-old section of wood of 'Royal Gala' trees growing in New Zealand. Three classes of spurs were sampled: purely vegetative spurs, those that flowered but did not carry fruit, and spurs on which a single fruit was borne. The bourse bud, in which flowers may form for the following year's crop, was dissected and bud appendages classified and counted. In addition, axillary buds from current-season shoots were sampled and dissected. Over the period 50–200 days after full bloom, the number of appendages in buds on vegetative spurs increased from ≈14 to 22, whereas the increase in buds on fruiting spurs was 14 to 20. In contrast, axillary bud appendage numbers increased from ≈11 to 14 over this period. By the end of the growing season, flowers were evident in a high proportion of buds of all classes. The critical appendage number at which the change from a vegetative to floral status became visible was ≈18 for spurs on 1-year-old wood, but 13 for axillary buds. The time at which flowers were able to form varied among years. The degree of flower differentiation that occurred prior to leaf fall was highest in vegetative buds and was reduced by flowering and fruiting, and was lowest in axillary buds.

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Effect of Spacing and Rectangularity on Tree Growth, Yield, Light Interception, and Fruit Quality of Y-trellis-trained Apple Trees

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In 1986, an orchard systems trial was planted with 'Empire' and 'Jonagold' on M.26 rootstock to compare the performance of the Y-trellis training system at a range of spacings and rectangularities. There were four in-row spacings ranging from 90 cm to 3.66 m and four between-row spacings ranging from 3 to 6 m, giving tree densities from 472 trees/ha up to 3588 trees/acre. Rectangularities ranged from 0.83 to 6.67. In several cases, different spacings gave the same tree density, but with different rectangularity. Trees were trained to a Y-shaped trellis with a 60° angle. Scaffold branches were trained to the wires on each side of the Y in a fan-shaped arrangement. At the closest in-row spacing only two scaffolds were allowed per tree, while at the widest in-row spacing up to 12 scaffolds were allowed per tree. At the end of 11 years, tree weight and cumulative yield per tree were negatively correlated to tree density, while light interception and cumulative yield per hectare were positively correlated to tree density. However, the relationship was weakened by differing results with different rectangularities at the same spacing. As rectangularity increased at a given density, tree size, yield, and light interception were reduced. However, at the lower densities, trees failed to completely fill the trellis when rectangularity was low, thus limiting yield per hectare. Fruit red color was reduced at the highest densities and increased with increasing rectangularity.

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Morphology of Two-year-old Limb Sections and Mid-season Spur Quality of Four Apple Cultivars on Five Dwarfing Rootstocks

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This study was conducted at three locations (Manhattan, Kan.; Wichita, Kan.; Wooster, Ohio) for 3 years (1994–1996). At bloom, 2-year-old limb sections from 'Smoothie', 'Jonagold', 'Empire', and 'Rome' on M.9EMLA, Bud 9, Mark, Ottawa 3, or M.26EMLA were evaluated for flowering and vegetative, spurs (5 cm or less), short shoots (5–15 cm) and long shoots (>15 cm). In mid-August, spur quality was estimated by randomly selecting five spurs per cultivar rootstock combination. There were significant location and year differences for all the morphological and spur quality characters measured. Across locations and years, the following characteristics were consistently high for the cultivars listed: stem density of flowering spurs for 'Empire'; and leaf area, bud-diameter and average leaf size per spur for 'Jonagold'. The most consistently high characteristics across locations and years for the rootstocks were for stem density of flowering spurs for Mark and leaf number, leaf area, bud-diameter, and average leaf size per spur for M.26EMLA. Stem density for flowering short shoots was highest for 'Smoothie' and M.9EMLA in Wooster, 'Jonagold' and Bud 9 in Wichita and 'Rome', 'Jonagold', and Bud 9 in Manhattan. Flowering long shoot stem density was highest for 'Smoothie', 'Jonagold', and M.26EMLA in Wooster, 'Smoothie' in Wichita, and 'Jonagold' and Ottawa 3 in Manhattan. There were some significant cultivar by rootstock interactions. The most-consistent interactions across locations and years were for stem cross-sectional area, stem length, stem density of flowering spurs, and flowering short shoots and bud-diameter per spur.

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Increasing Tree Complexity and Bearing Potential in Young 'Fuji' Apple Trees

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Under typical South African growing conditions, 'Fuji' apple (*Malus domestica* Borkh.) trees are characterized by strong apical dominance during the first few years after planting. This, together with the current lack of suitable precocious rootstocks and the tip-bearing habit, causes willowy "blind wood" growth with few flowering positions, and delays bearing until the third leaf when a crop of less than 10 tons/hectare can be realized. Promalin (GA₄₊₇) and benzyladenine,

Abbott Laboratories) was used in combination with apical meristem defoliation and Agral or Armoblen as surfactant/penetrant to induce sylleptic shoot growth in an effort to increase tree complexity (i.e., branching) without having to resort to pruning, which is dwarfing and delays bearing. The treatments were tested on 'Fuji' grafts, 1-year old trees and 2-year old trees in the 1993–1994, 1994–1995, and 1995–1996 seasons, respectively. Concentrations tested were 0, 500, 750, or 1000 ppm, as single or multiple applications in spring. In all trials, randomized, complete block designs were used. Control trees had few, if any, sylleptic shoots or spurs, whereas Promalin in combination with leaf removal or in combination with Armoblen caused significant sylleptic growth to occur. Generally, multiple applications spaced fortnightly, gave best results. Sylleptic shoots were ≈15 cm long, terminated in a reproductive bud, and did not influence the length of the "mother" shoot or the trunk circumference. Based on these results, a combination of multiple applications of 500 ppm Promalin with Armoblen as penetrant, and no leaf removal, is being tested semi-commercially this season.

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Performance of Eight Apomitic Selections as Apple Rootstocks

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In 1987, 'Starkspur Supreme Delicious' and 'Melrose' were planted on eight apomitic apple selections made in Germany by Dr. Hanna Schmidt for use as rootstocks and compared to trees on M.7. Selection 2, was the most precocious, followed by trees on M.7, with selections 1 and 7 being less precocious than M.7. Selections 2 and 8 were 25% larger than M.7, while 1, 3, 4, and 7 were similar in size and 5 was 15% smaller than trees on M.7. Selections 2 and 8 had the highest cumulative yields/tree, followed by trees on M.7, with all other selections having lower yields. Internal bark necrosis (IBN) developed on the 'Delicious' trees, with the most-severe symptoms on selections 1, 3, 4, 5, 6, and 7, with less-severe symptoms on 8 and very little present on trees on M.7. IBN was correlated with leaf Mn levels. In 1995, the highest density of flowering spurs occurred on M.7 and selections 3 and 7, with lower densities in selections 2 and 5. Selection 2 had the highest density of non-flowering spurs, followed by selection 5, with all others having lower densities similar to trees on M.7.

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Impact of Temperature on Apple Fruit Growth

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Apple fruitlet growth responses to temperature were studied, for different durations following bloom (DAFB), under controlled environment (CE) conditions. Container-grown trees of 'Red Delicious', 'Golden Delicious', 'Braeburn', 'Fuji', and 'Royal Gala' were placed in different maximum/minimum temperature regimes, ranging from 9/3 to 25/15°C for various periods, including 10–40, 10–80, and 40–80 DAFB. Temperature treatments were selected to identify possible differences between mean and maximum/minimum differential effects. Trees were placed outdoors following the CE treatment to allow impacts on subsequent fruit development to be determined. The impact of temperature was dramatic. For example, fruit expansion rate for 'Red Delicious' varied from 0.12 mm/day at 9/3°C to 0.98 mm/day at 25/15°C. Furthermore, the cell division phase was considerably longer under cooler temperatures. The influence of post-bloom temperature, for even short durations, was evident at harvest in both fruit size and in different fruit maturity indices. Differences in temperature sensitivity were evident amongscultivars. A detailed model has been developed to integrate the responses that have been determined.

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Shading and Leaf Age Effects on Total Phenolic Content and Specific Leaf Weight of Apple

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The effects of shading and leaf age on the production of foliar phenolics of two apple (*Malus domestica* Borkh.) cultivars, 'Liberty' and 'Red Rome Beauty', were studied. Potted trees were grown outdoors and their leaves tagged weekly when they reached 20 mm in length. This process continued for the duration of the experiment. At 3 weeks from budbreak, the trees were placed in three shade treatments: 0% shade (control), 60% shade, and 90% shade. After 5 weeks, the leaves were collected for phenolic assay. Specific leaf weight (SLW) was determined

from the leaf below the tagged leaf. Shade significantly affected the total phenolic content. Leaves in 0% shade had the highest levels of total phenolics. The phenolic content decreased with increasing shade, with trees in 90% shade having a 72% reduction in total phenolics. There was a significant shade by leaf age interaction. There was a decrease in total phenolic content with increasing leaf age except for those leaves whose development occurred before the experiment was started. The 1-week-old leaf had the highest phenolic content, while 4-week-old leaf had the lowest amount. The 5- and 6-week-old leaves that had been tagged prior to the onset of the shade treatments has similar phenolic content in all treatment. SLW significantly decreased with increasing shade and increased with leaf age. Results of this study indicate that light and leaf developmental stage are important factors in the total foliar phenolic content, but, once phenolics are synthesized, shading does not affect their content.

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ReTain™, A New Harvest Management Tool for Apple Production

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ReTain™ is an organic, water-soluble formulation that contains 15% (w/w) of aminoethoxy-vinylglycine (AVG). AVG, a naturally occurring plant growth regulator, competitively inhibits ACC (1-aminocyclopropane-1-carboxylic acid) synthase, the enzyme responsible for the conversion of S-adenosylmethionine (SAM) to ACC, the immediate precursor of ethylene in plants. ReTain has been under commercial development for the past 6 years, which includes U.S. EPA-approved Experimental Use Permit (EUP) programs in 1995 (Shafer et al., 1996, Proc 23rd Annu. PGRSA Mtg., p. 233–234) and 1996. Under the 1996 EUP, ReTain was tested on nearly 4000 acres of apples in 18 states. When used according to label directions (i.e., 50 g AVG/acre applied 4 weeks before anticipated harvest) with a nonionic surfactant, ReTain effectively reduced preharvest drop and generally resulted in fruit of higher quality than untreated (control) or naphthaleneacetic acid (NAA)-treated fruit. ReTain can delay fruit maturity (as indexed by starch conversion) by ≈7 to 10 days. ReTain-treated fruit were typically firmer (by 0.5 to 1.0 lb), produced significantly less ethylene, and maintained notably greater firmness through storage. The incidence and severity of watercore in 'Delicious' was significantly reduced by ReTain, as was the frequency of fruit cracking in 'Fuji' and 'Gala' in several trials. Based on this benefit profile, ReTain can be an effective harvest management tool for apple growers. U.S. EPA approval for the commercial registration of ReTain is anticipated prior to the 1997 use season.

65 ORAL SESSION 14 (Abstr. 470–477) Characterization, Evaluation, Utilization– Landscape Plants

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Physioecological Characteristics of *Hanabusaya asiatica*

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In an attempt to obtain the basic data for the development of *Hanabusaya asiatica* as horticultural plants, studies were conducted on the habitat environment, ecological characteristics, various treatments for breaking seed dormancy, and morphological and flowering characteristics of *H. asiatica* at different growth stages. *Hanabusaya asiatica* was distributed around areas of 850–1400 m above sea level with an inclination of 5–43°. The vegetation structure of *H. asiatica* was represented in groups as *Quercus mongolica* and *H. asiatica*. In a subgroup, *Symplocos chinensis* v. *leucocarpa* for. *pilosa*, *Magnolia sieboldii*, and *Acer mono* were included. Indication species of *Quercus mongolica* and *H. asiatica* were *Quercus mongolica* (B1 layer), *Tilia amurensis* (B2 layer), *Rhododendron schlippenbachii* (S layer), *Ainsliaea acerifolia* v. *subapoda*, *Athyrium nipponicum*, *Spuriopimpinella brachycarpa*, and *Carex siderostica* (K layer). Soil pH was about 5.4, and soil fertility was relatively in a good condition. The optimum conditions

for seed germination was at 25Y.

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Foliar Morphology and Anatomy of Hard Maples Vary with Geographic Origin

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Differences in foliar morphology and anatomy of hard maples (*Acer saccharum* Marsh. and *Acer nigrum* Michx. f.) may explain contrasting responses to moisture stress of these species. We conducted a 2-year study to examine leaf morphology and anatomy of populations of hard maples indigenous near the 43°N latitude from 94°W longitude in Iowa to the 71°W longitude in Maine. Leaves were collected from shoots exposed to direct solar radiation on multiple trees at each of 24 sites in 1995, and at 36 sites in 1996. Samples collected in 1995 showed stomate frequency on the abaxial leaf surface ranged from 380 to 760 stomata/mm². Mean guard cell pair width and length were 16 and 17 μm, respectively. Stomate frequency related quadratically to longitude, was greatest for leaves from Iowa, and was negatively correlated with mean annual precipitation of the sample site. Leaf thickness did not vary with longitude and averaged 96 μm. Palisade thickness showed a greater correlation than mesophyll thickness to total leaf thickness. Mesophyll thickness was more highly correlated than palisade thickness to specific leaf mass, which did not vary with longitude and averaged 5.2 mg·cm⁻². Analysis of leaves collected over both years showed trichome frequency and lamina area were related quadratically to longitude; the largest and most pubescent laminae were from westerly sites. These studies are being coordinated with greenhouse experiments on responses of seedlings from selected populations to moisture deficits.

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Survival and Growth of Amur maackia Seedlings Across North America

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Amur maackia (*Maackia amurensis* Rupr. & Maxim.) has potential for use in small, urban, or cold landscapes. Although Amur maackia is becoming increasingly popular, plants are currently grown from open-pollinated seed populations, and there has been no selection of cultivars. We have addressed the effects of climate on growth and have begun field trials for selection of horticulturally superior genotypes. In May 1995, a field trial near Ames was begun with 337 plants. These were selected from more than 2000 greenhouse-grown seedlings to represent 32 half-sibling seed groups from 16 arboreta across North America. After two growing seasons, the increase in stem length among seed groups ranged from 3% to 75%. Survival rate did not vary with seed group. In a related study, 30 plants from six half-sibling groups have been established at each of 10 sites in the U.S. and four in Canada to assess effects of location on survival and growth. The influence of seed group on survival after 1 year varied with the trial site location. Survival among combinations of half-sibling group and trial location ranged from 0% to 100% (mean = 54%). Half-sibling group and trial location affected growth without interaction. The greatest growth across locations, an 83% increase in stem length, was shown by seeds that originated from a tree at the Arnold Arboretum. At the 14 locations, changes in stem length over half-sibling groups varied from <0% in Ithaca, N.Y., to 179% in Puyallup, Wash.

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Drought Resistance among Freeman Maples

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Freeman maples (*Acer x freemanii* E. Murray) are marketed as stress-resistant alternatives to red maples (*Acer rubrum* L.), but few data from direct comparisons of these species are available. As a first step in comparing the stress resistance of red maple and Freeman maple, responses to drought were studied in *Acer x freemanii* 'Autumn Fantasy', 'Celebration', and 'Marmo'. Plants grown from rooted cuttings were treated by withholding irrigation through four drought cycles of increasing severity that were separated by irrigation to container capacity. Drought reduced shoot dry mass, root dry mass, and height growth by 64%, 43%, and 79%, respectively, over all cultivars. Predawn leaf water potential was reduced by 1.16 MPa over all cultivars, and stomatal conductance data indicated water

use was more conservative over all root-zone moisture contents after repeated cycles of drought. Specific mass of drought-stressed leaves increased by 25% for 'Autumn Fantasy', and microscopy to determine leaf thickness and cellular anatomy is ongoing. 'Autumn Fantasy' also had the lowest ratio of leaf surface area to xylem diameter, and 'Autumn Fantasy' and 'Celebration' had higher ratios of root to shoot mass than 'Marmo'. Pressure-volume curve analysis revealed osmotic potential of drought-stressed plants at full turgor was 0.24 MPa more negative than controls, and droughted plants had a greater apoplastic water percentage than controls. Although osmotic adjustment during drought was similar among cultivars, differences in specific mass of leaves and in ratios of transpiring and conducting tissues suggest cultivars of Freeman maple vary in resistance to drought in the landscape.

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Lowest Survival Temperature (LST) Estimations in *Kalmia*, *Viburnum*, and *Magnolia* by Controlled Freezing

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Stems of 38 varieties of *Kalmia latifolia*, 33 varieties of *Viburnum*, and 45 varieties of *Magnolia* were screened for low-temperature tolerance on eight dates during the winters of 1995–96 and 1996–97. Terminal 6- to 8-cm stem cuttings were shipped overnight on ice to Orono, Maine, and processed immediately upon arrival. Cuttings were subjected to a controlled freezing regime with a lowest test temperature ranging from -31°C to -42°C. Following freezing, stems were incubated for 5 to 14 days at 21°C and evaluated for injury. Lowest survival temperatures (LST) for each variety were estimated as the lowest temperature at which 100% of stems were undamaged. Varieties of *Viburnum dentatum*, *V. lantana*, *V. opulus*, and *V. trilobum* were rated as consistently very cold-tolerant, with LSTs of at least -36°C on all test dates. All *V. plicatum* var. *tomentosum* varieties showed inconsistent survival and LST estimations. Midwinter LST estimates in *Kalmia latifolia* showed 40% of the tested varieties remained undamaged at or below -36°C. Ten percent of *K. latifolia* varieties tested were damaged at -24°C or warmer, with the remaining varieties having LSTs somewhere between -24°C and -40°C. Varieties of *Magnolia* showed inconsistent survival with LSTs estimated for only 5% of those tested. Direct comparisons by variety, test date and source will be discussed with emphasis on consistent LST estimation. Varieties of *K. latifolia*, *Viburnum*, and *Magnolia* best suited for use in northern landscapes will also be discussed.

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Low-temperature Tolerance of Testing Woody Ornamental Plants: A Comparison of Ice-seeded vs. Nonseeded Methodologies

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Accurate assessment of the low-temperature tolerance of woody landscape plants is essential to ensure proper siting and use of specific varieties in the landscape. Laboratory determination of lowest survival temperature (LST) has become a popular area of study in recent years, yet there has been no standardization of technique among the many labs conducting this work. One of the major differences in technique employed across the country is the presence or absence of ice seeding of samples prior to the testing procedure. This presentation will present results of a series of studies conducted to determine the need for and efficacy of ice seeding treatments for LST determination in woody plants. A series of four studies was conducted over a 3-year period to test the difference in LST estimation with and without ice seeding. Twenty-two taxa, including both deciduous and evergreen species, were subjected to controlled freezing at ≈4°C/hr. with test samples removed from the freezer every 3°C. Following a 24-hr thaw and 5 to 7 days of incubation at 21°C, 100% RH, stems were sliced longitudinally and visually assessed for damage to vascular tissues. In the majority of cases, ice seeding was determined to have no significant affect on LST determination. In several species (*Kalmia latifolia*, *Vaccinium angustifolium*), the introduction of ice seeding into the protocol resulted in greater variation and less distinct determination of LST.

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Ornamental Landscape Potential of Several *Ribes* Species

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Several species of *Ribes* have ornamental qualities worthy of consideration in residential and commercial temperate zone landscape plantings. *Ribes sanguineum* Pursh has been selected and cultivated throughout the Pacific Northwest, and boasts of early spring flowers of white, pink, or red. The two species of golden currants, *R. aureum* Pursh and *R. odoratum* Wendl. f., have brilliant yellow-flowered racemes. *Ribes* species exhibit a broad diversity of plant habit and texture ranging from the upright 2.5 m, vigorous, and fully armed Menzies Gooseberry, *R. menziesii* Pursh, to the prostrate shade-loving Crater Lake currant, *R. erythrocarpum* Coville & Leiberg. *R. viburnifolium* A. Gray remains evergreen in mild climates throughout the year. The foliage of some selections of *R. americanum* Miller and *R. cynosbati* L. brighten to a brilliant crimson red in the fall. The fall foliage of other species, such as *R. hirsuta* L., develop a continuum of color on their branches, from bright red at the apex, through orange and yellow to green towards the base. Spring bloom data and ratings of fall color for species in the Corvallis Repository collection will be described.

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The Influence of Vegetation on UHIs, MUHIs, and Microclimate of Selected Southern Cities

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Urban areas have average annual temperatures 2–3°C warmer than surrounding rural areas, with daily differences of 5–6°C common. A suggested reason for this temperature difference is the extensive use of concrete, asphalt, and other building materials in the urban environment. Vegetation can moderate these temperatures by intercepting incoming radiation. The influence of vegetation patterns on the magnitude of urban and micro-urban "heat islands" (UHI and MUHI, respectively) is compared for several cities including Houston, Austin, College Station, and Ft. Worth, Texas; Huntsville, Ala.; and Gainesville, Fla. Temperatures for all cities studied were greatest in the built-up areas and dropped off in suburban areas and adjacent rural areas. In Houston, surrounding rice fields were 3–5°C cooler than urban areas. Heavily built-up areas of Austin were 2–4°C warmer than parks and fields outside of the city. In all of the cities, large parks were typically 2–3°C cooler than adjacent built-up areas. Large shopping malls varied in nocturnal winter and summer temperature, with winter temperatures near door openings 2–3°C warmer, and summer daytime temperatures as much as 17°C cooler beneath trees. This effect seemed to persist at the microclimatic scale. Areas beneath evergreen trees and shrubs were warmer in the winter than surrounding grass covered areas. Video thermography indicated that the lower surfaces of limbs in deciduous trees were warmer than the upper surfaces. Overall, vegetation played a significant role, both at the local and microscale, in temperature moderation.

66 ORAL SESSION 15 (Abstr. 478–484) Plant Growth Regulators/Marketing– Floriculture/Foliage

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Growth Regulator Effects on Development of Three Bedding Plant Plugs

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Salvia (*Salvia splendens* F.), vinca (*Catharanthus roseus* L.), and pansy (*Viola x wittrockiana* Gams.) were examined to determine efficacy of growth retardants for inhibiting stem elongation of seedlings in the plug stage and after transplanting to 10-cm pots. Studies on salvia showed plugs sprayed with single applications of ancymidol at 10 or 20 ppm, paclobutrazol at 30 or 60 ppm, or daminozide/chlormequat tank mix at 2500/1500 ppm inhibited plug elongation by 17% to 22%. Pansy plugs were sprayed either once or twice with ancymidol at 5, 10, or 15 ppm. Number of applications was statistically significant with two applications reducing elongation by an average of 35%, whereas a single application resulted in a 23% average reduction. Ancymidol concentration was significant in reducing stem elongation with increasing rates in pansy; however, the concentration and application time interaction was not significant. In both pansy and salvia, plant size

at flowering was similar to controls after transplanting. Vinca plugs were sprayed with ancymidol at 5, 10, or 15 ppm either the 3rd week, 4th week, or both weeks after sowing. As ancymidol concentrations increased, plug height decreased, and the concentration effect was greater week 3 than at week 4. Two applications of ancymidol was most effective in retarding stem elongation (36%) followed by one spray the 3rd week (29%) and one spray during week 4 (20%).

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Application of Growth Retardants in Subirrigation Water

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Trials involving growth retardants applied in subirrigation water were conducted to evaluate the potential for this method of application and to determine critical concentrations for production of several floriculture crops. Eight concentrations of paclobutrazol or ancymidol ranging from 0 to 0.1 mg·liter⁻¹ were applied continuously (from planting) to five crops. Based upon regression equations, paclobutrazol concentrations resulting in 20% size reduction were 0.005, 0.024, 0.017, >0.1, and >0.1 mg·liter⁻¹ for begonia, chrysanthemum, impatiens, petunia, and salvia, respectively; for ancymidol, respective concentrations were 0.003, 0.01, 0.10, >0.1, and 0.058 mg·liter⁻¹. A second set of trials compared the efficacy of a one-time vs. continuous application of paclobutrazol via subirrigation starting at 2 to 3 weeks after planting. For begonia, a one-time subirrigation application of 0.01 mg·liter⁻¹ paclobutrazol resulted in 30% size reduction, while 0.003 mg·liter⁻¹ applied continuously resulted in 20% size reduction. For impatiens, a one-time subirrigation application of 0.1 mg·liter⁻¹ paclobutrazol resulted in 31% size reduction while 0.03 mg·liter⁻¹ applied continuously resulted in 40% size reduction.

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Chemical Regulation of Growth of Perennial Bedding Plants

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Perennial growers experience marketing difficulty when the stem length, or height of their perennial stock is excessive. Both wholesale and retail outlets desire to keep height to a minimum, while still promoting the production of flowers. The objective of this study was to screen containerized, spring-planted perennials for response to the growth retardants Sumagic, Bonzi, and B-Nine. Each perennial variety used was treated with B-Nine (Daminozide at 5000 ppm Bonzi (paclobutrazol) at 240 ppm, and Sumagic (uniconazole-P) at the following rates: 0, 40, 80, 120, and 160 ppm. Pre-cooled plugs of cultivars were selected from the genera Achillea, Coreopsis, Echinaceae, Digitalis, Gaillardia, Phlox, Rudbeckia, Alcea, Veronica, and Monarda. A randomized complete block design was implemented. Eight of the nine cultivars were responsive to Sumagic, with a 12% to 79% range of reduction in height. Seven cultivars were responsive to Bonzi with a 20% to 61% range of reduction. Only one cultivar was responsive to B-Nine, requiring two applications of 5000 ppm, to yield a 22% reduction in height at 4WAT. Based upon growers' desire for up to 50% height reduction, a 30% height reduction assessment point was established as a minimum rate for production, and a 50% to 60% reduction was established as the maximum landscape rate (based upon in-landscape persistence).

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Cutting Production of Poinsettia Cultigens Grown in Central Florida

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Production of stock plants is essential for the asexual propagation of poinsettia, but variability exists among cultigens in the development of axillary shoots under high day/night temperatures of central Florida. Thirty-eight and 44 cultigens were grown during 1995 and 1996, respectively, and were evaluated for cutting production and subsequent growth of harvested cuttings. Plants were pruned twice prior to cutting harvest, with a projected cutting number of 21 in 1995 and 27 in 1996. Cuttings were graded into three groups based upon stem caliper and overall quality: #1, #2, and cull. Number of #1 cuttings/plant in 1995 ranged from 3.4 to 18.6, represented by 'Cortez' and 'Ball 838', respectively; a majority of the cultigens produced between 14 and 16 cuttings in the top grade. Number of usable (#1 and #2) cuttings ranged from 4.9 to 30.0, represented by 'Cortez' and 'Jolly Red', respectively, with a mean of 20.2. Stem caliper of cuttings measured

7 cm from terminal apex ranged from 0.55 cm of 'Mikkel 520' to 0.91 cm of 'Ball 838'. Cuttings of 'Cortez' and 'Red Splendor' had poor lateral development. During 1996, number of #1 cuttings ranged from 9.8 ('Picacho') to 22.2 ('Freedom'), with a mean of 16.6. Number of usable cuttings ranged from 14.2 to 31.9, represented by 'Cortez' and 'Spotlight Dark Red', with a mean of 25.3. Stem caliper ranged from 0.55 cm ('Ball 865') to 0.79 cm ('Supjibi'). Cuttings taken from plants of the 'Cortez' series produced few, if any, laterals, while 'Marblestar' and 'Jolly Red' had up to 50% aborted axillary buds.

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Whole Plant and Histological Analysis of Poinsettia Stem Breakage

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Poinsettia stem breakage reduces plant quality and marketability. The cultivar 'Freedom' is susceptible to stem breakage; however, the severity of stem breakage varies with crop and year. The following four experiments were conducted to determine the factors that influence stem breakage of 'Freedom' poinsettias: 1) Cutting Stem Diameter. Cuttings were graded by stem diameter into small (5.0–5.4 mm), medium (6.0–6.7 mm), and large (7.3–8.3 mm) cuttings. 2) Premature Lateral Shoot Development. Small (1- to 3-cm-long) leaves near the shoot tip of the rooted cuttings were excised to remove the lateral shoots from apical dominance prior to pinching, thus causing the lateral shoots to develop prematurely. 3) Container Spacing. The control group was spaced to 35.6 x 35.6 cm at the time of pinching. The plants in one treatment were spaced to 23.1 x 23.1 cm 25 days after pinching, and then spaced to 35.6 x 35.6 cm 11 days later. The plants in a second treatment were grown pot-to-pot for 36 days after pinch, at which time they were spaced to 35.6 x 35.6 cm. 4) Node Number. Plants were pinched to eight nodes, while the control group was pinched to 5 nodes. Tissue development in the stem crotch; i.e., the area of lateral stem attachment to the main stem, was observed by microscopic examination of paraffin-embedded samples from each experiment every 2 weeks until anthesis. Lateral shoot strength was quantified by hanging a plastic beaker from the lateral stem and gradually adding water until stem crotch failure occurred. We observed that stem strength increased as cutting stem diameter increased. Plants pinched to eight nodes produced weaker lateral shoots than those pinched to five nodes. Premature lateral shoot development and container spacing did not affect stem strength.

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A Business Study of Michigan Retail Florists

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In the spring of 1996, Michigan State Univ. and the Michigan Floral Assn. mailed a comprehensive business survey to all Michigan floral retailers. This was the first nonpartisan study of the retail florist industry in Michigan. Based upon the 183 responses from full-service retail florists (those who deliver and subscribe to a wire service), a profile of the "typical" Michigan florist was constructed. Data presented will include general business operations, such as store floor space and length of time in operation, delivery services, wire service membership, advertising and marketing practices, staffing and wages, and annual profit and loss figures. Results provide a comparative benchmark for common retail florist business practices and can be used to assess the impact certain business operations may have on sales and financial success.

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Consumer Preferences for Geranium Flower Color, Leaf Variegation, and Price in Five U.S. Markets

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Consumers in five U.S. markets evaluated photographs of geranium plants with regard to purchase likelihood. Photographic images were colored electronically to produce uniform geranium plants with five flower colors (pink, white, red, lavender, and blue) and three leaf variegation patterns (dark zone, white zone, and no zonal pattern). Photographs were mounted on cards with five selected price points ranging from (\$1.39 to \$2.79). We randomly generated an orthogonal array, partial-factorial design for consumers to rate a reduced number of choices. Consumers shopping in cooperating garden centers located in Dallas, Texas;

Montgomery, Ala.; Athens, Ga.; Charlotte, N.C.; and Wilmington, Dela., rated 25 photographs on the basis of their likelihood to purchase the plants shown. Conjoint analysis revealed that customers in the Georgia garden center placed the highest proportion of their decision to buy on leaf variegation (29%), while customers in the Alabama outlet placed the most emphasis on price (46% of the decision). Shoppers in Texas valued flower color most highly (58% of their decision to buy). Demographic characteristics and past purchase behavior also varied widely, suggesting diverse marketing strategies for geraniums.

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Plant Growth Regulators (GA₃ and CCC) and Silverleaf Whitefly Effects on the Induction of Tomato Irregular Ripening in Dwarf Cherry Tomato

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External and internal tomato irregular ripening (TIR) symptoms have been associated with the feeding of silverleaf whitefly (SLW), *Bemisia argentifolii* Bellows and Perring. Soil drench application of gibberellic acid (GA₃) (100 ppm, Trial 1 and 2) and cycocel (CCC) (2000 ppm, Trial 1; 1000 ppm, Trial 2) were applied to dwarf cherry tomato (*Lycopersicon esculentum*) in the presence and absence of SLW to mimic the TIR disorder induced by the SLW. Application of GA₃ induced external and internal TIR symptoms similar to the SLW-induced disorder in 'Florida Petite'. There were essentially no TIR symptoms in fruit treated with CCC, an inhibitor of GA biosynthesis. In Trial 1, internal white tissue in GA₃, SLW, and CCC treatments was expressed in 97%, 95%, and 4% of the total fruit, respectively. Incidence of external TIR symptom was highest (56%) in the GA₃ plus SLW treatment. In Trial 2, GA₃ application in the presence (83%) or absence (85%) of SLW resulted in the highest incidence of fruit with internal white tissue. External TIR symptoms induced by GA₃ in the presence and absence of SLW were reduced with CCC application. These results suggest that the TIR disorder in tomato is induced by the SLW may be a GA₃-regulated disorder.

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Influence of Bacterial Speck Control Materials and Application Timing on Yield of Processing Tomatoes

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Bacterial speck caused by *Pseudomonas syringae* pv tomato is a major spring-time disease of tomato during rainy weather conditions in California. Application timing as a calendar spray was compared to pre-anticipated rainfall treatments of either cupric hydroxide alone or in a combined tank-mix with mancozeb. Plots were established in grower fields with natural infestations. In some instances, moderately severe infestations of speck caused as much as a 25% reduction in yield and slight delays in fruit maturity. Timing of treatments prior to rainfall was superior to calendar sprays. Slight improvement in disease suppression was achieved with a tank mix of mancozeb with copper compared to copper alone.

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Introducing Tomcast and Action Thresholds for Processing Tomatoes in Western Kentucky

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Farmers' field trials conducted in western Kentucky counties in 1995 and 1996 showed that dramatic reductions in insecticide usage are possible using scouting and action thresholds. Five-acre plots were scouted and treated according to action thresholds while adjacent 5-acre plots were treated weekly with insecticides. Seven out of 10 insecticide sprays were eliminated, saving \$65/acre for the 1995 season.

There were no differences in yield, insect damage, or fruit quality between the scouted plots and the plots that were treated weekly. Assuming similar low pest populations in all 885 acres of the company's contracted fields, savings could have amounted to nearly \$31,000 for 1995 after deducting scouting costs. There were no yield or quality differences from three test plots treated according to regularly scheduled applications and three plots treated according to action thresholds for insect pests and according to Tomcast predictions for fungal disease control in 1996. We have demonstrated the value of using Tomcast as an aid in making fungicide spray scheduling decisions for processing tomatoes in Kentucky. Although we were able to greatly simplify the Tomcast-CR10 datalogger interface program in 1996, there were still difficulties in getting information from the university-based computer to the company making spray applications. The company will be able to access the datalogger and obtain the information directly in 1997. The further analyses of "Skybit" satellite data collected in 1996 should also tell us whether this type of information might be used instead of a remote datalogger thus simplifying the process even further. We plan to build on the quick adoption of the Tomcast system and to make it sustainable by transferring "ownership" to the growers and processing company in 1997.

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Long-term Evaluation of Cover Crop and Strip Tillage on Tomato Yield, Nematode Populations, and Foliar Diseases

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A long-term experiment in the same site was planted to evaluate potential yield, nematode, and disease problems with tomatoes (*Lycopersicon esculentum* Mill.) in a strip-till system. Treatments consisted of conventional tillage (CT) and strip tillage (ST), rye (*Secale cereale* L.), wheat (*Triticum aestivum* L.), and perennial ryegrass (*Lolium perenne* L.) cover crops and a 2-year rye-tomato rotation. Results of the first 5 years indicate a decrease in tomato yield over time for both tillage treatments and cover crops. Tomato yields were lower following wheat and perennial ryegrass than rye. Strip-tillage reduced yield compared to conventional tillage in only 1 year out of 6. Yield increased overall for treatments in 1992, with highest yield in the rye-tomato rotation. Bacterial speck/spot symptoms on foliage, although minor, were significantly greater in ST than in CT plots during the last 3 years. No major consistent trends in incidence and severity of bacterial and fungal diseases and of disorders of fruit were evident during the 5-year period, and neither fruit yield nor quality were significantly affected by these factors. Root-knot nematodes (*Meloidogyne hapla* Chitwood) were numerically less numerous in the rye-tomato rotation than in other treatments; both root-knot and root lesion nematodes [*Pratylenchus penetrans* (Cobb)] tended to be less numerous under CT than under ST. Tomatoes grown under reduced tillage appear more sensitive to plant parasitic nematodes and preceding cover crops than in conventional tillage.

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Plant Diversity and Its Effects on Populations of Cucumber Beetles and Their Natural Enemies in a Cucurbit Agroecosystem

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To assess the value of uncultivated vegetation for control of cucumber beetles, populations of striped (*Acalymma vittatum* Fabr.), spotted (*Diabrotica undecimpunctata howardi* Barber), and western cucumber beetles (*Acalymma trivittatum* Mann.) (Coleoptera: Chrysomelidae) and natural enemy Diptera flies (as an indicator of *Celatoria* spp. parasitoids), Pennsylvania leatherwings (*Chauliognathus pennsylvanicus* DeGeer) (Coleoptera: Cantharidae), lady beetles (Coleoptera: Coccinellidae), Hymenoptera wasps, and spiders were monitored with sticky traps on 50-m transects running through a field of *Cucumis sativa* L. 'Arkansas Littleleaf' into bordering uncultivated vegetation. Plant species composition was determined in square plots around each sticky trap by estimating total plant cover and height distribution of plants from 0 to 1.0 m. In both years, numbers of cucumber beetles increased and numbers of Diptera decreased towards the crop. These trends increased monthly to peaks in Aug. 1995 (0.3 to 6.0 striped cucumber beetles; 40.0 to 15.3 Diptera) and July in 1996 (0.1 to 7.1 striped cucumber beetles; 46.7 to 15.5 Diptera). Abundance of individual plant species contributed more to maximum R^2 regression of insect populations than

did measures of plant diversity in sampling squares. Diptera were negatively correlated with sweet-vernal grass ($r = -0.65$ at 0 m) and wild rose ($r = -0.62$ at 0.5 m) in 1995, and goldenrod ($r = -0.31, -0.59,$ and -0.53 at 0.5, 0.75, and 1.0 m, respectively) in 1996, but positively correlated with wild violets (*Viola* spp.) ($r = +0.38$ at 0 m) in 1996. Cucumber beetles were negatively correlated with wild violets ($r = -0.30$ at 0 m) and white clover (*Trifolium repens*) ($r = -0.37$ at 0 m) in 1996. These results suggest that increasing or decreasing specific plants in uncultivated vegetation might be useful for influencing pest and beneficial insect populations in cucurbit production.

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Effect of Buckwheat as a Flowering Border on Populations of Cucumber Beetles and Their Natural Enemies in Cucumber and Squash

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Cucumber beetles *Acalymma vittatum* (Fab.) and *Diabrotica undecimpunctata howardi* (Barber) (Coleoptera: Chrysomelidae) are major pests of cucurbits, and biological methods are needed for their control. A floral border of buckwheat *Fagopyrum esculentum* (Moench) was planted perpendicular to *Cucumis sativa* L. 'Arkansas Littleleaf' and *Cucurbita pepo* L. 'Seneca' rows to assess effects on populations of cucumber beetles and the presence of natural enemies. Numbers of Diptera were used as an indicator of potential border attractiveness to natural enemies *Celatoria diabroticae* (Shimer) and *Celatoria setosa* (Coquillett) (Diptera: Tachinidae). Sticky traps and modified Malaise traps at increments from the border were used to monitor insect numbers. There was a quadratic decline from 19.5 Diptera in the border to 2.8 Diptera at 20 m from the border in June 1995 and linear declines from 14.8 and 14.2 Diptera in the border to 9.8 and 6.8 Diptera at 36 m in June and Aug. 1996, respectively. Numbers of striped cucumber beetles were variable, with a non-significant ($P = 0.08$) linear increase from 13.0 insects in the border to 17.5 insects at 36 m in June 1995, but quadratic decreases to 27 m in June, July, and Sept. 1996. Similar declines as distance from the border increased were found in numbers of tachinid flies (Diptera: Tachinidae) and Hymenoptera wasps and Pennsylvania leatherwings, *Chauliognathus pennsylvanicus* (Deg.) (Coleoptera: Cantharidae) and lady beetles (Coleoptera: Coccinellidae) in 1996. No meaningful effects on cucumber (1995) or squash (1995 and 1996) yield were found. Although the natural populations of *Celatoria* spp. were not high enough to achieve control, these results suggest that flowering borders may be useful as habitats for releasing natural enemies of cucumber beetles. Numbers of Pennsylvania leatherwings, *Chauliognathus pennsylvanicus* (Deg.) (Coleoptera: Cantharidae) showed a significant linear decline from 2.1 insects in the border to 0.2 insects at 36 m in June 1996, but no significant relationship was found in 1995 or in Aug. 1996.

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Induction of Adult Female Sweetpotato Weevil (*Cylas from-icarius elegantulus* Summers) Volatile Attractant Triggered by Root Periderm Feeding

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The sweetpotato weevil is the single most critical insect pest of the sweetpotato worldwide. While male weevils can be lured to traps using a synthetic female pheromone, crop losses are not adequately reduced since damage is caused by the larvae arising from eggs laid by female weevils in the storage roots. Identification of a female attractant could greatly enhance the control of the insect. The leaves and storage roots are known to emit volatiles that attract the female and in the following tests, we demonstrate that feeding by female weevils stimulates the synthesis of a volatile attractant which attracts additional females to the root. Undamaged, artificially damaged, and female weevil feeding damaged periderm were tested in dual-choice and no-choice olfactometers. Volatiles from feeding damaged roots were significantly more attractive than undamaged and artificially damaged roots. To test whether the volatile attractant was of weevil or root origin, volatiles were collected in MeCl2 after removal of the weevils and fractionated on a megabore DB-1 capillary column using a GC fitted with a TC detector. Fractions were collected from the exit port and their activity index (AI) determined using dual choice and no choice olfactometry. The active fraction was ascertained and active components identified via GC-MS.

Effect of Chitosan on Tissue Maceration and Enzyme Production by *Erwinia carotovora* in Potato

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We have investigated the relationship between chitosan treatments and maceration of potato tissue by macerating enzymes secreted by *Erwinia carotovora* causal agent of soft rot of potato. *Erwinia* isolated from potato showing soft rot symptoms was used for inoculation. The bacteria secreted a wide spectrum of enzymes that degraded potato cell walls. Polygalacturonase (PG), pectate lyase (PL), pectin-methyl-esterase (PME), cellulase, xylanase, and protease showed the highest activity in potato tissue inoculated with the pathogen. Accordingly increased maceration and cell death were observed. On the other hand, in chitosan-treated tissue and challenged with the pathogen, significant decrease in enzymatic activity and tissue maceration were observed, more so with increasing chitosan concentration. This observation confirmed that chitosan interfered with multiplication and pathogenic powers of the bacteria, thereby improving cell texture and viability. Crude extracts obtained from treatments were subjected to sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) to assess pectinase activity. The electrophoretic profiles showed significant lytic zone of pectin degradation in the control, which decreased with increase in chitosan concentrations. No lytic zone was observed at 8 mg·ml⁻¹ chitosan concentration and was comparable to intact activity in untreated potato tissue. Pectic enzyme reaction products were analyzed to see the action pattern of pectinases in the crude extracts. Cellulose chromatographic profiles revealed monomers and dimers of polygalacturonic acid up to 6 mg·ml⁻¹ chitosan concentrations. The results suggest that chitosan significantly inhibits bacterial growth and the production of macerating enzymes by the pathogen and thus chitosan can be a potential anti-bacterial agent.

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Expression of Soluble Invertase in Carrot (*Daucus carota*)

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The β -fructofuranosidases (invertases) cleave sucrose and related sugars into fructose and glucose. The enzyme is present in most plant tissues in multiple forms. Carrots contain an insoluble β -fructofuranosidase, which is ionically bound to the cell wall and soluble β -fructofuranosidases. The *Rs* locus in carrot conditions the accumulation of sucrose, fructose, and glucose. The inbred B493 is homozygous for the recessive allele (*rs/rs*) and accumulates high levels of sucrose, while most carrots accumulate glucose and fructose (*Rs/Rs*). Increased consumer interest in sweeter carrots require greater understanding of sucrose metabolism and its biochemistry. We established gene transformation systems for carrots using *Agrobacterium*-mediated and particle bombardment-mediated methods. Intact soluble invertase cDNA was synthesized from B493 and other carrots as measured by RT-PCR. The cDNA fragment was cloned into pBI121 and into a sequencing vector. B493 callus was transformed by *Agrobacterium* containing the pBI121 vector with invertase driven by the 35S promoter. Invertase expression was compared in *rs/rs* and *Rs/Rs* transformed carrots (with invertase overexpression) and non-transformed carrots. These results improve our understanding of the role of soluble invertase in sucrose metabolism of carrot.

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Comparative Accumulation of Carotenoid Content during Vegetative Growth and Postharvest Storage in Four Carrot Genotypes

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Carotenoids have been shown to be important both nutritionally and medicinally. Carotenoid accumulation was compared during growth and storage of four carrot genotypes: *YY y₁y₂y₂RPRP*, *yyY₁Y₁Y₂Y₂RPRP*, *YY Y₁Y₁Y₂Y₂RPRP*, and *rprp*. These genotypes exhibit orange, yellow, white, and pale-orange

roots respectively. The orange and pale-orange genotypes are near-isogenic for *rp*, a gene that reduces total carotenoid content by 93%. Genotypes were grown in replicated field plots during 1996 and stored for 8 months at 4°C. Samples of root tissue were removed at 7-day intervals during vegetative growth and 4-week intervals during the postharvest period. Total carotenoid content were quantified using HPLC and spectrophotometric analyses. Increases in carotenoid content of 119% and 79% in *rprp* and *YY y₁y₂y₂RPRP* and decreases of 6% and 64% in *YY Y₁Y₁Y₂Y₂RPRP* and *yyY₁Y₁Y₂Y₂RPRP* respectively, were measured between 62 and 100 days after planting. At 100 days after planting, *YY y₁y₂y₂RPRP* exhibited 10-fold greater carotenoid content than *rprp*. Carotenoid content in *yyY₁Y₁Y₂Y₂RPRP* and *YY y₁y₂y₂RPRP* increased during the first 28 days of storage and decreased subsequently. Meanwhile, *rprp* began to decrease in carotenoid content at day 14 of storage. HPLC analysis at $\lambda = 445$ nm revealed two large unique peaks in *rprp* with elution times of 27 and 28.7 minutes that were of lesser abundance in *YY y₁y₂y₂RPRP*, suggesting that the rate of β - and α -carotene accumulation is not the only difference between *YY y₁y₂y₂RPRP* and *rprp*.

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Toward Characterization of and Breeder-friendly Molecular Markers for Genes Affecting Carotene accumulation in Carrot (*Daucus carota*)

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The *Y2* locus conditions α - and β -carotene accumulation in the xylem (core) of carrot roots. The dominant allele suppresses carotene, but not xanthophyll accumulation, resulting in yellow-cored roots. Individuals homozygous for the recessive allele are rich in carotenes and are therefore orange-cored. Increased consumer interest in high carotene produce requires improved understanding of carotene biosynthesis and color development and more-efficient breeding techniques. We examined 103 F₂ individuals generated from inbred populations differing in core carotene content. Bulked segregant analysis identified AFLP bands putatively linked to *Y2*. Linkage was confirmed for some bands by mapping. Linked bands were excised from gels, re-amplified, cloned into pGEM vectors, and sequenced. Cloned fragments and sequence information were used to characterize larger genomic regions to identify codominant markers. Currently we are developing codominant, PCR-based markers that can be used to rapidly genotype individuals in breeding programs, to characterize wild, feral, and cultivated populations for diversity and evolution studies, and to examine the role of *Y2* in carotene accumulation.

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A Genetic Model and Molecular Markers for *Meloidogyne javanica* Resistance in Carrots

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Nematodes impart significant damage to carrot production worldwide. Genetic resistance was studied for *Meloidogyne javanica*, one of the three major nematodes affecting carrots in warmer climates. F₂, F₃, and backcross families of 'Brasilia' x B6274 were evaluated for resistance in inoculated seedlings. Resistance was conditioned by one, or two linked, dominant loci. Molecular markers were also evaluated with bulked segregant analysis. Three RAPD markers and AFLPs were associated with resistance loci.

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Plant Regeneration and Genetic Transformation of *Brassica campestris* ssp. *pekinensis* via Organogenesis

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In order to regenerate explants of *Brassica campestris* ssp. *pekinensis*, known to be one of the most difficult crops to regenerate via organogenesis, three different explants, cotyledon, hypocotyl, and leaf, were cultured on MS basal medium supplemented with several plant growth regulators. In the medium containing NAA at 0.5 mg/L and BAP at 3.0 mg/L, the shoot regeneration, when hypocotyl was used as explant, was found to be quite effective. In the case of cotyledon, the most suitable combination of plant growth regulators was NAA at 1.0 mg/L and BAP at 3.0 mg/L. Treatment of AgNO₃ (1.0 mg/L) for shoot regeneration gave positive results in general. Zeatin at 2.0 mg/L was very effective in shoot

induction of leaf explant, especially when combined with BAP at 2.0 mg/L, NAA at 1.0 mg/L, and AgNO₃ at 0.5 mg/L. A system to produce transgenic plants in *Brassica* spp. has also been developed using hypocotyl and cotyledonary-petiole segments and shoot-tips. An explants from 4-day-old seedlings were inoculated with an *Agrobacterium tumefaciens* strain containing a disabled tumor-inducing plasmid pTiT37-SE carrying a chimaeric bacterial gene encoding hygromycin and kanamycin resistance, along with other genes of interests. The explants were co-cultured for 2 to 6 days before transfer to hygromycin and kanamycin selection media. Shoots regenerated directly from the explants in 1 to 4 weeks and were excised, transferred to shoot elongation medium, rooted in root induction medium, and planted in soil. Genetic transformation was confirmed by kanamycin or hygromycin resistance, GUS activities, and Southern blotting.

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Utility of DNA Flow Cytometry for Ploidy Determination of Anther-derived Broccoli: Effect of Leaf Age and Sampling Protocols

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Broccoli (*Brassica oleracea* L. Italica group) breeders routinely use anther or microspore culture to produce dihaploid (diploid), homozygous lines. During the culture process, polyploidization occurs and diploid regenerants can result. However, polyploidization may not occur at all, or it may involve a tripling or quadrupling of the chromosome complement. Thus, regenerated populations must be screened to identify the diploids that are the regenerants most likely to set seed and serve as inbred lines. DNA flow cytometry has proven a useful procedure for determining ploidy of anther derived regenerants. This study was undertaken to evaluate the effect of leaf age and sampling procedures on ploidy determination via flow cytometry. Anther-derived plants were analyzed at a four- to five-leaf stage (transplant stage) and at time of heading (mature plant stage). In addition, leaves were sampled on a given date and stability of the flow cytometry preparations was evaluated over 7 days. Lastly, the stability of ploidy readings of leaves stored at 4°C was examined over a 7-day period. In only one case out of 123 comparative assays did leaf age affect ploidy determination. For that exception, a haploid at transplant stage was a diploid at the mature plant stage. Flow cytometry preparations and also leaves stored at 4°C gave consistent ploidy determinations up to four days after preparations were made or tissue was refrigerated, respectively. These results indicate that broccoli breeders can make flow cytometry preparations on site and send them offsite for flow cytometry analysis. Alternatively, leaves could be refrigerated, sent offsite, and then prepared and analyzed at another location.

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Use of Genomic in Situ Hybridization (GISH) to Track Genetic Introgression in Onion

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Introgression of genes in species crosses can be observed morphologically in backcrossed or selfed progenies, but the phenotype does not give information about the movement of DNAs. Cytogenetic markers allow for visualization of specific DNAs in a genome. Few cytogenetic markers are available in onion to monitor the introgression of DNA in species crosses. Genomic in situ hybridization (GISH) provides a way to locate unique DNA sequences contributed by parents. We are using GISH to monitor the movement of DNAs from *A. fistulosum* into *A. cepa*. Results of experiments using *A. fistulosum* as probe DNA, and *A. cepa* as blocking DNA will be reported. Also presented are hybridization sites observed in F₁BC₃ progeny of the GISH.

85 ORAL SESSION 18 (Abstr. 500–507) Breeding & Genetics—Fruits/Nuts

500

Development and Utilization of a Core Collection in *Theobroma cacao* based on RAPD Marker-based Estimates of Genetic Distance

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An increased need to understand the genetic relationships among cacao (*Theobroma cacao*) germplasm exists to identify cultivars that possess resistance to witches' broom disease (caused by *Crinipellis pernicioso*). Loss of production due to witches' broom disease in important cacao-growing areas, such as Bahia, Brazil, has generated a strong demand for disease-resistant varieties. Varieties based on single sources of resistance have been released; however, other genotypes are needed to enlarge the genetic diversity of cultivars in breeding programs. A core collection has been created to represent the range of genetic diversity available among the more than 600 cacao accessions at Centro de Pesquisa do Cacau (CEPEC). The cacao core facilitates access to the collection and is intended to enhance its use. This core collection was created from RAPD marker-based estimates of genetic distance among a subset of 270 accessions from the entire collection. The subset was sampled based on 1) witches' broom disease resistance data, 2) random sampling of the collection, and 3) random sampling of recently acquired accessions. Differences in RAPD marker frequencies were used to identify accessions in a witches' broom disease breeding program that contribute to the genetic diversity of the collection as a whole. In addition, differences in RAPD marker frequency allowed the comparison between accessions in the original collection and those acquired from new geographic regions that may expand the collection's genetic diversity.

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Pawpaw [*Asimina triloba* (L.) Dunal] Germplasm Evaluation Using RAPD Markers

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Kentucky State Univ. (KSU) is the national clonal germplasm repository for *Asimina* species. Previous evaluation of the KSU pawpaw collection using 24 isozyme markers demonstrated that pawpaw has a relatively higher genetic diversity than that noted for other plant species with similar species characteristics (long-lived, woody, perennial, out-crossing, temperate, widespread, etc.). Current evaluation using RAPD markers will provide us with a more-accurate insight into pawpaw genetic diversity and population structure. In a preliminary experiment, one hundred 10-mer primers (OA1-20 through OE1-20, Operon Technologies Inc.) were screened against 32 commercial cultivars or advanced selections. A subset of 24 primers that amplify only the most-informative markers were used for germplasm evaluation. Sixty-eight RAPD markers were identified and used for determining genetic parameters. One-hundred-twenty pawpaw accessions were sampled from the KSU repository for RAPD analysis. These accessions represented nine widely distributed states within pawpaw's native range. RAPD data were subjected to various analyses using the NTSYS-PC computer program (ver. 1.8). Information generated from isozyme and RAPD markers will be used to formulate future germplasm collection strategies from wild populations within the native range. The implications of such information to the genetic enhancement of our repository and establishment of a core collection will be discussed.

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Estimation of Genetic Variation in Grapes Based on RAPD and Isozyme Analysis

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Genetic relationships among 42 grape accession of at least 15 species were estimated and compared using RAPD and isozyme techniques. These accessions were either hybrids or wild collections of the Asiatic species, the American species, the European grape (*V. vinifera*), and muscadine grape (*V. rotundifolia*). A total of 196 RAPD fragments were generated from twenty 10-mer primers. The pairwise similarities among the accession ranged from 0.46 to 0.94. A dendrogram was generated based on the RAPD similarity coefficients. Species/accessions were basically grouped together in accordance with their geographic origins. The similarities and dendrogram resulted from the RAPD analysis were consistent with the ones generated from the isozyme data, and also consistent with the known taxonomic information. This result suggest that the RAPD method, like isozyme, is an useful tool for studying grape genetic relationship/diversity and origination.

Evaluation of RAPDs for Identification of Selfed Progeny in Cultivated Cranberry

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Most varieties of the American cranberry (*Vaccinium macrocarpon*) cultivated today were selected from native selections or breeding progeny between the late 1800s and mid-1900s. We have previously shown using RAPDs that contamination, i.e., a mixture of genotypes, is common in commercial bogs. One source of contamination could be establishment of selfed progeny. The purpose of this study was to determine how effective RAPDs would be in distinguishing selfed progeny from the parent. Results suggest that the number of scorable polymorphic bands is low compared to outcrossed or unrelated progeny. Thus, five to nine primers were used as compared to the three primers normally required to separate outcrossed and unrelated clones. Segregation of some RAPD bands was not consistent with expected mendelian ratios. However, using 9 to 12 polymorphic bands, only 3% to 5% of the selfed progeny had fingerprints identical to the parent. Additional primers should further reduce this percentage. It was also noted that certain cultivars exhibited a large number of non-parental bands. The origin of the non-parental bands has not yet been determined.

504

Seasonal Expression of a 700–800-Base Pair Transcript in Bark Tissues of Peach (*Prunus persica*)

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Cold acclimation in temperate, woody plants involves distinct changes in gene activity and protein expression. We have been identifying proteins and genes that are associated with seasonal changes in cold hardiness. Seasonal changes in a 60-kDa dehydrin and its corresponding transcript have been identified, as well as seasonal changes in 16- and 19-kDa storage proteins. Further screening of a cDNA library, constructed from cold-acclimated bark tissues collected in December, identified a 700–800-bp clone that was seasonally expressed in Northern blots. The transcript began to accumulate in October, reached a peak in November–December, and then began to decline. By April, the transcript was no longer present in bark tissues. The transcript size indicates that this gene may be related to either the 16- or 19-kDa storage proteins previously identified; however, an amino acid sequence of the protein for comparison has not yet been obtained. Interestingly, the transcript is also expressed during the early stages of peach fruit development. A similar pattern between seasonal expression and fruit development has been observed for a peach dehydrin transcript. Analysis of a partial sequence of the clone has indicated a similarity to genes encoding proteinase inhibitors and thionins (a class of biocidal proteins). More definitive characterization of the gene and identification of its corresponding protein are in progress.

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Immunolocalization and in Vitro Cryoprotective Activity of PCA60: A Peach Dehydrin

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Cold acclimation in temperate, woody plants is a complex phenomenon that involves distinct changes in gene activity and protein synthesis. In previous research, a 60-kDa protein (PCA60), belonging to the dehydrin family of stress-related proteins, was identified in peach bark, and its corresponding gene (*ppdhn1*) was cloned and characterized. Presently, we report on the results of immunolocalization studies and in vitro cryoprotection assays. Seasonal collections of current-year stems were embedded in LR White or epoxy resin and sections of bark were probed with either a polyclonal antibody directed against a 15 amino acid sequence consensus region of dehydrins or a polyclonal antibody directed against partially-purified PCA60. In vitro cryoprotection assays utilized lactose dehydrogenase (LDH), a cold-labile enzyme. Immunolocalization at the light level indicated that the dehydrin was confined to the cytoplasm and absent in organelles. This localization was preliminarily confirmed at the ultrastructural level. LDH assays indicated cryoprotective activity in total protein extracts collected from winter bark tissues but completely absent in extracts of summer bark tissues. Preliminary LDH assays utilizing purified PCA60 also demonstrated cryoprotective activity. In general, the data further support a role for dehydrins in

cold acclimation of woody plants.

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Determination of Nuclear DNA Content and Ploidy Level in *Rubus* by Flow Cytometry

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Knowledge of the chromosome number in *Rubus* would be valuable when planning crosses and identifying plants, etc., however, preparation of tissue for microscopic evaluation and chromosome counting is difficult and time-consuming. Flow cytometry offers a more-efficient approach to this task. DNA flow cytometry was used to determine the nuclear DNA content in 22 *Rubus* genotypes. The genotypes represented a range of reported chromosome numbers from 2x to 12x. Six of the genotypes were representatives of *Rubus ursinus*, which is reported to have both 8x and 12x forms. Samples of nuclei were prepared from leaf discs of newly emerged and mature leaves following published protocols with some modifications. The DNA content was estimated by comparison of the fluorescence of *Rubus* nuclei with an internal DNA standard. There was an increase in nuclear DNA content concurrent with the increase in chromosome number. In these studies DNA flow cytometry could differentiate genotypes that differed by 2x, such as 6x and 8x, but could not reliably distinguish genotypes that differed by 1x, such as 7x vs. 8x or 6x. Aneuploids cannot be differentiated at this time.

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Stylar Proteins Associated with Gametophytic Self-incompatibility in the *Prunus*

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Stylar proteins of four *Prunus* species, *P. avium*, *P. dulcis*, *P. mume*, and *P. salicina*, were surveyed by 2D-PAGE combined with immunoblot and N-terminal amino acid sequence analyses to identify S-proteins associated with gametophytic SI in the *Prunus*. All four S-allelic products tested for *P. dulcis* could be identified in the highly basic zone of the gel. These S-proteins had Mr of about 28–30 kDa and reacted with the anti-S₂-serum prepared from Japanese pear (*Pyrus serotina*). Two of six S-allelic products tested for *P. avium* could be also identified in the 2D-PAGE profiles, with roughly the same pI and M_r as those of S-proteins of *P. dulcis*. Putative S-proteins for *P. mume* and *P. salicina* were found in the same area of 2D-PAGE as the area where S-proteins of *P. avium* and *P. dulcis* were located. N-terminal amino acid sequence analysis of these proteins revealed that they were similar to S-RNases reported previously.

86 ORAL SESSION 19 (Abstr. 508–515) Cell & Tissue Culture—Vegetables

508

Influence of Seedling Pretreatment and Explant Type on Watermelon Shoot Organogenesis

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Several methods have been published on shoot regeneration from watermelon cotyledon explants. The major differences in regeneration protocols include the light environment in which seeds are germinated and the cotyledon region used. The purpose of these experiments was to compare the two main protocols for plant regeneration and develop one general procedure. To fulfill this objective, seeds were germinated in vitro in darkness or 16-hr light photoperiod for 7 days. Cotyledon explants from four watermelon cultivars ('Crimson Sweet', 'Minilee', 'Sweet Gem', and 'Yellow Doll') were prepared from both dark- and light-grown seedlings. Apical and basal halves were obtained by making a cut across the cotyledon width. Apical and basal quarters were made, for comparison, by cutting apical and basal halves longitudinally. All explants were incubated on shoot regeneration medium for 6 weeks followed by a 3-week cycle on shoot elonga-

tion medium. The percentage of cotyledons with shoots was 1.7-fold greater for cotyledons derived from seedlings incubated in darkness than those germinated in light. Shoot formation was about 10-fold greater for explants from cotyledon basal halves and quarters than apical halves and quarters. According to these results, the best watermelon regeneration protocol should consist of basal explants from in vitro-germinated seedlings incubated in the dark for 7 days.

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Sprouting Characteristics of Microtubers, Minitubers and Field-grown Tubers of Three Micropropagated Potato Cultivars

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Tubers of three potato cultivars (Norland, Desiree, and Russet Burbank) produced on field-grown plants, greenhouse plants (minitubers), and in-vitro plantlets (microtubers) were kept at 5, 10, and 20°C. Sprouting was recorded throughout a 14- to 22-week storage period. The effect of cultivar, temperature, and tuber size closely followed previous research for field- and greenhouse-produced tubers. For in-vitro produced microtubers, the temperature effect followed an expected pattern, but the cultivar effect was different from that observed for field and greenhouse tubers. Two sprouting indices were developed (sprouting rate index and sprouting ratio index) to quantitatively describe the sprouting characteristics. Correlation coefficients suggest that the "sprouting ratio" method can be an acceptable alternative to the "sprouting rate" method.

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Effects of Different Cytokinin-like Compounds on Invertase Activity during Potato in Vitro Tubercization

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The effects of different cytokinin-like compounds on invertase activities at different tuberization stages of potato (*Solanum tuberosum* L. 'Atlantic') were examined. Single nodal segments were cultured on MS medium plus 6% sucrose and supplemented with either 2 mg kinetin/L, 0.1 mg thidiazuron (TDZ)/L, 1.0 mg AC 243,654/L, 0.1 mg AC 239,604/L, or no cytokinin. Tissue samples for determining invertase activity were taken at three stages of tuberization: stage 1, the "hook stage"; stage 2, the "swelling stage"; and stage 3, "tuber initials." Invertase activity was significantly affected by the interaction between cytokinin-like compounds and tuberization between cytokinin-like compounds and tuberization stages. The highest invertase activities in the stolons at stage 1 were found in kinetin and TDZ treatments. Invertase activity in the stolons on the control medium significantly increased from stage 1 to 2 and decreased at stage 3. Invertase might play a role in either stolon elongation or carbohydrate utilization by increasing the pool of reducing sugars.

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Salinity Tolerance Evaluations in Micropropagated Potato

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The relative salinity tolerance of 130 North American and European potato cultivars were assessed in vitro using nodal cuttings micropropagated in salinized medium. Each cultivar was evaluated twice, using five single-node cuttings, at each salt level (0, 40, 80, and 120 mM NaCl). After 1 month in culture, plantlets were destructively harvested for shoot and root lengths, fresh and dry weights, and the data corrected for differences in cultivar vigor. Multivariate cluster analysis was used to partition this population, based on the six relative growth parameters. Six cultivars were top-ranked at all salinity levels.

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Interaction of Culture Vessel Size, Medium Volume, and Carbon Dioxide Levels on the Growth of Various Plants in Vitro

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Ultra-high levels of CO₂, i.e., >10,000 ppm, enhance tissue culture growth and

offers a relatively simple and inexpensive method to improve plant productivity in vitro. Growth responses employing ultra-high CO₂ levels differ considerably in the literature. Unfortunately, various culture vessels and systems have been employed, making comparisons difficult. In this study, the influence of the vessel container size, medium volume, and various CO₂ concentrations (0 to 50,000 ppm) was studied on the growth obtained from lettuce and spearmint cultures. All three of these factors influence growth responses from plants cultured in vitro. Vessel types tested included: culture tubes, Magenta containers, 1-quart jars, 0.5-gallon jars, and 1-gallon jars having culture volumes of 55, 365, 925, 1850, and 3700 ml, respectively. Increasing the size of the culture vessel resulted in an increase in growth regardless of the CO₂ level tested. For example, fresh weight of spearmint increases of >250% can be obtained in by employing a 1-quart jar compared to using a culture tube. Increasing medium volume using various vessel types, especially using high concentrations of CO₂, resulted in dramatic growth increases. For example, a >100% increase in fresh weight could be obtained by increasing the medium volume from 50 ml to 100 ml within a 1-quart jar. These studies suggest that plant growth promoted by supplemental CO₂ is limited by the culture vessel size and medium volume. Differences in growth responses obtained in past CO₂ studies could be related to vessel type and medium volume as well as the CO₂ levels employed. Future in vitro studies should consider these factors in the evaluation of the influence of Ultra-high CO₂ levels on plant growth. Peculiar growth responses, especially pertaining to rooting and shooting exhibited by cultures grown in ultra-high CO₂ levels will also be discussed.

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Photoautotrophic Micropropagation of Tomato Plantlets

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'HanaQueen' tomato plantlets were cultured under conditions with different levels of sugar, photosynthetic photon flux, CO₂ concentration, and number of air exchanges of the vessel. Effects of medium substrates (Gelrite or vermiculite) and explant preparation (with or without leaves) on growth of the plantlets were also examined. After 20 days in culture, photoautotrophically cultured plantlets with leafy explants, under increased PPF, CO₂, and ventilation rate of the vessel had twice as much dry weight as those cultured conventionally with non-leafy explants under low PPF, CO₂, and ventilation rate of the vessel. Dry weight of the plantlets was significantly greater when cultured with leafy than non-leafy explants. Net photosynthetic rate of the plantlets increased linearly as culture period when cultured without sugar, and remained almost zero when cultured with sugar, regardless of other culture conditions. Results obtained in this experiment have shown that tomato plantlets can be grown photoautotrophically, and the net photosynthetic rate was greater under photoautotrophic than under conventional photomixotrophic conditions.

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Simulation of the Time Courses of CO₂ Concentration in the Culture Vessel and Net Photosynthetic Rates of Potato Plantlets Cultured Photoautotrophically and Photomixotrophically in Vitro under Different Lighting Cycles

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Potato (*Solanum tuberosum* L. cv. Benimaru) plantlets were cultured under four lighting cycles (photoperiod/dark period: 16 h/8 h, 4 h/2 h, 1 h/0.5 h, and 0.25 h/0.125 h) photoautotrophically (without sugar in the medium), and photomixotrophically (with sugar in the medium) in vitro for 28 days. Simulations of time courses of CO₂ concentration in the vessel (Ci) and dry weight accumulation of the plantlets cultured photoautotrophically were conducted using a previously developed model (Niu and Kozai, 1997). While underestimation and overestimation of time courses of Ci in some treatments were observed, the simulated results of Ci and dry weight accumulation of the plantlets generally agreed with the measured ones. The difference of net photosynthetic rate response to Ci throughout the culture period was examined between the plantlets cultured photoautotrophically and photomixotrophically. Quantitative relationship between daily net photosynthetic rate (daily net production) and vessel ventilation rate per plantlet was simulated under various CO₂ levels outside the vessel for given sizes of potato plantlets cultured photoautotrophically in vitro to aid appropriate CO₂ enrichment and vessel design in commercial micropropagation.

Effects of Nitrogen and Sucrose Level on the Regeneration of *Cichorium intybus* L. var. *sativus*

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The regeneration medium supplemented with 2.0 mg/L BAP and 0.1 mg/L IAA allowed high efficient shoot regeneration from leaf discs and petioles of *Cichorium intybus* L. var. *sativus*. Multiple shoots ranged from 10 to 14 per explant were observed only 10 to 15 days after the initial culture. Reduced nitrogen and sucrose levels influenced on shoot regeneration frequency and growth rates. Especially, in *C. intybus* L. var. *sativus* cv. Cesare explants cultured in the medium containing 50 mg/L MS macroelement and 1.5% sucrose displayed high regeneration frequency of 100%.

87 ORAL SESSION 20 (Abstr. 516–522) Growth & Development—Small Fruits/ Viticulture

Previous Cropping and Light History Influence Early Season Vegetative Development of Grapevines

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Early season vegetative development of grapevines was studied in the year after imposing three cropping levels to mature 'Seyval' vines in the field or establishing two light levels to potted 'DeChaunac' vines growing in the greenhouse. Heavily cropped 'Seyval' vines (averaging 90 buds, 15.8 kg fruit per vine over the previous two growing seasons) had 85% fewer count buds and 31% fewer non-count (latent) buds than lightly cropped vines (averaging 25 buds, 9.7 kg fruit per vine). The rate of leaf area expansion was reduced on heavily cropped vines. Covering 'DeChaunac' vines in the greenhouse with 80% shade from bloom onwards reduced the leaf area per shoot in the year after treatment by reducing both the rate of leaf appearance and the rate of leaf expansion. The leaf at node four from the base of the shoot had the greatest area on both shaded and control vines; however, the area was reduced 33% on shaded vines. Data from the greenhouse experiment were used to model the effect of leaf size at the transition from sink to source on total source leaf area per shoot. Prior to bloom the total source leaf area per shoot was increased when individual leaves became sources earlier, i.e., at a lower percent of their final size. Whether a leaf became a source at either 30%, 50%, or 80% of its final size had little effect on total source leaf area per shoot after bloom. The proportion of source to sink leaf area at bloom was greater than 90% for both slow- and rapidly growing shoots (those on shaded and control vines, respectively). Expansion of grapevine leaves was reduced by heavy cropping and low light levels in the previous year, greatly reducing the source leaf area per shoot.

The Effects of Growth Regulators on Shoot Propagation and Rooting of *Vitis* Following in Vitro Axillary Bud and Shoot Apex Culture

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Axillary buds of 'Valiant' grapevine (*Vitis* spp.) grown in vitro were transferred onto Murashige and Skoog (MS) medium supplemented with different cytokinin and auxin combinations and concentrations. It was found that culture medium caused statistically important differences in number of nodes, number of fully expanded leaves, number of multiple shoots, number of roots, and length of shoots. MS medium supplemented with 1.0 mg BA/liter in combination with 0.01 mg NAA/L was found to be the best medium for shoot growth and callus production. MS medium supplemented with the combination of 0.5 mg BA/L and 0.01 mg NAA/L was the best medium for explant rooting. The medium containing BA and NAA encouraged better shoot growth than those containing BA alone. When the concentration of BA in the medium was increased, multiple shoot proliferation and teratological structures of explants increased, but the number of small leaves and length of internode decreased. Axillary bud culture led to better shoot growth than was found for shoot apex culture. The presence of leaves positively affected shoot growth from axillary buds. Also placing the axillary buds horizontally onto the

medium gave better shoot proliferation and growth than placing them vertically.

Yield and Quality of 'Banaty' Grapes in Response to Spraying Iron and Zinc

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During 1995 and 1996, yield and quality of 'Banaty' grapes in response to spraying chelated iron and zinc singly or in combination each at 0.025%, 0.05%, 0.1%, 0.2%, or 0.3% was investigated. Each concentration was applied once, twice, three, four, or five times. Results showed that there was a gradual increase in berry set, cluster number, yield, cluster weight, berry weight, total soluble solid sugars, and total anthocyanins with rising concentrations and number of sprays of each fertilizer. Total acidity tended to reduce with such treatment. Combined spray of both fertilizers, particularly at 0.1% four times, gave satisfactory improvement in both quantity and quality of grapes. Spraying at concentrations higher than 0.1% or spraying more than four times failed to show any measurable effect on all of the studied traits. The best results with regard to yield and quality of 'Banaty' grapes were obtained on vines that received four sprays of iron and zinc each at 0.1% in chelated form.

Behavior of 'Red Roomy' Grapevines to Application of Urea, Urea-formaldehyde, Sulfur, and Some Iron Compounds

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The effect of single or combined application of urea-formaldehyde at 80 g N/vine, sulfur at 0.4%, and three compounds of iron (chelated, sequestered, and sulfate forms as 0.1%) on productivity of 'Red Roomy' grapevines was studied during 1995 and 1996. A substantial increase in berry set, number of clusters, yield weight of clusters and berries, total soluble solid sugars, and anthocyanins was observed because of the application of these fertilizers singly or in combination. Total acidity in the juice was reduced because of application of these fertilizers. Combined application of urea-formaldehyde, sulfur, and chelated iron gave the best results with regard to yield and quality of berries. An economical yield was obtained on 'Red Roomy' vines supplied with urea-formaldehyde at 80 g/vine, sulfur at 0.4%, and chelated iron at 0.1%.

Influence of Rootstock on Seasonal Levels of N and K in Petioles of Two Grape Cultivars

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Petioles were gathered at three times during the season: bloom, veraison, and harvest, in two trials 'Chardonnay' (Ch) and 'Cabernet Sauvignon' (CS). In each trial, scions were grafted onto 14 rootstocks. Petioles were analyzed for NO₃-nitrogen, %N, and %K. Averaged over rootstocks, CH petiole NO₃ levels were highest at harvest and lower at both bloom and veraison. A similar trend was seen in 'Cabernet Sauvignon', although, on average, NO₃ levels were higher on all sampling dates. In Ch, the rootstocks 'Ramsey', 'St George', and '110R' were among the highest in NO₃, while Harmony and 1616C were among the lowest. In CS, O39-16 was among the highest in NO₃, while 44-53M was among the lowest. In both cultivars and among all rootstocks, petiole NO₃ was positively correlated with petiole %N in Ch, petiole K declined throughout the year, while in CS most rootstocks were relatively stable. In Ch, the rootstocks 'Harmony', '1616C', and '44-53M' had high levels of K, while in CS '44-53M' was among the highest.

Effect of Dormex on 'Roomy Red' Grape Vines (*Vitis vinifera* L.)

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The present investigation was carried out during 1994 and 1995 seasons on 'Roomy Red' grape vines cultivated in Minia and Beni Suef governates to study the effect of Dormex and/or overcropping on 'Roomy Red' grape vines. Bud opening, number of clusters per vine, as well as the yield and its physical and chemical properties, were studied. Results indicated that Dormex overcame the irregularity

of bud opening. At the same time, bud opening preceded the control by about 4 weeks. The percentage of bud opening, fruit set, as well as the number of clusters per vine, were increased. On the other hand, over-cropping had a vice versa effect on the previous parameters as compared with the control. Results also indicated that onion was of less effect than berseem in this concern.

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Evaluation of Mechanized Vineyard Production Systems for Barbera (*Vitis vinifera* L.) Grapevines Grown in the San Joaquin Valley

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The availability and cost of labor are important concerns for many California wine grape growers. Greater state and federal labor regulations, increased grower liability, increased efforts to control illegal immigration, and mandated increases in the minimum wage are causing growers to investigate production systems that may reduce labor requirements and costs. The purpose of this experiment was to determine the influence of training system and mechanization on vegetative growth, yield, fruit composition, labor requirements, and production costs for wine grapes grown in the San Joaquin Valley of California. Barbera vines grafted on Freedom rootstock were used in the experiment. Treatment variables examined were training system (bilateral cordon, non-positioned vs. bilateral cordon, vertical shoot positioned) and pruning method (hand vs. machine pre-pruning with hand follow-up). The experimental design used was a randomized complete block with data analyzed as a factorial. There were five blocks and all treatment combinations were evaluated. Data were collected during the 1994 and 1995 seasons for vegetative growth, yield, fruit composition, pruning labor requirements, and machinery performance. Few treatment effects were observed on vegetative growth, yield, and fruit composition during the course of this study. When significant differences were noted for these parameters, training system had a greater impact than pruning method. In contrast, labor requirements and production costs displayed a significant response to pruning method. Machine pre-pruning reduced pruning labor requirements from 41 man-hours per acre to 24–28 man-hours per acre per year. Pruning labor requirements were reduced by ≈40% and the costs associated with pruning were reduced by ≈30%.

93 ORAL SESSION 21 (Abstr. 523–527) Postharvest Physiology–Floriculture/ Foliage

523

Nitrogen and Sulfur Effects on the Production and Postharvest Longevity of Pot Chrysanthemums

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Research on hydroponically grown mums showed that nitrogen (N) levels applied can be reduced when adequate sulfur (S) is also applied. However, changes in stem length, leaf area, and time-to-flower can be affected. Our goal was to evaluate whether reduced N levels in combination with S would affect commercial production and post-harvest longevity of pot mums. 'White Diamond' was grown in a peat:perlite:vermiculite medium following a commercial production schedule. N levels applied were 50, 100, 150 and 200 mg/L. S levels were 0, 5, 10, 20, and 80 mg/L. The treatment design was a complete factorial 4 x 5 with 20 treatment combinations. The experimental design was a split-plot with N levels as the whole-plot and S levels as the split-plot factor. Variables measured were plant height, leaf area, days to bud set, days to first color, and days to flower opening. Plants were ship to the Univ. of Florida for postharvest evaluation. Data were analyzed using SAS PROC MIXED AND PROC REG. N and S interactions were significant for all variables measured except flower longevity. Plants receiving 0 mg/L S did not produce inflorescences, had shorter stems, and less leaf area regardless of N levels. Plants receiving 50 mg/L N and some S produced inflorescences, but were of inferior quality to plants receiving 100, 150, and 200 mg/L N. Plants receiving 200 mg/L N and 80 mg/L S showed breakdown of plant architecture. Plants of commercial quality were obtained at 100, 150, and 200 mg/L N in combination with either 5, 10, or 20 mg/L S.

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The Effect of Light and Temperature on the Physiological Status of Bedding Plant Plugs during Short-term Low-temperature Storage

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Previous research has shown that low-temperature storage can be used to maintain bedding plants in plug trays when weather conditions in spring make scheduling of transplanting difficult. The objective of this study was to determine what physiological changes occur during the short-term, low-temperature storage of plug seedlings. Plants of two bedding plant species, *Geranium* and *Vinca*, were stored at 2, 6, or 10°C and under low light or dark conditions for 4 weeks. Data were collected at three sampling dates (0, 2, or 4 weeks after beginning of storage) and included dry and fresh mass, total leaf area, leaf chlorophyll content and chlorophyll fluorescence as well as electrolyte leakage and soluble sugar content of leaf and root tissue. The parameters will be discussed in relationship to plug seedling survivability, quality, and growth responses under the experimental storage treatments.

525

Extending Potted Bougainvillea Post-production: NAA, STS, and Ethanol

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The effect of NAA [16.5 mg/L or 500 mg/L sprayed once at end-of-production from two different sources: wettable powder (Fruitone) and sodium hydroxide solution (Sigma)], STS (0.5 mM sprayed once at end-of-production and 0.4 mM sprayed every 15 days after bracts started to be apparent) and ethanol 50% (v/v) solution, sprayed twice: at end-of-production and immediately after simulated transport) were tested using two types of completely randomized experiments. At the end-of-production plants were placed for 3 days under simulated transport conditions (171°C, no light) and then placed under interior conditions (211°C and 11 mol·s⁻¹·m⁻² of cool-white fluorescent light 12 h/day). Every other day during post-production the number of bracts not completely developed (ED), as well as the number of completely (CD) developed, bracts remaining in the plants were assessed. Among the post-production treatments tested, NAA (500 mg/L) and STS (applications every 15 days during production) + NAA (16.5 mg/L) were the most-efficient treatments. Ethanol and STS (one single application) did not control bract abscission efficiently and did not increase plant longevity. Plants treated with NAA abscise more not completely develop bracts than completely developed bracts. Use of NAA in potted bougainvillea requires fully developed bracts at end-of-production.

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Effect of Postharvest Temperature and Storage Duration on Growth and Flowering of the Phalaenopsis Orchid

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On 6 Sept. 1996, container-grown vegetatively propagated Phalaenopsis Atien Kaala 'TSC22' plants were harvested and individually weighed. The bare-root plants were packed in cartons with shredded newspaper and placed in incubators at 15, 20, 25, or 30°C air temperature. Control plants were undisturbed. After 4, 7, or 14 days, one-third of the plants were removed from each temperature treatment, weighed, planted in pots, and then placed in a greenhouse. Mass loss (primarily water) increased with increasing air temperature and duration in storage. Symptoms of chilling injury (yellow blotches on leaves) were inversely related to 15 and 20°C storage temperatures. Chilling injury became more severe as storage duration increased. Plants had little or no chilling injury at 25 and 30°C, regardless of storage duration. Leaf loss was most severe on plants stored at 15°C for 7 or 14 days or at 30°C for 14 days. Increased storage duration up to 14 days did not affect the time of spiking (appearance of the flowering shoot) for plants stored between 15 and 25°C. Those kept at 30°C, regardless of the duration, spiked 5 to 8 days after the control. The results suggest that vegetative Phalaenopsis plants harvested in late summer should be stored and shipped at 25°C. Under such conditions, plants could lose 20% of the fresh mass between harvesting and planting without adversely affecting subsequent performance.

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Extension of Postharvest Keeping Time of *Antirrhinum majus* L. Cut Flowers with Hydrogen Peroxide

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Three percent hydrogen peroxide (H_2O_2) was diluted with deionized water (dH_2O) to 0.75%, 0.38%, 0.19%, 0.09%, or 0.05% H_2O_2 plus 1.5% sucrose for use in evaluation of *Antirrhinum majus* L. (snapdragon) cut flowers. Other vase solutions used as controls included: 300 ppm 8-hydroxyquinoline citrate (8-HQC) plus 1.5% sucrose; dH_2O plus 1.5% sucrose; and dH_2O . A completely random design with 7 replications was used. Flowering stems of three commercial inbreds and one F_1 hybrid of snapdragon were cut when the first five basal florets opened. Each stem was placed in an individual glass bottle containing one of the eight different treatments. Flowering stems were discarded when 50% of the open florets wilted, turned brown, or dried. Postharvest life was determined as the number of days from stem cutting to discard. Addition of H_2O_2 to vase solutions at rates of 0.19 and 0.09% resulted in postharvest life not different from that obtained with 8-HQC plus sucrose. Hydrogen peroxide plus sucrose extended postharvest life of snapdragon cut flowers 6 to 8 days over dH_2O and 5 to 7 days over dH_2O plus 1.5% sucrose.

94 ORAL SESSION 22 (Abstr. 528–534) Culture & Management—Vegetables

528

Effect of N Source on Photosynthesis and Plant Dry Matter Yield of Tomato

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The objective of this study was to determine if winter legume or grain cover could support net photosynthesis (P_n) and plant dry matter production comparable to recommended rate of synthetic N. The following winter/spring fertility treatments were applied: 1) 0 N winter/0 N spring, 2) 0 N winter/90 $kg \cdot ha^{-1}$ N spring, 3) 0 N winter/180 $kg \cdot ha^{-1}$ 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. 'Mountain Pride' tomato was planted in all plots in spring. Plant dry weight and P_n were measured at flowering, fruiting and prior to senescence. The highest P_n (22.78 $\mu mol CO_2/m^2$ per s) and leaf dry weight (115.2 g/plant) were obtained at fruiting, while highest branch dry weight (194.5 g/plant) occurred prior to senescence. There was significant increase in plant dry weight during reproductive growth phase. Tomato plants receiving supplemental N from crimson clover or hairy vetch had P_n and plant dry weight comparable to those receiving synthetic N. The results of this study indicated that legume cover crops were as effective as commercial N fertilizer for supporting photosynthesis and vegetative growth of tomato.

529

Nitrogen Sources for Tomato and Pepper Production

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Three nitrogen sources applied through drip irrigation were compared to preplant-applied urea to evaluate their effects on tomato (*Lycopersicon esculentum* Mill.) and bell pepper (*Capsicum annuum* L.) earliness, yield, and blossom end rot (BER) in 1995 and 1996. Calcium nitrate ($CaNO_3$), urea ammonium nitrate (UAN), and ammonium nitrate (NH_4NO_3) were applied at 11.2 kg N/ha weekly beginning 2 weeks after transplanting for a total of 8 weeks. The urea treatment received 112 kg N/ha before planting and fertigated treatments received 22.4 kg N/ha from urea before planting. In 1995 only, two additional treatments were fertilized with chicken manure only (1.3N–0.7P–0.8K) at 112 kg N/ha and 168 kg N/ha. In 1996, nitrogen treatments were compared at two levels of potassium fertilization: 0 or 269 kg K/ha. 'Sunrise' or 'Mountain Spring' tomatoes and 'Ranger' peppers were transplanted into black plastic in mid to late June each year. Nitrogen treatments had no effect on marketable or total yield, fruit size, or BER of tomatoes. Total pepper yield was lower with urea than with $CaNO_3$; early and marketable yields showed similar trends, but differences were not consistently significant. UAN and NH_4NO_3 pepper yields were usually similar to yield with $CaNO_3$, but did not always differ from urea yields. Compost treatments produced yields intermediate

between urea and fertigated treatments in 1995. In 1996, peppers from UAN and NH_4NO_3 plots had more BER (0.5% to 1%) than $CaNO_3$ plots (0%); urea plots had an intermediate amount of BER (0.2%).

530

Microirrigation and Antitranspirant Rates and Cultivar Effects on Tomato Yields on Sand

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Two tomato (*Lycopersicon esculentum* Mill.) cvs. Agriset 761 and Equinox, were grown in spring and fall 1996 with two microirrigation rates 1x (HI) and 0.75x (LO) of the open pan evaporation and sprayed either weekly or biweekly with Anti-Stress 2000 (acrylic polymer) at 2.33 $L \cdot ha^{-1}$ in 280 to 561 $L \cdot ha^{-1}$ H_2O during the first 10 weeks of the season. Tomato yields were similar with HI or LO irrigation rate and with antitranspirant sprays or water control. In both seasons, 'Equinox' had a higher early but lower seasonal total marketable yield than 'Agriset 761' ($P \leq 0.05$). Residual soil concentrations of NO_3-N and K were higher ($P \leq 0.05$) with the LO, than with HI irrigation rate.

531

Effect of Antitranspirant and Fertilization on Stomatal Conductance, Transpiration, Mineral Nutrition, and Growth 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. Leaf stomatal conductance, transpiration rate, and growth were depressed by GLK-8924. In contrast, higher fertilization rate increased plant growth but leaf stomatal conductance and transpiration rate were not affected until 3 weeks after GLK-8924 treatment. With 24 g NutriCote per pot, lamina N concentration in GLK-8924 treated plants was 12.5-fold of that in untreated plants, regardless of GLK-8924 concentration. Lamina P, K, Fe, and Cu were greater while S, Ca, Mg, Mn, B, and Zn were not affected by GLK-8924. The reduced growth by GLK-8924 may be due to the reduced stomatal conductance while the increased growth by high fertilization may be due to influences on plant nutritional status.

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Phosphorus Requirements for Lettuce Transplant Growth Using a Flotation Irrigation System

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Phosphorus applied at frequent rates via the flotation irrigation system affected growth of both roots and shoots of lettuce transplants grown with a flotation irrigation system. After an initial P addition of 15 $mg \cdot L^{-1}$, further P additions up to 90 $mg \cdot L^{-1}$ P resulted in a minimal growth response. Transplants produced with 0 P had similar poor growth, regardless of the amount of N applied. Nitrogen at 100 $mg \cdot L^{-1}$ improved the response of shoot growth to any level of P, but adversely affected root growth compared to N at 60 $mg \cdot L^{-1}$. Quality transplants had a root to shoot ratio of ≈ 0.25 , total root lengths between 276 and 306 cm, and total root area between 26 and 30 cm^2 in a 10.9- cm^3 cell volume. Only 30% of the plants produced with 0 P could be pulled from the transplant flats, compared to $\approx 90\%$ pulling success with added P. All pretransplant P treatments had a similar effect of increasing head mass at harvest time, and in reducing time to maturity regardless of production season. At transplanting, plants produced with transplant P were larger than those produced with no transplant P. Thus, at least 15 $mg \cdot L^{-1}$, supplied every 2 days via flotation irrigation, is recommended for production of high quality lettuce transplants in a peat+vermiculite media containing low concentrations of water extractable P.

Evaluation of Diagnostic Technologies for Assessing the N Nutritional Status of Lettuce

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Twenty field experiments were conducted to evaluate the response of iceberg lettuce (*Lactuca sativa* L.) to N and evaluate various diagnostic technologies as tools for assessing the N nutritional status of lettuce. Lettuce yields showed a curvilinear response to N in most experiments. Generally, the dry midrib nitrate-N test and the sap nitrate-N test appear to be sensitive indicators of the N nutritional status of lettuce after the folding stage of growth. The chlorophyll meter was not a sensitive indicator of the N nutritional status of lettuce. Preliminary data also show that canopy reflectance, including digital analysis of aerial photographs, is correlated to N nutritional status of lettuce. However, reflectance technologies do not readily distinguish between N deficiencies and other factors (insects, diseases, water stress, etc.) that affect plant biomass and color. Because plant tests do not appear to be sensitive indicators of N nutrition during early growth stages (before folding), a post-thinning (and pre-sidedress) soil nitrate-N test is currently being evaluated.

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Hydroponic Greenhouse Production of Fresh-market Basil in Colorado

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Fresh-market basil is becoming 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 an inorganically 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 and fresh weight was determined. During the 2nd and 3rd months of harvest, productivity from the plants treated with the organic fertilizer was greatest in the perlite system. However, productivity from the plants treated with the traditional fertilizer was greatest in the bag mix and rockwool systems.

95 ORAL SESSION 23 (Abstr. 535–542) Nutrition–Tree Fruits

535

The Phloem Mobility of Boron Alters Symptom Expression and Management of Boron in Plants

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We have demonstrated that boron (B) is freely phloem mobile in a number of crop species and we predict that B will be mobile in all species that transport polyols (mannitol, sorbitol, dulcitol). This finding directly contradicts accepted dogma and profoundly influences the diagnosis and management of B in almond, apple, apricot, cherry, pear, peach, plum, prune, celery, and other species. In the majority plants, B moves in the xylem with the transpiration stream. Once B enters the leaf, it remains there with little or no redistribution. As a result, there is always a decreasing concentration gradient of B from old to young leaves and B toxicity symptoms always occurs in the old leaves first, typically exhibiting tip and margin burn. In species in which B is mobile, these symptoms do not occur. When almond, peach, and plum were exposed to high B in the growth medium, the predominant site of B accumulation was fruit, young stems and apical meristems. As a consequence, the earliest symptoms of B toxicity in species in which B is phloem mobile are observed in the young shoot meristems and fruits. Foliar application of ¹⁰B isotope demonstrates that B is readily transported to neighboring fruits and buds of almond, apple, and nectarine. In apple seedlings, plant B requirements can be fully satisfied solely by foliar application to a few mature leaves. This strongly suggest that foliar B applications can be used as an

efficient means for B fertilization in *Malus*, *Prunus*, and *Pyrus* species. Details of the studies and their implications for B management will be discussed.

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Remobilization of Nitrogen from Storage Pools of Mature Apple Trees Depends on Nitrogen Status

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Remobilization of reserve N and uptake of soil N in winter and spring were assessed in relation to the N status of trees. Ten-year-old 'Newtown Pippin' apple trees on M.7A rootstock were fertilized to create moderately vigorous trees, trees with above-ground portions (tops) and roots relatively low in N (L/L), tops high in N and roots low in N (H/L), both tops and roots high in N (H/H), or tops low in N and roots high in N (L/H). Labeled (¹⁵N) fertilizers were used to tag the soil and frame and root N pools in the moderately vigorous trees prior to winter and spring remobilization. The level of ¹⁵N in the buds and new growth was monitored throughout winter and spring. Nitrogen stored in the aerial part of the tree was first to be remobilized to meet N requirements of the developing buds. Root and soil N reached the flower buds simultaneously. Trees of the L/H treatment transported labeled N upward to the bud as early as 9 Feb., even though average air temperature was close to 7°C, whereas L/L trees did not send any root-¹⁵N to the buds until 2.5 later. When trees received an abundance of N in the fall (H/H and L/H), their buds grew faster in the spring and they bloomed earlier compared with L/L and H/L trees. For root to shoot N translocation to start early (in winter), the bud needed to be low in N and the roots had to have adequate N reserves.

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Effects of Root Zone Temperature on the Kinetics of Nitrogen Uptake of Non-bearing Apple Trees

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Low root-zone temperature is one of the potential causes of low rate of plant nutrient uptake in spring. In this period, fruit trees are frequently supplied with nitrogen and a delay in root absorption could lead to an increase of nitrate leaching. In this study we assessed the effect of low root temperature on kinetic of nitrogen absorption of apple trees. One-year-old rooted cuttings of 'Mark' apple rootstocks were subjected to two root temperature: 8 ± 1°C (LT) and 23 ± 1°C (HT). Four days after treatment imposition, the potted plants were supplied with 20 mg of N as NH₄NO₃, enriched with 10 atom% of ¹⁵N. One, 2, 4, and 8 days after fertilization, tree root system was inserted into a Sholander bomb where a 0.325-Mpa pressure was applied to collect the xylem sap from the stem cross section. The sap exudation rate was always depressed by low root temperature. Nitrogen flow through the xylem vessel was highest in HT plants the day after fertilization (10-fold higher than LT), then decreased constantly. In LT plants, N flow was low the first and the second day after fertilization then reached the maximum 4 days after fertilization, when it was significantly higher than in HT plants. The amount of fertilizer-N found in leaves reflected the different movement rate of N observed in the two treatments. In HT trees fertilizer-N reached a plateau 2 days after fertilization, while in LT it linearly increased over time. This results suggest that root zone temperature of 8°C, although causes a delay (2–4 days) in nitrogen uptake, does not represent a serious limiting factor for N nutrition of tested apple trees.

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Uptake and Translocation of Fall- and Spring-applied Zinc in Bearing Apple Trees

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A zinc timing study was carried out in 'Jonagold'/'EM26 trees using labeled zinc chloride (98.8 atom% Zn-68). In the fall, five spurs with strong flower buds on each of five trees were labeled with a micropipet with a solution of 1000 ppm Zn at the rate of 240 µg of Zn per leaf. Almost all the Zn-68 applied was recovered in the fallen leaves. Next spring, leaves and flowers clusters sampled from the treated spurs showed that only 3% of their total Zn was fertilizer-derived. A spring application was performed on five spurs and young terminal shoots of each of five trees. The developing leaves were labeled with 500 ppm Zn-68 solution at petal fall. Two weeks later, the entire spurs and the treated shoots were sampled. Zinc remained in the treated areas and it was not transported below or above the

application zone. The study supports the contention that Zn is highly immobile in the tree and, if needed, it should be applied in early spring in order to promote rapid leaf and shoot growth. Fall applications of Zn-68 were absorbed but not transported from the treated leaves to the surrounding tissues. Therefore, Zn was not recycled for the next year's growth.

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Effect of Water and Nutrient Stresses on Apple Rootstock Growth, Respiration, and Capacitance

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We are evaluating techniques for measuring intact apple rootstock (*Malus domestica* cv. M.9 and MM.111) responses to low, medium, and high soil-water potential, and low, medium, and high concentrations of N, K, and Ca, in sterile sand culture. Root respiration and functional surface area were estimated with an IRGA chamber and electric capacitance meter, respectively. Root length and surface area were determined by digital image analysis of extracted root systems. Low N supply reduced root respiration, while low K levels increased respiration relative to well-nourished controls. Calcium effects were inconsistent among the rootstocks. Total root length and respiration rates of MM.111 were higher than M.9, but M.9 had higher root:shoot ratios. Root capacitance was correlated with total root length ($P < 0.001$); and M.9 root systems had greater capacitance than MM.111. In a related field experiment, root growth and respiration of 4-year-old 'Mutsu' apple trees on M.9 rootstock were measured in soil under low and moderate drought stress established by rain exclusion shelters, using capacitance and IRGA meters, and a minirhizotron video camera inserted into Plexiglas tubes transecting the rhizosphere. Root growth rates peaked in July (coinciding with maximal shoot growth), then declined gradually during late summer; but variability among trees was greater than among water stress treatments. Root/soil respiration maxima of $4.5 \mu\text{mol CO}_2/\text{m}^2$ per s occurred in mid June, late July (when new root counts peaked), and the end of August (when root turnover was maximal).

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Effect of Sampling Date and Production Zone on the Predictive Capacity of Bitter Pit through Magnesium Infiltration in 'Granny Smith' and 'Braeburn' Apples

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Bitter pit is the most important physiological disorders for apples in Chile. During the 1995–96 season, the predictive capacity of bitter pit through magnesium infiltration of the fruit in commercial orchards of three locations in South Central Chile: San Fernando (SF), Curico (CU), and San Javier (SJ) was established. Three orchards were chosen in each location and for each cultivar; fruit were collected 60, 40, and 20 days before commercial harvest. Fruit were infiltrated for 2 min with magnesium chloride at 0.05 M using vacuum levels of 500 or 100 mm Hg for 'Granny Smith' and 'Braeburn', respectively. The predictive capacity (correlation between predicted and effective bitter pit—after 90 days at $2^\circ\text{C} + 10$ days at 18°C) increased closer to harvest; with regards to location: SF > CU > SJ. Bitter pit-like symptoms, caused by Mg infiltration stabilized 16 days after infiltration. Bitter pit incidence was better predicted than severity. Bitter pit was better predicted for 'Granny Smith' than for 'Braeburn'.

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Relationship between Nitrogen Fertilization and Bacterial Canker in 'French' Prune

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Bacterial canker (BC), caused by *Pseudomonas syringae* pv. *syringae* van Hall, is a serious disease of stone fruits that occurs most commonly in young orchards. Many factors can predispose or increase the risk that trees develop BC such as sandy or compacted soils, low soil pH, inadequate tree nutrition, frost or cold injury, genetic susceptibility, and presence of ring nematode, *Criconebella* spp. However, questions still remain about how these factors influence disease incidence in 'French' prune, *Prunus domestica* L. In 1991, we established a 3.64-ha plot in Winters, Calif., to determine the effects of nitrogen (N) fertigation on growth responses and yield of young prune trees. N was applied through a surface drip system at 0, 0.11, 0.23, and 0.45 kg actual N/tree per year as UN32 urea (Unocal,

Sacramento Calif.) with 1/10th of the total amount delivered per application every other week from May through September starting in 1992. Two other treatments were also included: 0.064 kg N/tree per year through surface drip if % leaf N dropped below 2.3%, and 0.23 kg N/tree/year delivered in small amounts every irrigation via an automated buried drip system. Symptoms of BC began appearing primarily in the 0- and 0.064-N treatments in 1993. During 1995 and 1996, we demonstrated highly significant relationships between low N status measured in leaves and increased incidence of BC. Furthermore, we determined levels of N application via drip irrigation, which resulted in good yields, vigorous growth, and lack of BC in our test plots, but also minimized N use and potential for nitrate leaching into groundwater. These and additional results will be presented.

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Emitter Placement and Calcium Plus Boron Solution Affect Elemental Content of Spur 'Delicious' Apples

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Physiological disorders of apples, such as cork spot and bitter pit, are a result of low soil calcium, low or excessive soil moisture, large fruit size, and environmental conditions. We report on the effect of microirrigation treatments on apple fruit when irrigation is applied as water alone or water plus a calcium (Ca)/boron (B) solution with applications applied over the tree canopy or under the tree canopy. Apples were harvested from trees in their 4th to 7th leaf and the number of fruit and size of fruit varied from year to year. In most years, there were no significant differences among treatments for fruit Ca. Fruit B was significantly higher in treatments where B was applied through the irrigation. Fruit N/Ca levels were lower when the fruit size was smaller, which was due to a higher number of fruit per tree. Year to year variations in fruit Ca levels also were likely to temperature, humidity, rainfall, fruit size, and shoot growth.

99 ORAL SESSION 24 (Abstr. 543–547) Culture & Management—Turf

543

Mineral Nutrient Content of Selected Turfgrass Species and Cultivars

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Limited information is available concerning the mineral nutrient content of different turfgrass species. There is a need to develop sufficiency ranges for turfgrasses under various management programs. The nutrient concentration of a turfgrass provides an indication of the nutrient status and quality of the turf. A study was conducted to assess the mineral nutrient composition of selected turfgrass species and cultivars. Plant tissue samples of the following turfgrasses were collected: creeping bentgrass, *Agrostis palustris* Huds. 'Penncross'; bermudagrass, *Cynodon dactylon* (L.) Pers. 'NuMex Sahara', 'Santa Ana', 'Texturf 10', and *Cynodon dactylon* (L.) Pers. x *Cynodon transvaalensis* Burt-Davy 'Tifgreen', 'Tifway'; perennial ryegrass, *Lolium perenne* L. 'Medalist X Blend'; St. Augustinegrass *Stenotaphrum secundatum* (Walt.) Kuntze 'Seville'; and zoysiagrass, *Zoysia japonica* Steud. 'El Toro' and *Zoysia japonica* x *Zoysia tenuifolia* Willd. ex Trin. 'Emerald'. Three samples of each cultivar were collected, washed with deionized water for 30 s, and dried in a forced-air oven at 70°C for 72 hr. Plant samples were analyzed for both macronutrient and micronutrient concentration. For the bermudagrass cultivars, the concentrations of potassium (K) and magnesium (Mg) were less than $20.0 \text{ g}\cdot\text{kg}^{-1}$ and $2.0 \text{ g}\cdot\text{kg}^{-1}$, respectively, and less than known sufficiency levels. 'Tifway' and 'Texturf 10' had lower nitrogen (N) concentrations than other bermudagrasses. 'Penncross' and 'Medalist X' had the highest N concentrations. Zoysiagrass had low concentrations of N, phosphorus (P), calcium (Ca), K, and Mg. The concentration of copper (Cu) was low for zoysiagrass and three bermudagrass cultivars ('Texturf 10', 'Tifgreen', and 'Tifway'). There were differences among the turfgrasses for manganese (Mn) and zinc (Zn) concentrations.

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Turfgrass Evaluation Under Artificial Shade in the Greenhouse

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Establishing and maintaining turfgrass in the shade is one of the most challenging problems facing turfgrass managers and home owners. A greenhouse study was initiated to determine the shade tolerance of centipedegrass [*Eremochloa ophiuroides* (Munro.) Hack.], carpetgrass [*Axonopus affinis* Chase], and selected St. Augustinegrass [*Stenotaphrum secundatum* (Walt.) Kuntze] cultivars ('Floratam', 'FX-10', 'Seville', and 'TR 6-10'). Plants were grown under artificial shade (85% polypropylene shade cloth) and full sun. Actual percent shade (%shade=(PAR under shade/PAR under sun)*100) was determined by measuring photosynthetically active radiation (PAR) under shade cloth and full sun adjacent to the shade structure using a quantum sensor. Pots were arranged in a completely randomized block design with four replications. All turfgrasses, except 'TR 6-10', had a significant reduction in total dry weight in the shade compared to those in the sun. 'TR 6-10' had the highest root, leaf, and total dry weight in the shade. 'FX-10' had the lowest root, leaf, and total dry weight in the shade. Plants grown under the shade treatment compared to those in the sun resulted in an average decrease in stolon number of 13 and in total stolon length of 170 cm. In the shade, 'Floratam' and 'Seville' had the longest stolon internode lengths, while 'Floratam' had the longest in the sun. There were significant differences for leaf length between the shade and sun treatments, except for carpetgrass and 'FX-10'. 'Floratam' and 'FX-10' had differences in leaf width between the sun and shade.

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The Methodological Study of Under-soil Heating System (USHS) for Warm-season Grass

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Recently, full-green turf on the sports fields in a winter period is highly required. The negative factor for warm-season grass pitch is its winter dormancy. Winter overseeding (WOS) is one of the successful methods to make them seem green. However, maintenance cost for winter overseeded turf is relatively expensive, and WOS itself involves some difficulties. On the other hand, under-soil heating (USHS) has been used only for cool-season grass pitch, but for warm-season grass pitch for the purpose to make them full green in a winter term. The objectives of this study are: 1) to confirm USHS's effectiveness for warm-season grass, 2) to make the specified system itself, and 3) to estimate the approximate heat demand. The results indicate that USHS can make warm-season grass green and maintain much higher turf quality, even in a severe winter period. The parameters needed to create the system are obtained. Those includes: heating pipe's spacing and depth, initial media temperature, and required soil temperature. In addition, USHS needs plastic cover for insulation, which light, air and water can pass through. Compared with WOS, this method can reduce maintenance fee and procedures such as preparation for WOS in a fall and transition in a spring. Thus, it can prolong total playing period. Moreover, it is easy to maintain the turf quality higher and maintenance cost can be less than WOS. The future subjects are to assess weed invasion, pests and diseases levels induced by USHS or by excess humidity, and to create a special maintenance program for this method.

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The Response of 'Tifway' Bermudagrass to Growth Retardants as Charged-hydrophilic Polymers or Foliar Spray under Two Irrigation Systems

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A study of applying growth retardants under overhead and subsurface irrigation systems was conducted on bermudagrass (*Cynodon dactylon* L. cv. Tifway) grown from rhizomes in 15-cm pots containing sand medium. Paclobutrazol (50%) at 2 mg/pot was used as foliar spray or charged-hydrophilic polymers (Super Sorb C) and either incorporated or put below medium surface. Mefluidide (28%) at 0.01% ml/pot was used only as foliar spray. Before spray treatments, grasses were cut at 2 cm from medium surface, and the second cut was made at the 6th week from treatment. All growth retardant treatments reduced grass height compared to non-treated plants. The lowest grass height was produced by paclobutrazol as foliar spray under overhead irrigation in the 6th and 9th week. By the 9th week, all hormonal treatments under the two irrigation systems had no effect on grass quality, color, and establishment rate. Both paclobutrazol foliar spray and below medium surface charged-polymer treatments under subsurface irrigation had the lowest water loss and dry weight by the 6th and 9th week. The paclobutrazol

charged-polymer treatment under subsurface irrigation had also the the lowest root dry weight among all treatments. Although mefluidide foliar spray was less effective on grass height than paclobutrazol, they had similar effect on water loss and shoot dry weight.

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In Vitro Regeneration of Buffalograss [*Buchloe dactyloides* (Nutt.) Engelm] through Immature Inflorescence Culture

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Buffalograss is native to the Great Plains of North America. Its excellent drought resistance and low growth habit make it a good choice for a low-maintenance turf. A reproducible and efficient regeneration protocol of buffalograss is critical for further genetic transformation. By using immature inflorescences as explants, we have achieved the regeneration of buffalograss of two female clones, '315' and '609', a male clone, NE 84-45-3, and a synthetic cultivar, 'Texoka'. Somatic embryogenesis was observed. The medium used for callus initiation was MS basal medium supplemented with various concentrations of 2,4-D and BA. After 4 weeks of dark culture, calli with nodular structures were transferred to the same basal medium supplemented with BA and either a reduced rate of 2,4-D or no 2,4-D. It was demonstrated that 2,4-D at 2 or 3 mg/L is optimal for embryogenic callus production. The presence of BA from 0.1 mg/L to 0.5 mg/L was required for the regeneration of '315', '609', and NE 84-45-3. For 'Texoka', 2,4-D at 0.5 mg/L with BA at 0.3 mg/L in the regeneration medium favored normal development of somatic embryos that were capable of germination. A genotypic effect was observed with regard to embryogenic callus production; explants of the male genotype NE 84-45-3 exhibited a higher percentage of embryogenic callus formation than was found for the two female genotypes. A significant seasonal effect was also observed with inflorescences collected in early May exhibiting a higher percentage of callus formation than those collected in the summer and fall.

106 ORAL SESSION 25 (Abstr. 548–555)

Postharvest Physiology–Vegetables

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Rapid Detection of Senescence-related Volatiles of Fruits and Vegetables

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Volatile production is known to change with stages of plant organ development. Research has primarily focused on ripening-related volatiles; however, the potential exists to use volatiles as markers of organ damage and senescence. We have employed gas chromatography/mass spectrometry to establish stages of senescence based on volatile profiles of whole and lightly processed broccoli and carrot. An air-tight chopping apparatus was used as a flow-through chamber system and the exit gas stream analyzed for each commodity with and without tissue disruption. For carrot, isoprenoid pathway volatiles, such as 3-carene, caryophellene, α -caryophellene, and β -pinene, increase with damage and tissue senescence. Similar trends were obtained for broccoli with volatiles characteristic of β -oxidation and shikimic acid pathways. Time and condition-related volatile profile changes will be presented for carrot, broccoli, and strawberry.

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Sensory Evaluation Correlates with Flavor Volatile Profiles of Ripe Tomato Fruits

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'Agriset-761' and 'CPT-5' tomato fruits were harvested at green stage and subsequently exposed to a postharvest exogenous ethylene-air mixture (100 ppm C₂H₄ at 20°C). Tomatoes with visual symptoms of ripening (breaker stage = <10% red coloration) were removed from ethylene treatment after 1, 3, and 5 days and were transferred to 20°C and 85% RH. At "table-ripe" stage (full red coloration and 4-mm fruit deformation after 5 sec@9.8N), whole fruit samples were analyzed for difference/discrimination sensory evaluations, aroma volatile

profiles, and chemical composition. Flavor of fruits gassed for 1 day was rated significantly different than that of fruits gassed for 3 or 5 days (n = 25 panelists) for both cultivars. Several panelists noted the perception of "rancid" and "metallic" tastes, and "lingering" aftertaste in fruits gassed for 5 days. Chemical composition assays showed that flavor differences could be partially due to a significant increase in pH values between fruits gassed for 1 and 5 days (4.23 and 4.34, respectively for 'Agriset-761') and a significant decrease in titratable acidity (0.91% and 0.73%, respectively, for 'Agriset-761'; 1.04% and 0.86%, respectively, for 'CPT-5'). No significant differences in soluble solids content or total sugars were found in any treatments for either cultivar. 'Agriset-761' showed significant increases in the concentrations of acetone, hexanal, 2+3 methylbutanol, and a decrease in 2-isobutylthiazole, whereas, 'CPT-5' fruits showed significant increases in hexanal, 2+3 methylbutanol, trans-2-heptenal, 6-methyl-5-hepten-2-one, 2-isobutylthiazole, β -ionone, geranylacetone, and a decrease in ethanol concentration. In both cultivars, these significant differences in important aroma volatile compounds could be of enormous relevance in the perception of off-flavor/off-odors.

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Molecular Mass Changes in Cell Wall Pectins of Tomato Fruit Locule Tissue in Response to Deesterification

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Changes in the gel filtration behavior (apparent mol mass) of cell wall pectic polymers have been observed in a number of ripening fruits, including some that express little or no detectable polygalacturonase (PG). Pectins from tomato (*Lycopersicon esculentum*, Mill. v. Solar Set) fruit locule tissue show limited depolymerization during ripening, although alkali-soluble polymers are of reduced mol mass relative to water- and chelator-soluble polymers (Plant Physiol. 111:447). This study addressed whether the lower mol mass of alkali-soluble polymers was a consequence of extraction or specific metabolism of these wall polymers. Pectins from sequential water and chelator extractions of ethanol-insoluble solids from mature green tomato locule tissue were subjected to alkaline conditions. The size distribution of both water- and CDTA-soluble pectins treated with weak alkali were downshifted and similar to those extracted directly by weak alkali, indicating structural similarities of the three pectin fractions. Spectrophotometric analysis showed no involvement of β -elimination hydrolysis in the apparent mol mass reduction. The alkali-treated polymers were of greatly enhanced susceptibility to PG-mediated degradation. The alkali-associated changes also occurred in response to pectinmethylesterase hydrolysis. The results indicate that deesterification can strongly influence gel filtration behavior of pectins and may explain the apparent mol mass decreases of pectins in fruits not containing PG.

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Qualities of Hot Water- and Calcium-treated Tomatoes after Storage

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Mature green tomatoes (cv. Vibelco) were immersed in water at 42°C for 90 min or in water (42°C for 90 min) containing 2% calcium chloride prior to storage at 2 and 15°C for 2, 4, and 6 weeks. Control fruits were immersed in 20°C water for 90 min. All fruits were subject to poststorage ripening at 20°C for 6 days. Weight loss, chlorophyll and lycopene content, pH, TSS, TA, firmness, and electrolyte leakage were determined after storage or 6 days after storage. Control fruits showed lower weight loss, less lycopene content, pH, TSS, firmer but more chlorophyll content, pitting, decay, TA, and electrolyte leakage than treated fruits. Compared to hot water-treated fruits, lower pitting, decay, less chlorophyll content, and electrolyte leakage while more lycopene content, TA, and firmness were detected in combine hot water- and calcium-treated fruits. Extended storage time resulted in higher pitting and decay. Fruits stored at chilling temperature (2°C) showed higher chilling susceptibility to pitting and decay than those were stored at nonchilling temperature (15°C).

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Internal Bruising Affects Chemical and Physical Composition of Tomato Fruit

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Tomato (*Lycopersicon esculentum* L.) fruits, cv. Solarset, were harvested at the mature-green stage and treated with 50 μ L/L ethylene at 20°C. Breaker fruits (<10% red coloration) were dropped from 40 cm onto a smooth, solid surface and held along with undropped fruits at 20°C and 85% relative humidity. At table-ripe stage, pericarp, placental, and locular tissue were individually excised and analyzed for total carotenoids, total soluble sugars, soluble solids content, titratable acidity, density (locule tissue), polygalacturonase activity, and electrolyte efflux (pericarp tissue). Internal bruising caused by impact forces significantly affected pericarp and locule tissues, but not placental tissue. For bruised locule tissue, total carotenoids content decreased by 37.1%, vitamin C content by 15.6%, and titratable acidity by 15.3% as compared to control. However, density was increased by 3.0%. For bruised pericarp tissue, vitamin C content decreased by 16.5%, while polygalacturonase activity and electrolyte efflux increased by 33.3% and 24.8%, respectively. The development of abnormal ripening following an impact was confined to locule and pericarp tissues and appears to be related to the disruption of cellular structure and stimulation of enzymic activity.

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Reducing Bell Pepper Bruising during Postharvest Handling

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Green bell pepper is a popular vegetable in the United States. Michigan is the 5th-leading production area, producing 480,000 cwt of green bell peppers in 1994. The tender skin of the green bell pepper covers a crisp, fragile flesh that is easily bruised, cracked, or crushed. During commercial harvest and postharvest handling operations, bell peppers undergo several transfers, each of which has the potential for causing mechanical injury to the pepper fruit. These mechanical injuries include abrasions, cuts, punctures, and bruises. Mechanical injuries and bruises are defects that affect the market grade of the peppers, and may reduce pepper quality and subsequent shipping life. The impacts occurring in a pepper field and on a Michigan packing line were measured using an Instrumented Sphere. Field tests attempted to duplicate how pickers harvest bell peppers into 5-gal pails and empty them into empty wooden tote boxes. Other tests were on an entire packing line. Most bruising on packing lines occurred at the transfers between different pieces of equipment when the peppers fell or were propelled from conveyors onto uncushioned metal plates or rollers. Several transfer points were identified as areas where much of the mechanical damage occurred and improvements were suggested to the packer. Bell peppers were found to bruise on their shoulders; therefore, shoulder bruises may be used as an indicator of injury. The major problems with packing lines were excessive height differences between line components, lack of control of rolling velocity, and lack of cushioning on hard surfaces.

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Effect of Salinity on Blossom-end Rot of Tomato in the Closed Insulated Pallet System

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Incidence of blossom-end rot (BER) of tomato is known to increase with increasing salinity in hydroponics and field tomato crops due to osmotic stress and imbalanced ionic ratio in the media solution. The present investigation evaluated salinity effects on the occurrence of BER of tomato in a completely closed root environment known as the closed insulated pallet system (CIPS). The CIPS is a continuous sub-irrigation capillary system with water moving from reservoir to rootzone in response to plant uptake and loss through transpiration and growth. In CIPS, fertilizer reserve is placed at the top surface of the root matrix, so fertilizer ions move downward by diffusion. Various tomato genotypes were seeded directly into CIPS in Spring. The experiment was terminated at a 100-day growing period. The incidence of BER was calculated as percent affected fruits. Salinity treatments consisted of five concentrations ranging from 0 to 10 g/L NaCl. One salinity treatment was 1 g/L CaCl₂. In CIPS, the salt gradient created by uptake of saline water had lowest concentration at the top of root compartment where fertilizer was placed. Therefore, there was minimal ionic interactions between fertilizer ions and ions from the saline water. The uptake of water and plant growth decreased with increasing salinity concentration. The addition of Ca in the sub-irrigation water had no effect on the occurrence of BER. The incidence of BER correlated negatively with salinity level and plant growth in the CIPS.

Effect of 6-Benzylaminopurine on Sugar Profile and Senescence of Asparagus Spears Stored at 0°C

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To help elucidate the relationship between decline in sugar (especially sucrose) and senescence in asparagus (*Asparagus officinalis* L.), spears with or without tips were treated with 6-benzylaminopurine (6-BAP) and stored during 25 days at 0°C. 6-BAP was applied using a cheesecloth soaked with 100 ppm solution (30-s contact) immediately after harvesting to the tip or to the cut surface for spears that had 2 cm of the tip removed. Time-dependent profile of fluorescence, chlorophyll content, amount of fructose, glucose, and sucrose were measured for four segments from tip to the base of the spears over. Respiration rate and general visual quality were also evaluated for the whole spear on a daily basis. Three replications were used for all evaluations. 6-BAP reduced respiration rate of spears with intact tips, slowed the decline in fluorescence, and slowed chlorophyll degradation for the tip during 25 days of storage at 0°C. Respiration rate was higher in spears that had the tip removed, regardless the use of 6-BAP; however, the decline of fluorescence and chlorophyll degradation were lower in 6-BAP-treated spears. Application of 6-BAP also slowed the decline in sucrose content. 6-BAP effects were more marked when comparing with spears lacking their tip. The visual quality was higher in spears with tips that were treated with 6-BAP.

107 ORAL SESSION 26 (Abstr. 556–563)

Nutrition–Vegetables

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Advances in Plant Nutrition: Re-evaluating Hoagland's Hydroponic Recipe after a Half Century

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Although the principle of mass balance is well-understood, few people understand how Hoagland and Arnon used it to develop their famous nutrient solution recipes. Here I review: 1) the application of mass balance in deriving unique hydroponic solution recipes, 2) the dangers of dumping and replacing hydroponic solutions, 3) the need to alter the silicon and chloride concentrations in Hoagland's solution based on recent advances in our understanding of plant nutrient requirements.

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N and K Requirements of Carrot on Sandy Soils in Florida

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Carrot production in Florida has been centered in two major organic-soil vegetable production areas. These areas are the Everglades Agricultural Area near Belle Glade, in southern Florida, and the Zellwood vegetable area in central Florida. The state of Florida is currently in the process of purchasing most of the organic soils used for vegetable production near Zellwood, leading to a movement of vegetable production to the surrounding sandy soil or to other vegetable production regions in the state. The move to sandy soils has led to questions by growers about fertilization of vegetables such as carrot. We conducted a series of fertilization experiments with 'Nantes' and 'Imperator' carrot to evaluate yields and carrot quality responses to N and K. Carrot yield was maximized with 170 kg·ha⁻¹ N, confirming current extension recommendations for carrot on sandy soils in Florida. The soil used for the K study tested medium (50 mg·kg⁻¹) in K (Mehlich-1 extracted). Carrot yield responded positively to K up to 50 kg·ha⁻¹ K, near the amount predicted for soils testing N medium in K.

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An Evaluation for Pod Calcium Concentration between Eight Commercial Cultivars of Snap Beans and Eight of Dry Beans (*Phaseolus vulgaris* L.)

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We have previously observed significant variation for pod Ca concentration among snap bean genotypes. In the present experiment, we compare pod Ca con-

centration between snap bean and dry bean genotypes. Eight snap bean cultivars and eight dry bean cultivars were chosen to be evaluated for pod Ca concentration in summers of 1995 and 1996 at Hancock, Wis. The experimental design consisted in randomized complete blocks with three replications in 1995 and six in 1996. Snap and dry beans were planted in June and hand-harvested in August for both experiments. Soil analysis showed 430 ppm of Ca in soil at time of planting. No additional Ca was applied. Plots consisted of 10 plants each. Harvesting was made by collecting a pooled sample of medium size pods from the 10 plants. Ca determinations were made using an atomic absorption spectrophotometer. Data was presented as mg of Ca per gram of dry weight, pooled from both years, and analyzed using SAS. Results reflected significant differences between genotypes. Checkmate (5.5) showed the highest pod calcium concentrations and Labrador (3.9) the lowest among snap beans. G0122 (5.1) resulted in the highest and Por-rillo (3.6) the lowest within dry beans. Results were consistent across years. Snap beans (4.6) presented significantly higher pod calcium concentration than dry beans (4.2). Apparently, snap bean genotypes have the ability to absorb calcium from the soil more efficiently than dry bean genotypes, and this phenomenon is not significantly influenced by environmental factors.

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The Effects of Nitrogen on the Growth, Development, and Medicinal Compound Yield of the Sundew *Drosera adelae*

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Drosera spp. are used in alternative medicine as sources of the beneficial naphthoquinone compounds plumbagin (5-hydroxy-2-methyl-1,4-naphthoquinone) and 7-methyljuglone. Presently, *Drosera* are harvested from the wild with great detriment to bog habitats. This study focused on the development of a hydroponic rockwool culture of the sundew *D. adelae*. Tissue-cultured plantlets were raised as transplants in peatmoss. The transplants were planted directly into rockwool slabs primed to pH 6. Three levels of ammonium nitrate fertilizer were applied, the highest level of which approximated natural peat bog levels. Growth and development of the plants was monitored. Plants from each nitrogen treatment were harvested and subjected to extraction with toluene. Subsequently, high-performance gas chromatography was used to separate and quantify the naphthoquinones present in the extract. This method was used for three harvests: harvest of transplants, harvest after 2 months, and after 4 months of active growth.

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The Gradient Concept: A Potential Nutritional Paradigm Shift

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The conventional nutritional paradigm has been described as an empirical evaluation of how yield varies with nutrient application and is considered as a trial-and-error procedure. The gradient concept shifts the emphasis from variations in fertilizer application to one specific procedure designed to stabilize the ionic composition of the soil solution; thus providing the potential to enhance productivity beyond the limits of the trial-and-error procedure. By maximizing nutrient movement by diffusion and minimizing movement by mass flow (with the water), movement of nutrients and water to the root can be synchronized with removal by the root. A surface source of soluble nutrients (primarily N–K) in conjunction with a constant water table are the basic parameters. With the shift to a gradient-oriented procedure, commercial tomato yields in Florida (1970s) more than doubled. The Earth Box™, made of recycled plastic (manufactured by Laminations, Inc., Scranton, Pa.) is designed to maintain the parameters for a containerized gradient concept. Tomato yields have averaged 6 to 8 kg/plant (two plants/box). With the addition of side air spaces to the original air space between the media and the water table, the average yield increased by 20% to 30% with a maximum of 11.3 kg/plant (Fall 1996). With minimal water (for transpiration only), minimal management (maintaining the water table), minimal pollution (no leaching), and the associated nutritional stability, the containerized gradient concept has the potential to become a universal sustainable production system for the commercial grower as well as the home gardener.

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Relationship Between Antiplatelet Activity and Sulfur Fertility in Hydroponic and Field-grown Onions (*Allium cepa*)

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Organosulfur compounds in onion extracts inhibit the aggregation of human blood platelets. Antiplatelet activity is important to human cardiovascular health. We hypothesized that modification of sulfur fertility may increase organosulfur compound concentration and thereby affect platelet inhibitory activity in onion. Four contrasting onion genotypes were grown at four sulfur levels in a hydroponic system in the greenhouse and in contrasting sulfur environments in seven field locations in Wisconsin, Oregon, and New York. The contrasting field sites were comprised of sandy soils with a mean sulfate level of 5.4 ppm and muck soils with a mean sulfate level of 20.3 ppm. Onions grown in field environments with increased soil sulfur concentrations had significantly higher antiplatelet activity (33% higher than sand-grown onions; $P < 0.001$). The greenhouse experiment was conducted in hydroponics with nutrient solutions containing four sulfur levels ranging from 0.8 mM to 15 mM sulfate. The 10-mM sulfur treatment resulted in onion bulbs with 10% higher antiplatelet activity over those grown in the 0.8-mM sulfur treatment ($P < 0.06$). These data suggest that sulfur concentration in nutrient solution and in soil may be directly responsible for the increased antiplatelet activity in onion extracts observed in this study.

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Strength of Onion-induced Human Antiplatelet Activity is Associated with Plant Development

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Much of the medicinal activity induced by vegetable *Alliums* is derived from a suite of organosulfur compounds formed following hydrolysis of the *S*-alk(en)yl-L-cysteine sulfoxides (ACSOs). One of these medicinal activities is the inhibition of blood platelet aggregation; a factor that may influence cardiovascular health. Concentrations of ACSOs in the onion bulb ebb-and-flow during the vegetative phase, suggesting they act as storage forms of sulfur. To examine whether medicinal efficacy paralleled these changes, I tracked bulb, leaf, and inflorescence-induced antiplatelet activity during reproductive growth of four onion genotypes. Levels of bulb-induced antiplatelet activity dropped sharply for the first 8 weeks following the end of vernalization. Leaf-induced antiplatelet activity also dropped rapidly for the first 4 weeks, but rose precipitously by week 6. The rapid loss in leaf-induced antiplatelet efficacy between week 6 and week 8 suggests a recycling of these organosulfur compounds from the leaves to the developing flower stalk and inflorescence, which would be needed for protection against insect pests. Overall, I found a dramatic decrease in bulb-induced antiplatelet activity concomitant with an initially similar decrease and subsequent increase in leaf-induced antiplatelet activity. These were complemented by the presence of high levels of antiplatelet activity induced by the inflorescence. These data indicate development mediates the medicinal activity induced by onion plants. Furthermore, the flux of antiplatelet activity induced by various plant organs suggests that this medicinal trait is serendipitously associated with the storage and cycling of sulfur in onion plants; perhaps in response to insect predation.

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Crop Nutrient Survey Results for Five Vegetable Crops in Dade County, Florida

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A baseline survey was conducted to determine grower fertilizer management practices for five vegetable crops: beans, malanga, potatoes, sweet corn, and squash. This was done in conjunction with a 3-year replicated fertility trial with four vegetable crops (1993–94 through 1995–96) in the Homestead area. Questions included: fertilizer rates and timing, source(s) of fertilizer recommendations, soil and tissue testing, irrigation, changes in practices, summer cover crops, rock plowing, spacing, and type of fertilizer used. Survey results will be presented.

108 ORAL SESSION 27 (Abstr. 564–571) Thinning—Fruits/Nuts

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Multi-site Thinning Comparisons with 'Empire' and 'McIntosh' Apples

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Many chemical, environmental, and physiological factors have been reported to be important to apple chemical thinning, so we have been developing a multi-site and multi-year database of chemical thinning results and potentially important factors. For 3 years, we have conducted replicated thinning trials in 'Empire' and 'McIntosh' apple orchards at six or seven sites around New York state in different climatic regions. Different concentrations of NAA and Accel (primarily benzyladenine), NAA/carbaryl and Accel/carbaryl combinations and unthinned controls were tested with treatments applied at the 10-mm king fruit stage by airblast sprayers. Flower cluster counts, set counts, yields, fruit sizes, and other factors thought important to thinning response (orchard condition/history, weather, application conditions, etc.) were measured or estimated in each trial. Analysis of factor importance is continuing, but some general results have come from the thinning trials so far. Thinning effectiveness varied among years from poor to adequate. There have not been consistent thinner concentration responses. Commercial NAA and Accel concentrations have not thinned adequately. NAA/carbaryl and Accel/carbaryl have thinned the most. For the same crop load, trees thinned with Accel or the carbaryl combination have had better fruit size than when thinned with NAA.

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The Effects of Different Ratios and Concentrations of Benzyladenine and GA₄₊₇ on Fruit Size and Yield of Apple Trees

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In 1996, benzyladenine, or GA₄₊₇, or different ratios of BA : GA₄₊₇ (100:1, 10:1 and 1:1) were applied to 10-year-old 'Empire' apple trees on M.9 at 10-mm fruit size and 19-year-old 'Redchief Delicious' apple trees on M.9 or M.9/MM.111 at 7.6-mm fruit size. Each chemical or combination of BA and GA was applied at three rates (50, 100, or 150 ppm) and at 75 ppm with 1.25 ml of carbaryl/L. At harvest, fruits were sampled from each treatment to determine fruit shape, firmness, color, total cell number, average cell size, and percentage of intercellular space. The positive rate response on fruit size and negative rate response on crop load of 'Empire' became less significant for each formulation as the amount of GA₄₊₇ in the formulation increased. The same was true for 'Delicious', but less pronounced. At low rates of BA, formulations containing GA resulted in more thinning than BA alone. However, at higher rates of BA, formulations containing GA caused significantly less thinning than BA alone. For treatments combined with carbaryl, crop load increased linearly in 'Empire' with increasing amounts of GA₄₊₇ in the formulation. The treatment that provided the largest fruit size for 'Empire' was BA@150 ppm, while for 'Delicious' it was BA@75 ppm + carbaryl. Both varieties showed the greatest reduction in crop load with the 100:1@75 ppm+ carbaryl treatment when compared to the controls. These data suggest that GA₄₊₇ in formulation with BA may inhibit the thinning action of BA at moderate and high rates.

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Blossom Thinning Effects of Pelargonic Acid, Endothalic Acid, and Hydrogen Cyanamide in Apple and Peach

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Effects of various concentrations of Dormex (hydrogen cyanamide, a.i. = 49%), pelargonic acid and endothalic acid, applied at 60% and full-bloom, on fruit set and yield of 'Early Spur Rome' apple and 'Redhaven' peach were studied over 2 years. A full-bloom application of Dormex at 0.25% and 0.31% (% formulation) alone or 0.125% endothal followed by a post-bloom thinner reduced fruit set and increased fruit size in apple. A double application of endothal at a rate of 0.125%, once at 70% bloom and again at full-bloom, also was effective in thinning and increased fruit size in apple. Pelargonic acid was effective in thinning in apple when applied at a rate of 0.187% at 60% bloom and again at full-bloom. Return bloom in apple was better when blossom thinners effectively thinned blossoms. Dormex application at a rate of 0.31% at full-bloom showed the highest return

bloom in apple. All three chemicals were effective in thinning in peach when they were applied before complete fertilization. However, only 0.31% Dormex application at full-bloom was effective in thinning peach when a high rate of fertilization had taken place.

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Cropping and Fruit Growth in Redchief 'Delicious': An Analysis of the Effect of NAA and Cytokinins

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Generally, NAA is effective in inducing fruit thinning in 'Delicious'. Although significant thinning may be induced, fruit size at harvest may not be closely related to crop load. Further, the magnitude of response to NAA may vary markedly between seasons. Herein, we present an analysis of response of 'Redchief Delicious' over several years (tree age 11–14 years old) to high-volume sprays of NAA (15 mg·L⁻¹), BA (25–50 mg·L⁻¹), and CPPU (5 mg·L⁻¹) at KFD of 8–12 mm. A single tree was used for each treatment replicated four to six times and response was measured by yield and fruit size distribution for each tree. In eight experiments over 4 years, NAA resulted in an average 22% reduction in yield, a 5.1% reduction in large fruit (70 mm+) and 2% reduction in small (<64 mm) fruit compared to NTC. There was a marked variation in response among years. Over 4 years, BA averaged a 5% decrease in yield, a 15% increase in large fruit and a 21% decrease in small fruit. In contrast, when NAA was combined with BA at 25–50 mg·L⁻¹, yield decreased an average of 30%, large fruit decreased by 68%, and small fruit increased 8-fold (2.54 vs 20.6 kg/tree). CPPU alone (2-year study) had no significant effect on yield, but increased large fruit by 60% and significantly reduced production of small fruit. When CPPU was combined with NAA, yield was reduced in both years and the amount of large fruit was increased in 1995, but decreased in 1996. NAA had a very inhibitory effect on fruit size in 1996. One explanation may be that the crop was produced by lateral fruit (king flowers were lost to frost), and NAA has a greater inhibitory effect on lateral than king fruit. Results will be discussed in relation to studies with 'Jonathan' and 'Empire'.

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Effects of Application Conditions and Adjuvants on Chemical Fruit Thinning of Apple

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In 1995, effects of adjuvants on fruit thinning with Accel [10:1 ratio of 6-benzyladenine (BA):GA₄₊₇] at 75 ppm BA were studied. Silwet L-77 was used at 0.027% (v/v). Regulaid and ultrafine spray oil were used at 0.125% (v/v). Treatments also included unthinned controls, NAA (naphthalene acetic acid) at 7.5 ppm plus 600 ppm carbaryl, and Accel plus 600 ppm carbaryl. 'Empire' apple trees on M.9/MM.111 rootstock in Milton, N.Y., were used in the 6th leaf. Trees were blocked by number of blossom clusters/cm² trunk cross sectional area. Applications were made at 1.5x concentration, using tree-row volume to calculate appropriate dilute volume. Each spray treatment was applied near the high temperature on each of three consecutive days around 10-mm king fruitlet diameter. Conditions were as follows: day 1—high temperature of 19°C with moderate drying time, and rain several hours after application; day 2—high temperature of 15.5°C and prolonged drying; and day 3—high temperature of 21.1°C and moderate drying. All treatments significantly thinned and enhanced fruit size compared to unthinned controls. Application conditions (treatment day) did not significantly affect response when compared within any spray treatment. However, in combined analyses, treatment with Accel or Accel with Regulaid resulted in significantly smaller fruit on day 1, when rain followed application, compared to these treatments on other days, or compared to Accel with other adjuvants on day 1. Accel with carbaryl resulted in largest fruit size and cropload reduction, but significantly reduced seed number/fruit. It is postulated that prolonged drying times occurring in cool conditions can compensate for reduced uptake rate at lower temperatures.

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Enhancement of Transcuticular Penetration of NAA with Ammonium Nitrate and Triton X Surfactants as Spray Additives

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The plant cuticle is the prime barrier to penetration of foliar-applied plant growth regulators (PGR). Spray additives of various chemistries are frequently included in a tank mix to increase performance of PGRs. We have reported that

urea and ammonium nitrate (AN) enhance transcuticular penetration of ¹⁴C-labeled NAA (pK_a 4.2) from aqueous droplets (pH 5.2) and their subsequent deposits through enzymatically isolated tomato fruit cuticular membranes (CM). Studies on effects of Triton X surfactants on AN-enhanced NAA penetration showed an additional 25% increase in NAA penetration and the AN:surfactant interaction was significant. Also, some alkylamine hydrochlorides increased NAA penetration. Studies comparing NAA penetration through tomato and pepper fruit and *Citrus* leaf CM in the presence of 8 mM AN or 8 mM ethylamine HCl showed that all three species exhibited the same trend for penetration at 120 h: ethylamine HCl > AN > NAA only. Comparative NAA penetration for CM of the three species was pepper > *Citrus* > tomato, with significant differences ($P > 0.006$) in NAA penetration, as indexed by initial slope and penetration after 120 h. On addition of AN, NAA penetration was greater (range 3% to 40%) for *Citrus* and pepper CM than tomato CM. When ethylamine HCl was added, NAA penetration through *Citrus* and pepper CM was less (–37 and –27%, respectively) than tomato CM as measured by the initial slope, but 6% and 11%, respectively, more than tomato CM for penetration after 120 h. The differences in NAA penetration among the three species cannot be explained by cuticle thickness, since pepper and tomato CM are 2.5- to 3.5-fold thicker than *Citrus* CM. We have suggested that the enhanced NAA penetration mediated by AN and ethylamine HCl (and other alkylamine HCl examined) may be related to their hygroscopic properties leading to greater deposit hydration. The significance of the differences among the species CM and surfactant-enhanced NAA penetration will be discussed, in relation to diffusion in the non-living, non-metabolic plant cuticle.

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Effect of Benzyladenine (BA) on Fruit Thinning and Carbohydrate Status in Apples

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BA applied at the 10-mm stage at 50 and 100 ppm thinned, increased fruit size, and seed abortion. Net photosynthesis was decreased and dark respiration was increased when temperature following BA application was high (30°C), whereas there was no effect when temperature was lower (20°C). The seed number in abscising fruit was greater in BA-treated fruit than in control fruit. The number of viable seeds in BA-treated fruit was reduced. Tipping the bourse shoot increased fruit set, regardless of BA treatment. BA did not thin fruit with 25 leaves or greater. The translocation of ¹⁴C-sorbital from leaves to fruit was promoted by BA application to the fruit, but not when BA was applied to the leaves. The thinning induced by BA will be discussed in relation to available carbohydrate.

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Chemical Thinning of 'Gala' Apples in California

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'Gala', the third most widely planted apple cultivar in California, requires early and precise thinning to produce good fruit size. Thus, chemical thinning would be ideally suited for this cultivar. However, the normally prolonged bloom for apples in California makes timing of chemical thinning applications difficult. In 1995 and 1996 trials, several chemical thinning treatments provided significantly reduced fruit set on 'Gala' compared to the untreated control. Three treatments showed promise for commercial use: 1) carbaryl, two applications at petal fall and again at 10–15 mm diameter of the king fruit; 2) carbaryl plus NAD at petal fall; and 3) carbaryl plus 6-benzyladenine and GA₄₊₇ (Accel®), two applications at petal fall and at ≈10 mm diameter of the king fruit. These treatments generally gave reduced fruit set per 100 flower clusters, fruit set per fruiting cluster and/or numbers of fruit removed by follow-up hand-thinning. None of these treatments showed evidence of phytotoxicity, and some increased fruit size over the untreated control.

109 ORAL SESSION 28 (Abstr. 572–579) Fruit Set & Seed Quality—Vegetables

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Deficit Irrigation during Fruit Set Influences Fruit Number of Watermelons

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Reductions in the supply of high-quality irrigation water from underground aquifers is affecting production and irrigation management in the Winter Garden of southwestern Texas. This study was conducted to determine how growth, yield, and quality of watermelons [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] grown with subsurface drip are affected by synchronizing irrigation with specific growth stages. In 1995 irrigation rates were: 1.0 evapotranspiration (ET) throughout the entire growth period (T_1); 1.0ET until fruit set followed by 0.6ET until final harvest (T_2); 1.0ET until fruit set followed by 0.6ET until first fruit maturity followed by 0.4ET until final harvest (T_3); 1.0ET until fruit set followed by 0.6ET until first fruit maturity followed by 0.2ET until final harvest (T_4). In 1996, two irrigation rates were constant 1.0ET (T_1) and 0.5ET (T_2), and two with varying ET rates throughout the entire growth period. Varying irrigation rates with specific growth stages had more influence on fruit set and early yield than on leaf and vine growth. Total marketable fruit yield ranged from 94.4 to 71.8 Mg·ha⁻¹ when 569 mm (T_1) and 371 mm (T_2) of irrigation water, respectively, were applied in Spring 1995, and from 90.3 to 80.9 Mg·ha⁻¹ when 881 mm (T_1) and 577 mm (T_2) of irrigation water, respectively, were applied in Spring 1996. However, plants irrigated with constant 0.5ET demonstrated greater water use efficiency than those with 1.0ET. Information on water use will assist farmers in designing management strategies that minimize risks due to uncertainties in weather and water supplies.

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Increased Plant Density and Shade Affects Flowering and Fruiting of Pumpkin (*C. pepo*)

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Increase in plant density often results in reduction in reproductive potential of individual plants in cucurbits. The reduction may be due to reduced female flower production or a reduction or a delay in fruit set or to decreased fruit size. To determine the cause of the reduction, flowering, and fruiting of two pumpkin cultivars was evaluated in four field experiments under four plant densities ranging from 4483 plants/ha to 23,910 plants/ha and in a greenhouse using three levels of shade. Weekly flower and flower bud counts were made in the field experiment starting at first anthesis. Flowers were determined to have either set or aborted or not have reached anthesis. Increasing plant population from 4483 plants/ha to 23,910 plants/ha resulted in an increase in number of flowers per unit area up to 11,955 plants/ha, beyond which there was a steep decline. Increased plant density also resulted in an increase in aborted female flower buds that did not reach anthesis. Increase in plant density only reduced fruit set at very high populations. Number of fruits per area increased linearly with plant density up to 11,955 plants/ha, but decreased at higher plant populations. Reducing incident light by 30%, 60%, and 80% in a greenhouse experiment resulted in reduction of both male and female flowers. At 80% shade, there was a complete suppression of female flowers, whereas male flowers were still being produced. The number of female flowers reaching anthesis was positively correlated with total shoot dry weight while floral buds and male flowers were not. Reduction of individual plant biomass under high-density plantings might therefore be limiting female flower production and yield.

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Differential Fruit Load in Melon (*Cucumis melo* L.) Affects Shoot and Root Growth, and Vine Decline Symptoms

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The effect of zero, one, and two fruits per vine on plant growth and reaction to *Monosporascus* root rot/vine decline were investigated. In the first study, four cultivars with differing levels of tolerance were evaluated ('Primo', 'Deltex', 'Caravelle', 'Magnum 45'). Vine decline ratings were taken weekly during the harvest period for 4 weeks. Treatments with no fruit showed delayed and less-severe vine decline symptoms. Temperature also effected vine decline symptom expression. In a Fall test, with lower temperatures during fruit maturity, symptoms were delayed in all treatments and often absent in treatments with no fruit load. Vine decline symptom expression is greatly effected by physiological (fruit load) and temperature stress. A subsequent study was conducted to more precisely quantify the effect of various fruit loads on shoot/root partitioning and vine decline symptoms. In addition to growth parameters root disease ratings were taken.

'Caravelle', the most-susceptible genotype, was grown under differing fruit loads as mentioned above in Weslaco and Uvalde, Texas. As fruit load increased, root size decreased. Increased vine decline symptoms were observed under higher fruit loads. The implications on germplasm screening and breeding for resistance will be discussed.

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Comparing Pre- and Post-pollen Production Temperature Stress on Fruit Set and Fruit Production In Male-sterile And Male-fertile Tomatoes

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Peet et al. (1997) demonstrated that in male-sterile tomato plants (*Lycopersicon esculentum* L. Mill cv. NC8288) (MSs) provided with pollen from male-fertile plants (MFs) grown at 24°C daily mean, percent fruit set, total number and weight of fruit, and relative seediness decreased linearly as mean daily temperature rose from 25 to 29°C. The primary parameter affecting these variables was mean temperature, with day temperature at a given night temperature, night temperature at a given day temperature, and day/night temperature differential having secondary or no effect. To compare the effect of temperature stress experienced only by the female tissues with that experienced by the male tissues or both male and female tissues, MSs and MFs were grown in 28/22°C, 30/24°C, and 32/26°C day/night temperature chambers. Fruit yield and seed number per fruit declined sharply when increased temperatures were experienced by both male and female tissues (MFs). There was no fruit set in any of the MSs assigned to the 32/26°C pollen treatment, mostly because of the limited amount of pollen available from MFs. Both fruit production and seed content per fruit were also greatly reduced in MSs receiving pollen from 30/24°C grown MFs for the same reason. For plants experiencing stress only on female tissues (MSs grown at high temperatures, but receiving pollen from MFs grown at the lowest temperature), there was also a linear decrease in fruit yield as growth temperatures increased, as previously seen by Peet et al. (1997), but the temperature effect was less pronounced than that on pollen production. Thus, for this system, temperature stress decreased yield much more drastically when experienced by male reproductive tissues than when experienced only by female reproductive tissues.

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Using Seed Volatiles as a Possible Indicator for Seed Deterioration during Storage

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All kinds of plant seeds evolve volatile compounds during storage. However, a reliable deterioration forecast method is still not established using volatile evolution, even though some preliminary work indicated a relationship between volatile evolution and seed deterioration (Fielding and Goldsworthy, 1982; Hailstones and Smith, 1989; Zhang et al., 1993). Here we review some of the previous work concerning seed volatiles and present some more recent research on the effects of seed moisture content on deterioration. We found that volatile evolution from seeds was controlled by seed moisture level. Generally, seeds tended to evolve more hexanal and pentanal under extremely dry conditions (below 25% equilibrium RH). The production of hexanal and pentanal decreased with increasing seed moisture level. On the other hand, methanol and ethanol increased with increasing seed moisture. All of the volatile compounds accumulated in the headspace of the seed storage container during storage. Therefore, it should be possible to use different volatiles to indicate the deterioration of seeds stored under different moisture levels. We suggest that hexanal may be used for seed assessing deterioration under dry storage conditions (below 25% equilibrium RH), while ethanol may be used for seeds stored under higher moisture conditions (above 25% equilibrium RH). [References: Fielding, J.L. and Goldsworthy, A. (1982) Seed Sci. Technol. 10: 277-282. Hailstones, M.D. and Smith, M.T. (1989) Seed Sci. Technol. 17: 649-658. Zhang et al. (1993) Seed Sci. Technol. 21:359-373.]

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Structural Changes in Lettuce Seed during Germination Altered by Genotype, Seed Maturation Temperature, and Priming

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Thermotolerance in lettuce seed at high temperature was investigated using primed and nonprimed seed or seeds matured at 20/10°C and 30/20°C. During seed germination at 36°C, the structural changes of the seed coverings in front of the radicle tip were observed in an anatomical study. In all seeds during imbibition, regardless of seed maturation temperature or priming, a crack appeared on one side of the cap tissue and the endosperm separated from the integument in front of the radicle tip. Additional changes took place during imbibition: the protein bodies in the vacuoles enlarged and were gradually depleted, large empty vacuoles formed, the cytoplasm condensed, the endosperm shrank, the endosperm cell wall dissolved and ruptured, then the radicle elongated toward this ruptured area. The findings suggested that the papery endosperm layer presented mechanical resistance to lettuce seed germination and the weakening of this layer was a prerequisite to radicle protrusion at high temperature. Seeds of 'Dark Green Boston', 'Everglades', and PI 251245 matured at 30/20°C had greater thermotolerance than those matured at 20/10°C. Results of the anatomical study indicated that the endosperm cell walls in front of the radicle of seeds matured at 30/20°C were more easily disrupted and ruptured during early imbibition than seeds matured at 20/10°C, suggesting that these seeds could germinate quickly at supra-optimal temperatures. From anatomical studies conducted to identify and characterize thermotolerance in lettuce seed germination, it was observed that genotype thermotolerance had the ability to reduce physical resistance of the endosperm by weakening the cell wall and by depleting stored reserves.

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Differential Control of Embryo Growth Potential in Lettuce and Tomato Seeds

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The effects of chemical or physical factors during pregermination imbibition phase, or on dry seeds, on embryo growth potential (EGP) was studied in lettuce (Grand Rapids and Mesa 659) and tomato (H-9889) seeds in relation to dormancy, invigoration, and vigor loss. Embryos were excised from treated seeds (washed if imbibed in chemical solutions) and their growth rate (a measure of EGP) followed at 25°C at high magnification (X55). Treated seeds were also germinated at 25°C. In lettuce seeds, dormancy inducing treatments, i.e., a 2-day dark soak at 25°C with 50–100 µM tetcyclacis (TCY) or a 2-day dark soak in water at 35°C, reduced the subsequent embryo growth and germination rate at 25°C. The reduction was prevented by 1 mM GA₄₊₇ or irradiation applied during dormancy induction. A -d osmoconditioning (OC) at 15C with -1.2 MPa PEG-8000 solution in light or in dark with added GA₄₊₇ enhanced the EGP; addition of TCY reduced the EGP and the TCY inhibition reversed by GA₄₊₇. A progressive reduction in EGP occurred with increase in vigor loss. In tomato seeds, a soak with 100 µM TCY in light or dark for 2 days at 30°C induced a dormancy, but had little effect on EGP. Application of GA₄₊₇ plus TCY prevented dormancy induction without affecting EGP. A 4-day matricconditioning (MC) at 25°C in light or dark with moist Micro-Cel E enhanced the EGP; TCY and/or GA added during MC, had little effect on EGP. EGP progressively decreased as the aging period increased. Thus, in lettuce, the EGP is coupled with the reversible -GA/GA or phytochrome-controlled dormancy induction/release process, enabling germination, its inhibition, or its enhancement. In tomato, the EGP is not subject to light or GA control. Reduction in EGP, accompanying vigor loss in both seeds, is independent of light or GA action.

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Combining Osmopriming and Biopriming

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Osmopriming has been shown to enhance seed performance by increasing germination rates and uniformity. Furthermore, these enhancements persist under less-than-optimum conditions, such as salinity, reduced water availability, and excessively high or low temperatures. Additional benefits include resistance to soil pathogens due to lower leachate levels and more rapid emergence. To augment these existing qualities, it would be advantageous to incorporate beneficial organisms that antagonize soil-borne diseases, combining the benefits of both systems into a single procedure. To accomplish this, processing tomato seeds (*Lycopersicon esculentum* Mill. OH8245) were bioprimed in aerated -0.8 Mpa NaNO₃ at 20°C for 4 days, at which time a mixture of nutrient broth, a defoaming agent, and beneficial bacteria that has been adjusted to the same osmotic potential is added. The bacteria used, *Pseudomonas aureofaciens* AB254, has

been proved to control *Pythium ultimum* on a variety of crop seeds. After 7 days the seeds are removed having been primed and colonized with 105 colony forming units (cfu)/seed. In the absence of pathogen pressure, osmoprimed and bio-osmoprimed seeds performed similarly improving overall germination by 40% after 3 days, as well as low temperature (10–15°C) germination. However, when these seeds were sown in soilless media inoculated with *P. ultimum*, osmoprimed and bio-osmoprimed emergence was 57% and 74%, respectively, showing the improvements that these biologicals can provide. Thermogradient table results, storage tests, cfu/seed, and pathogen control will be discussed.

116 ORAL SESSION 29 (Abstr. 580–588) Undergraduate Education

580

Outreach Baccalaureate Programs in Horticultural Sciences at the University of Florida

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Florida is one of the nation's leading states in citrus, foliage, vegetable, and ornamental crop production. The Univ. of Florida is the only public institution in the state of Florida that offers a bachelors degree in horticulture and/or environmental horticulture. The main campus in Gainesville is centrally located ≈400 to 500 miles from either end of the state. Changing population demographics within Florida have emphasized the necessity of developing programs to reach non-traditional students. Students who are place bound due to work or other responsibilities represent an increasing part of the potential market. The Univ. of Florida, recognizing the specialized needs of non-traditional students, established Bachelors of Science degree programs in environmental horticulture at the Fort Lauderdale and Milton research and education centers. The centers teach the same core curriculum being taught in Gainesville, but the centers also teach additional courses specific to their geographic location to allow for a tailored program. The off-campus facilities have teaching faculty at the centers to teach the courses and also use satellite technology to down link courses from Gainesville. The development of off-campus programs in Fort Lauderdale and Milton allow the Univ. of Florida to improve the effectiveness of educational programming to reach place-bound students.

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The Use of Interactive Television in Expanding the Teaching Mission of the Land-grant University

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The Trans Texas Video Conference Network (TTVN) has been linked to all Texas A&M Univ. campuses and most of the Regional Research and Extension Centers. The College of Agriculture and Life Sciences has funded an aggressive project of establishing TTVN class rooms in many departments across the College Station campus, including The Horticultural Science Dept. in 1997. The first two Hort courses taught were HORT 422 Citrus and Subtropical Fruits in Fall 1996 and HORT 418 Nut Culture in Spring 1997. This extended the class room 400 miles south to Weslaco, 300 miles north to Texarkana and Dallas, and 700 miles west to El Paso. Students at each site had video and audio interaction with the professor and with each other. Advantages included the availability of college credit courses to areas where this subject matter did not previously exist, which helps fulfill the Land-grant University Mission. Quality was maintained through lecture and lab outlines on Aggie Horticulture, the department's Web home page, term papers written to ASHS serial publications specifications, and rigorous examinations monitored by site facilitators. Lecture presentations were presented via Power Point, which took about twice as long to prepare than traditional overhead transparencies. Administrative problems remain, but will be solved when the requested Distance Education Registration Category is initiated so that subvention credit can be shared. The lecture portion of the graduate course, HORT 601 Nutrition of Horticultural Plants, will be taught in the fall semester 1997 at eight sites throughout the state.

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Horticultural Teaching Resources on the Internet

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Horticulture Teaching Resources is a web site at The Ohio State Univ. designed to provide high school and higher education horticulture educators free-access to curriculum resource materials. The information has been structured to facilitate the instruction of basic concepts in plant biology, propagation, nutrition, and plant materials. A searchable database interface is used to access color photos, lab exercises, and test questions. Users of the system can also provide URL addresses to their own resources for inclusion in the database. (<http://hortwww-2.ag.ohio-state.edu/hvp/htr/htr.html>)

583

Internship Opportunities Utilized to Enhance Horticultural Skills

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Horticulture requires knowledge, acquired skills, and practical experience. Knowledge and acquired skills are relatively easy to impart in the university setting; however, weekly laboratory sessions fall far short of providing students with the practical experience they need in the workplace. Internship programs provide students opportunities to reinforce the knowledge and skills they have acquired in the classroom and allow them to gain new experiences, techniques and ideas. At Texas Tech Univ., students are highly encouraged to take an internship after both their 2nd and 3rd years. During an average academic year, about 30% of horticulture students participate in an internship, while more than 50% complete an internship during their degree program. Arrangements are generally made to ensure the students will rotate through a wide variety of horticultural experiences. At the conclusion of their program, interns write a report summarizing their experiences and then give a short oral presentation to other students at a club meeting or in a class. These presentations peak the interest of the other students and serve to keep the program effective.

584

Enhancement of Student Learning through Newsletter Assignments and Peer Review

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A 200-level course at Iowa State Univ., Principles of Horticulture, has included a communication across the curriculum assignment for the past seven semesters involving ≈425 students. Each undergraduate student develops and writes an individual student newsletter on topics and for an audience of the student's choice. The semester-long project motivates students to practice a professional communication task, and teaches technical horticultural material and writing skills. The newsletters contain at least two separate articles for an intended audience, providing the students with an opportunity to learn technical information in subjects in which they are intensely interested, but may not be taught in a principles course. Drafts of the articles and newsletter project are peer-reviewed by the students to model the professional review process, provoke critical thinking, and provide students with more feedback than they would otherwise receive from the instructor alone. Additionally, peer-review facilitates writing intensive courses for the instructor who wishes to focus course activities on writing, but has limited time or resources for reviewing writing assignments. Student newsletter articles are selected to be included in quarterly department and extension newsletters, providing students with a real-world use of a communication across the curriculum assignment.

585

Leadership Perspectives in Horticulture: Meeting the Needs of Horticulture Students Through Interdisciplinary Education

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Placing the horticulture student on a path of professional development as a society-ready graduate for the 21st century takes more than technical knowledge. New types of team-oriented organizations are being created that were not even imagined a few years ago. To help empower students to survive in these organizations, the course "Leadership Perspectives in Horticulture" was created. This interdisciplinary course serves as a model for leadership skill instruction by incorporating the

component of leadership development into a technical horticulture course. The objectives of this course are to provide academic and historical perspectives in technical horticulture issues, develop skills in leadership, problem solving, and team building, complete a theoretical study of specific leadership models, and blend theoretical leadership models with horticulture issues by completing a problem solving experience. An overview of the course in addition to changes in leadership behavior of students will be discussed.

586

Development of a Software Prototype to Teach Students Landscape Estimation

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Development of this software was initiated after receipt of a USDA Higher Education Challenge Grant. The visually realistic software, which uses digital photography as a software base, will serve as an effective and cost-efficient means through which students in landscape horticulture programs can improve their skills in estimating job costs prior to entering the job market. The software will allow students, while in a classroom setting, to visualize a job site from various perspectives, determine the tasks (landscape installation/landscape maintenance) that must be accomplished, and calculate an estimate taking into account direct costs (materials, labor, equipment), indirect costs (overhead), and profit. The interactive nature of the software will allow students to compare their estimates with one of known accuracy generated simultaneously by the computer. Incorporation of this software into academic curricula should increase prospects of long-term success for the many students who plan to start their own landscape horticulture businesses soon after graduating from college and university programs.

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Development of a Hypertext, Graphics-rich Glossary for Use in Teaching Undergraduate Plant Propagation

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Computer-aided instruction is becoming ever-more popular in higher education. The visual nature of horticultural instruction makes it particularly amenable to teaching with computer-based graphic and hypertext formats. The Texas Tech Horticulture Faculty is interested in developing multimedia materials for instruction. Thus far, attention has been directed mainly at courses in introductory horticulture and plant propagation. For the plant propagation course, one activity is the construction of a hypertext glossary in the area of asexual propagation. Topics included in the glossary include propagation by cutting, layering, budding, grafting, and micropropagation. Multiple-choice exams are also available in the module so that students can assess their understanding of the subject matter presented. The glossary is not meant to replace lecture attendance, rather students will be encouraged to access the material outside of class to supplement lecture material. The student is presented a narrative with hot-text links that when activated, pull up additional information with a combination of text and graphics. Alternatively, students can access the same information from a hierarchical topic menu. Plant propagation instructors may also benefit from the glossary's ready supply of visuals that can be down-loaded and used in a traditional classroom format.

588

An Internship Program in a Diverse Horticulture Curriculum

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Internship credit has been offered for nearly 30 years. In more recent years, it has been formalized with specific guidelines developed in setting up an individual student program. Internship opportunities are facilitated through a career day, which has moved from fall to spring semester in which over 25 firms come on campus to present their opportunities. A detailed packet of information is distributed to the perspective intern and cooperator. A memorandum of agreement is developed with student, cooperator and internship coordinator which details credit, description of the program and hourly wage. Students are required to submit weekly reports and upon returning to campus must present an oral report to a student group and a written report to the internship coordinator. The

cooperator does a summary evaluation, which is submitted to the coordinator. A final interview with each student is done with the internship coordinator and a S/F grade is assigned.

118 ORAL SESSION 30 (Abstr. 589–596) Culture & Management—Vegetables/Herbs

589

No-till Production of Irish Potato on Raised Beds

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Potato (*Solanum tuberosum* L.) yields in Virginia and other hot climates are considerably lower than in cooler areas, predominately because of high soil temperatures during set and bulking of the tubers. Although organic surface mulches conserve soil moisture and lower soil temperature, often resulting in increased tuber yields, applying organic mulches is commercially cost-prohibitive. Preliminary experiments were conducted in 1995 and 1996 at the VPI&SU Agricultural Research Farm to compare production of 'Yukon Gold' potato in no-till (NT) raised-bed systems with standard conventionally tilled (CT) methods. No-till yields were higher than CT both years, although differences were not significant. Based on these data, the NT production system used in these experiments is a viable management option, at least in hot climates such as Virginia. Rainfall during tuber bulking in 1995 and 1996 was above average, even excessive at times, which possibly negated the beneficial soil-cooling and moisture-conserving effects of the in situ mulches on potato yield enhancement. Greater yield increases would be expected in NT plots in normal rainfall years.

590

Could Irrigation Increase Irish Potato Yields in the Southeast?

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Most potato (*Solanum tuberosum* L.) is produced as a non-irrigated crop in the southeastern United States. This practice makes potato yields dependent on rainfall pattern and amount. An irrigation scheduling method based on a water balance and class A pan evaporation data (E_p) was evaluated in Spring 1996 on a fine sandy loam soil with 'LaSoda' potatoes. Planting date was 9 Apr. and standard production practices were followed. The model was $(12.7 \text{ DAH} + 191) * 0.5 \text{ ASW} = D(\text{DAH}-1) + [E_p (0.12 + 0.023 \text{ DAH} - 0.00019 \text{ DAH} * \text{DAH}) - R(\text{DAH}) - I(\text{DAH})]$, where DAH is days after hilling (DAH = 0 on 14 May), ASW is available soil water (0.13 mm/mm), D is soil water deficit (mm), R is rainfall (mm) and I is irrigation (mm). Root depth expanded at a rate of 13 mm/day to a maximum depth of 305 mm. Root depth at hilling was 191 mm. Controlled levels of water application ranging between 0% and 161% of the model rate were created with drip tapes. The model scheduled irrigations on 35, 39, 43 and 49 DAH. On 85 DAH, potatoes were harvested and graded. Irrigation influenced total yield, marketable yield, and combined US #1 grades ($P < 0.01$; $R^2 > 0.85$). Mean marketable yields were 19, 28, and 21 t/ha for the 0%, 100%, and 160% irrigation rates, respectively. These results suggest that supplementing rainfall with irrigation and controlling the amount of water applied by adjusting irrigation to actual weather conditions could increase potato yields. Excessive water, as well as limiting water, reduced potato yields.

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Potato Growth Uniformity as Affected by Subsurface Drip and Seepage Irrigation

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Growth and production uniformity of potato (*Solanum tuberosum* L.) as influenced by conventional seepage irrigation and by subsurface drip irrigation was evaluated in field studies during two seasons in plots 16 rows (18.3 m) wide and 183 m long. Seepage irrigation water was supplied through ditches located on each side of each plot. Drip irrigation water was distributed through buried tubes placed under the beds 6.1 m apart extending the length of the rows. Water application throughout the plots was accomplished more rapidly with the subsurface drip system and water use during the two seasons was 33% less than with the

conventional seepage system. Tuber yield during the first season was similar with the two irrigation systems. During the second season, plant growth, tuber development, and tuber yield were sampled on alternate rows beginning on each outside bed, at each end of each plot, and in the middle of the plots. Irrigation method and bed location among the 16 beds had little influence of potato growth and development. With water flow from north to south, plant growth, and tuber yield were significantly higher from potatoes growing at the north end, lowest in the plot center, and intermediate from potatoes growing at the south end. These data indicate that potato production with the two irrigation systems was similar.

592

Effect of Elevated Root-zone Temperature on Tuber Initiation in Potato cv. Norland

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This experiment was performed to test the hypothesis that tuber formation in potato is inhibited by short-term increases in root-zone temperature. Micro-propagated potato cv. Norland plantlets were grown in recirculating nutrient film culture under daylight fluorescent lamps at $350 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ PPF with at 20/16°C thermocycle at $1200 \mu\text{mol} \cdot \text{mol}^{-1} \text{CO}_2$ under inductive (12-hr light/12-hr dark) or non-inductive (12-hr light/12-hr dark with a 15-min light break 6 hr into the cycle) photoperiods for 42 days. Root-zone treatments consisted of continuous 18°C, continuous 24°C, 18°C with a 24°C cycle between 14 and 21 DAP (prior to tuber initiation), and 18°C with a 24°C cycle between 21 and 28 DAP (during the period of tuber initiation). The root-zone temperature was maintained with a recirculating, temperature-controlled, heat-exchange coil submerged in each nutrient solution. Warm root-zone temperatures did not inhibit tuber formation under an inductive photoperiod. The non-inductive photoperiod resulted in a 65% reduction in tuber biomass compared to the inductive photoperiod. Continuous 24°C and exposure to 24°C prior to tuber initiation reduced tuber formation an additional 40% under the non-inductive photoperiod. Both continuous and transient 24°C root-zone temperatures increased biomass partitioning to root/stolons compared to the 18°C treatment under both photoperiods. Total plant biomass was highest in plants exposed to continuous 24°C under both photoperiods. Results suggest that transient episodes of warm (24°C) root-zone temperature do not inhibit tuber formation in potato under inductive photoperiods. However, transient episodes of warm (24°C) root-zone temperatures did interact with stage of development under the non-inductive photoperiod.

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Incremental Effects of Plasticulture System Components on the Growth and Yield of Three Echinacea Species

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The incremental effects of adding plasticulture system components in *Echinacea* production were determined after one growing season. *E. purpurea*, *E. angustifolia*, and *E. pallida*, were grown in four cultural systems: flat ground, raised bed, raised bed with plastic mulch, and raised bed with plastic mulch and a polyethylene mini-tunnel. Trickle irrigation was used in all systems, with fertilizers injected monthly into the irrigation water. Plant spacing was 0.22 m in rows spaced 0.25 m apart, with 1.30 m between each set of three rows, giving a density of 75,758 plants/ha. In all systems, root dry weight was highest for *E. pallida*, followed by *E. purpurea*, then *E. angustifolia*. Each system component increased the root dry weight, but the percent increase differed among species. The mean root dry weights from the flat ground system were 35.8, 17.1, and 12.0 g/plant for *E. pallida*, *E. purpurea*, and *E. angustifolia*, respectively; whereas from the system including all components they were 51.1, 27.2 and 21.7 g/plant, respectively. The leaf dry weight of *E. purpurea* also increased with each system component added, but the stem dry weight was reduced by the mini-tunnel. All species produced more flowers when grown on raised beds than when grown on flat ground. The effects of the plastic mulch and mini-tunnel on flower production differed among species.

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Ecophysical Traits and Production of a Semi-domesticated Hot Pepper Genotype (*Capsicum frutescens* L.) under Different Plastic Mulches

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Diurnal and seasonal water relations and ecophysiological variables (soil humidity, transpiration, evapotranspiration, stomatal resistance, morphological changes, production), matched with some microclimatological variables, were studied in a hot pepper (*Capsicum frutescens*) experimental plot. Two treatments of plants with plastic mulches were assigned, black and blank-opaque, to compare them with plants without a mulch, established at the Experimental Station of CIBNOR in La Paz Baja California Sur, Mexico. Plants with blank-opaque plastic mulch showed the highest values of flower number, fruit production, leaf area, and canopy-projected area. Also, the biggest evapotranspiration rates were recorded from January to April for plants under the blank-opaque plastic mulch. Soil water content appeared to be a primary determinant factor for production. Soils under the blank-opaque plastic mulch had the biggest water content along the experiment. Plants without any plastic mulch had the lowest availability of soil water, rendered the lowest fruit production, and registered the highest evapotranspiration rates. May and June were the months with the highest air temperature during the experiment. Plants with black plastic mulch had intermediate records among the other two groups. When plants were allowed to face a drought stress, they responded through an osmotic adjustment for maintaining a low water potential, and thus supporting a partial turgor pressure. This adjustment was evident to be coupled with a stomatal regulation in order to minimize the loss of water through the transpiration process. Some drought tolerance strategies as a leaf size reduction were more evident in plants without a mulch.

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Compost and Plastic Mulch Sustain Melon Growth over Three Years

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For 2 successive years, compost at rates of 0, 12, 24, and 48 t/acre were applied to a previously highly infertile field. Timothy was grown and harvested for these 2 years. Subsequently, for 3 consecutive years, through 1996, 'Earliqueen' muskmelons were grown in the same plots without any additional compost being added. Subplots consisted of plastic and paper mulch and bare soil. Yields increased with increasing rates of compost for each of the 3 years, although yields for all treatments declined in the 3rd year. Highest yields were with the higher rates of compost coupled with IRT mulches and red mulch. Generally, organic matter and pH increased with increasing compost rates. Foliar diseases were suppressed with compost; however, there was an interaction of suppression with plastic mulches.

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Amelioration of Blossom-end Rot of Bell Pepper by Rowcovers and Supplemental Calcium

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A 2-year study was conducted in eastern Oregon to evaluate the effects of hooped spunbonded polypropylene rowcovers and calcium fertilization on yield and quality of drip-irrigated bell pepper grown on black plastic mulch. The experiment was a complete factorial with four replications of two varieties, covered and uncovered plots, and three levels of supplemental calcium fertilization at 0, 34 and 68 kg·ha⁻¹ applied through the drip irrigation system as Ca(NO₃)₂. Marketable yields increased with rowcover, both at the first harvest and over the season. Blossom-end rot and sunscald were reduced substantially by rowcovers; the effect was greatest during the earlier harvests. First harvest and season total yield of fancy grade peppers increased linearly as rate of supplemental calcium increased, as did total marketable yield at the first harvest. There was a trend to decreasing yield of fruit with blossom-end rot as calcium rate increased, and the percent fruit with blossom-end rot at the first harvest decreased linearly with increasing rate of calcium fertilization. Yield of fruit affected by sunscald decreased linearly as supplemental calcium rate increased at the first harvest; overall, yield of sunscald fruit was reduced by application of calcium at either rate.

119 ORAL SESSION 31 (Abstr. 597–603)

Photosynthesis & Carbon Metabolism—Fruits/Nuts

597

Sorbitol Metabolism in Growing Tissues of Peach

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Sorbitol is the major photosynthetic product in peach. In sink tissues, sorbitol is converted to fructose via the NAD-dependent enzyme sorbitol dehydrogenase (SDH). A new assay is described that allows rapid, simple quantitation of SDH activity in growing shoot tips, root tips, and fruits. The activity was measured on the crude extract desalted with a Saphadex G-25 column to eliminate small molecules such as sugars and nucleotides. Optimum buffer type and pH for the enzyme as well as degradation by proteolytic enzymes and stability over time were determined in the present study. Inhibition by dithiothreitol (DTT) was detected at an inhibitor concentration as low as 2 mM, proving the similarity with mammalian SDH. Storage of samples at 4°C overnight resulted in significant loss of enzyme activity. Using this assay, we also correlated SDH activity with sink strength in peach.

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Use of ¹³CO₂ as a Tool to Investigate Carbon Partitioning in Field and Greenhouse-grown Apple Trees

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Instrumentation to measure soil respiration is currently readily available. However, the relationship between soil respiration and root activity or root mass is not known. Herein we report on preliminary result using a ¹³CO₂ pulse to the foliage to determine if ¹³C respiration can be related to either root activity or root mass. An experiment was performed in the field on a 5-year-old apple tree (cv. Jonagold on M7). The tree canopy was enclosed in a Mylar[®] balloon and 2.1 g ¹³CO₂ were pulsed in the balloon for 1 hr. After the pulse, air emitted by the soil and selected roots was collected every 6 hr for 8 days, by bubbling it in 2 M NaOH. ¹³C/¹²C ratios were measured with the mass spectrometer. The emission of ¹³CO₂ from the roots gradually increased after the pulse reaching a peak after 100 hr. The emission trend was not linear, but it seemed related to soil temperature. Leaves and fruit were also collected daily. ¹³C content in leaves was 1.15% right after the pulse, but it progressively decreased to 1.09% at the end of the experiment. The experiment was then repeated on 12 potted apple trees (cv. Redcort on M7) in greenhouse conditions. Six of them were maintained well-watered, whereas six plants were subjected to a mild water stress, by watering them with half of the volume of water used for well-watered plants. After the two soil moisture levels were achieved, the tree canopies of all the 12 trees were pulsed. Leaves, stems, and roots were ground and run in the mass spectrometer. The results of root emission rate were found to be similar to the field experiment. Results also indicated that, in our experiment, stress did not affect root respiration rate. Specific details of the physiology data will be presented.

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The Relationship between Rubisco Activity and Photosynthesis in Apple Leaves with Different Nitrogen Content

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Based on the curvilinear relationship between carboxylation efficiency and leaf N in apple leaves, we hypothesized that deactivation of Rubisco accounts for the lack of response of photosynthesis to increasing leaf N under high N supply. A wide range of leaf N content (from 1.0 to 5.0 g·m⁻²) was achieved by fertigating bench-grafted Fuji/M26 apple trees for 6 weeks with different N concentrations using a modified Hoagland solution. Analysis of photosynthesis in response to intercellular CO₂ under both 21% and 2% O₂ indicated that photosynthesis at ambient CO₂ was mainly determined by the activity of Rubisco. Measurements of Rubisco activity revealed that initial Rubisco activity increased with leaf N up to 3.0 g·m⁻², then leveled off with further rise in leaf N, whereas total Rubisco activity increased linearly with increasing leaf N throughout the leaf N range. As a

result, Rubisco activation state decreased with increasing leaf N. Photosynthesis at ambient CO₂ and carboxylation efficiency were both linearly correlated with initial Rubisco activity, but showed curvilinear relationships with total Rubisco activity and leaf N. As leaf N increased, photosynthetic nitrogen use efficiency declined with decreasing Rubisco activation state.

600

Photometric Measurements of Rubisco Activity in Leaves of Deciduous Fruit Crops

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Ribulose biphosphate carboxylase/oxygenase (Rubisco) initiates the photosynthetic carbon metabolism; therefore, its activity has been measured in many physiological studies. However, information on in vitro Rubisco activity from leaves of deciduous fruit crops is very limited and the reported activities are suspiciously low. We measured Rubisco activity in crude extracts of leaves of apple, pear, peach, cherry, and grape by using a photometric method in which RuBP carboxylation was enzymically coupled to NADH oxidation. Replacing polyvinylpyrrolidone with polyvinylpolypyrrolidone in the extraction solution significantly increased extractable Rubisco activity. Depending on species, freezing leaf discs in liquid nitrogen followed by storage at -80°C for only 24 hr reduced both initial and total Rubisco activity to 5% to 50% of that obtained from fresh leaves. Initial Rubisco activity from fresh leaf tissues of all species was well correlated with maximum Rubisco activity (V_{cmax}) estimated from gas exchange; an exception was pear, where initial Rubisco activity was higher than V_{cmax} . In most cases, initial Rubisco activity was approximately two to three times higher than net photosynthesis.

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Elevated CO₂ Increases Growth and Photosynthetic Efficiency of Citrus Rootstock Seedlings

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The objectives of these greenhouse experiments were to determine the effects of elevated CO₂ on growth, mineral nutrition, and gas exchange physiology of seedlings of four commercial *Citrus* rootstocks. We grew well-watered and fertilized seedlings of 'Volkamer' lemon (VL), 'Cleopatra' mandarin (CL), 'Swingle' citrumelo (SW), and 'Troyer' citrange (TC) cultivars (in decreasing order of vigor) in unshaded, air-conditioned greenhouses at ambient CO₂ (350 μmol/mol) or 2x ambient CO₂ for 5 months. CL was the smallest cultivar, had the lowest root/shoot (r/s) ratio, and lowest rates of CO₂ assimilation (A) of leaves, transpiration (E), and water-use efficiency, (A/E). Overall, daily whole-plant water use was correlated with single-leaf E. Elevated CO₂ increased both shoot and root growth similarly; therefore, r/s was not affected. Elevated CO₂ increased A, leaf dry wt/area, and leaf C, but decreased transpiration and leaf N so that leaf C/N, A/N, and A/E all increased. Although plant size of the four cultivars ranked similarly at both ambient and high CO₂, the more-vigorous cultivars grew proportionately more at high CO₂ than the less-vigorous cultivars. Growing cultivars at elevated CO₂ can yield insights into mechanisms determining vigor and relationships between A and plant growth.

602

Net CO₂ Assimilation of Apple following Application of Soybean Oil

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Soybean oil can be used as an alternative pesticide for fruit trees. Two separate studies were conducted to determine the effects of oil concentration on leaf phytotoxicity and net CO₂ assimilation (A_{CO_2}). In one study, concentrations of 0%, 2%, 4%, and 6% soybean oil in water were applied to individual shoots with a hand-held mist bottle. In the second study, 0%, 1.0%, and 1.5% were applied to whole trees with an airblast sprayer. Petroleum oil was applied as a separate treatment. Net CO₂ assimilation was measured on single leaves. Oil residue was removed from the leaf with chloroform, dried, and weighed. Chlorosis and defoliation occurred with applications of 4% and 6% soybean oil. No visible phytotoxicity occurred with 2% or less oil. Net CO₂ assimilation decreased as the rate of soybean oil increased from 0% to 4% oil, but there was no difference between 4% and 6%. Net CO₂ assimilation decreased with increasing oil concentration from 0% to 1.5% and recovered to the rate of the control on day 7. Net CO₂ assimilation

was negatively related to oil residue. At an equivalent oil residue, there was no difference in A_{CO_2} between petroleum and soybean oil. Below a residue of 0.15 mg·cm⁻², foliar phytotoxicity did not occur. Reductions in A_{CO_2} were small and did not last longer than 7 days if residues were ≤0.10 mg·cm⁻².

603

A Custom-built Scanner for the Estimation of the Radiation Intercepted by a Tree Canopy

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This work proposes a methodology, by light-scanning below the canopy, to directly estimate the photon flux radiation (400–1200 nm) intercepted by single or row canopies. The system is based on the assumption that the light intercepted by the canopy, at a particular time, corresponds to the difference between the incoming potential radiation on a ground surface area (able to include the ground area shaded by the canopy), and the actual radiation influx to that area in presence of the canopy. To this purpose, light-scanning equipment has been designed, built, and tested, whose main components are two aligned multi-sensor bars (1.2 m long) and a CR10 data logger, equipped with an AM 416 Relay Multiplexer (Campbell Sci. Ltd., U.K.). The radiation sensors (BPW 14N TELEFUNKEN) were chosen because of their spectral sensitivity, along with low cost. The sensors have been placed along the bars, at 5-cm intervals, and fitted with a Teflon® diffuser to provide a cosine correction. Radiation measurements are taken moving parallelly the bars on the ground, step by step, to monitor a sample point grid (5 cm by step length). Preliminary radiation scans were taken during the summer in a 3-year-old peach orchard, trained as delayed vaselette. Measurements were taken for a single canopy at various hours of the day. Moreover, radiation scans were taken at the same hour, over a 3-day timespan, while gradually defoliating the canopy. A custom-built software program has been developed for data handling. Mathcad software (Mathsoft Inc., U.S.) has been used to display the canopy shade image projected on the ground, the quantum map of the monitored area, and to calculate the light influx on the whole canopy. Moreover, the light spots on the ground determined by foliage gaps have been identified and the amount of radiation reaching the ground has been estimated.

120 ORAL SESSION 32 (Abstr. 604–611)

Culture & Management/Propagation–Tree Fruits/Nuts

604

Comparison of June-budded and Grafted Two-year-old 'Chandler' Walnut (*Juglans regia*) on Paradox Hybrid Root

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Fifty trees each of 1-year-old Paradox rootstock June-budded to 'Chandler' walnut and 2-year-old Paradox whipgrafted to 'Chandler' were planted in a 28 x 28-ft spacing on a Hanford sandy loam soil. Ten trees of each type were selected at time of planting and the number of roots, individual root diameter, trunk diameter, root dry weight, scion dry weight, and total dry weight were compared. All parameters, with the exception of root number, were significantly greater for the grafted 2-year-old rootstocks. Growth of the trees measured as trunk circumference 20 cm above the graft union was significantly greater for the grafted 2-year-old rootstocks following the first season. There was no significant difference in trunk circumference between the 1- and 2-year-old rootstocks following the second or third growing seasons.

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Walnut Rootstock Comparison and Own-rooted 'Chandler' vs. 'Chandler' on Paradox Rootstock

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In a comparison of six walnut rootstocks either nursery-grafted or field-grafted to 'Chandler' (*Juglans regia*), the highest-yielding trees after 9 years are on either seedling or clonal Paradox rootstocks. Trees growing on both Paradox rootstocks had higher yield efficiency than trees on the black rootstocks in both 1995 and

1996. Since 1993, relative tree size based on trunk circumference has not changed: southern California black (*J. californica*), seedling Paradox and northern California black (*J. Hindsii*) have remained significantly larger than clonal Paradox, Texas (*J. microcarpa*) or Arizona (*J. major*) black rootstocks. The smaller size of clonal as compared with seedling Paradox trees might be explained by a delay in field grafting success. Although both northern and southern California black rootstock trees were significantly larger than clonal Paradox trees, they did not differ significantly in yield and had significantly lower yield efficiency in 1996. Clonal Paradox trees have significantly smaller nut size than northern California black rootstock trees that can be explained by its higher yield efficiency. An adjacent trial planted in 1991 compares micropropagated 'Chandler' on its own root vs. 'Chandler' on seedling Paradox rootstock. In 1995 and 1996, own-rooted 'Chandler' had significantly greater trunk circumference, yield, and yield efficiency than did 'Chandler' on Paradox rootstock. Many of the trees on Paradox rootstock are growing very poorly compared to the own rooted trees. This could be due to diversity within the Paradox seed source. If own-rooted 'Chandler' trees become commercially available, they may have potential in areas where other rootstocks are undesirable because of hypersensitivity to cherry leafroll virus.

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Epicormic Sprouts from Branch Segments of Mature *Juglans nigra* L. as an Explant Source for in Vitro Culture

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At monthly intervals for 1 year, one branch was removed from the lower crown of three 30-year-old trees of black walnut (*Juglans nigra* L.). The basal 1.3 m of each branch was cut into four 32-cm-long segments that were placed horizontally in shallow plastic trays filled with perlite and watered daily with tap water. Branch segments cut early in the dormant season (29 Sept., 31 Oct., or 1 Dec.) or shortly after flushing (6 June) produced few, if any, epicormic sprouts. Approximately half the branch segments cut on 3 Jan. or 3 Feb. produced one sprout that elongated slowly. Most branch segments cut in the late dormant season (2 Mar., 30 Mar., 3 May) or growing season (5 July, 4 Aug., 6 Sept.) produced one or two sprouts >20 mm long. To prepare explants for in vitro culture, the terminal 2.5 cm was harvested when sprouts exceeded 3.0 cm, trimmed of all leaves, and disinfested. Explants were placed vertically in liquid Long & Preece (LP) medium supplemented with 3% sucrose, 0.3 µM TDZ, 0.05 µM IBA, and 1 µM BA. When shoots began to elongate (4 to 6 weeks), they were then placed horizontally on agar-solidified LP medium with liquid LP overlays to induce axillary shoot proliferation. Advantages of forcing epicormic sprouts on large branch segments are: 1) they can be a source of in vitro explant material for 6 to 7 months a year, 2) aseptic cultures can be easily obtained, 3) shoots from the base of branches may show more juvenility than shoots forced from branch tips, 4) softwood shoot wilting is not a problem as with forcing shoots from branch tips, 5) the procedure does not require preparing and changing forcing solutions, and 6) branch segments should have more stored food than dormant branch tips for forcing softwood growth.

607

Effect of ABA on Growth and Development of Walnut Somatic Embryos

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Development and maturation of somatic embryos is known to be abnormal in many species, particularly woody species. Precocious germination, abnormal cotyledon formation, and shoot development are three problems, among others, that occur during the growth and germination of walnut somatic embryos. Depending on the cultivar or line being cultured, as much as 50% of the embryos in any given culture may be abnormal. Reports in the literature have shown that ABA is useful in enhancing maturation and producing normal germination of somatic embryos of a variety of plant species. In order to overcome the difficulties of producing plants from somatic embryos in walnut, we have incorporated ABA in the nutrient medium in different concentrations and for different periods of time. Globular and cotyledonary embryos were separated and placed on DKW medium containing four different concentrations of ABA, 30, 60, 80, and 120 µM. Morphology, fresh weight, and germination of embryos grown on these different media were recorded. Embryos grown on ABA had lower fresh weight increases than controls, the actual growth depending on both the concentration of ABA present and the length of time

the embryos were grown on ABA-containing media. In addition, the percentage of embryos with normal morphology was considerably higher when embryos were grown on ABA. Other factors that were affected by the presence of ABA included the total number of embryos produced and the amount of senescence in the cultures. Germination of embryos was also improved as a result of their being cultured on ABA-containing media.

608

A Unique Bilayer Method for Rooting of in Vitro-produced Shoots of Chestnuts (*Castanea* spp.)

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The American Chestnut Foundation (ACF) has conducted a breeding program aimed at developing blight-resistant chestnut trees exhibiting the phenotype of American Chestnut [*Castanea dentata* (Marsh) Borkh]. Because such plants are difficult to propagate, we developed a protocol for in vitro multiplication of candidate blight-resistant plants resulting from the ACF breeding programs. Dormant shoots were taken from 5- to 8-year-old trees and forced, producing softwood growth for use as a source of explants for shoot multiplication. Best shoot proliferation took place on WPM containing 0.2 mg BA/L. Explant material for the rooting experiments was taken from 6- to 12-month-old proliferating cultures. The basal rooting medium consisted of WPM containing 0.01 mg IBA/L and was overlaid with a thin opaque layer. Rooting was enhanced overall with this bilayer approach. A "D/W" medium (DKW and WPM) was also used as a rooting medium containing 0.01 mg IBA/L and 0.2 mg BA/L, which further enhanced leaf quality and rooting for some genotypes. After several transfers on the bilayer system, explant growth appeared to become less juvenile in stem and leaf development and more analogous to mature later-season growth. The rooting responses and the time for rooting to be induced were highly variable among the different genotypes.

609

Rooting Ability of Microcuttings of Desert Almond (*Amygdalus arabica* Oliv.)

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Three experiments were performed to establish rooting procedure of *Amygdalus arabica* Oliv. Two-centimeter shoots grown in vitro on MS medium supplemented with IBA at 0.01 mg/L, BA 0.2 mg/L, sucrose 30.0 g/L, and agar 6.0 g/L were used in rooting microcuttings using three experiments: 1) IAA, IBA, and NAA at concentrations of 0.5, 1.0, and 1.5 mg/L during the whole experiment with 4 days of dark period; 2) effect of dark and light conditions and IBA and NAA treatments during root induction period (4 days), then shoots were transferred onto free plant bioregulators (PBR), MS medium until end of the experiment; 3) Rooting microcuttings after quick dipping in different NAA concentrations (0.0, 250, 500 ppm) or induced for 6 days in root induction medium (MS) with 3.0 mg/L NAA, then shoots were transferred onto containers containing 200 ml of peatmoss, perlite, or peatmoss : perlite mixture (1:1, v/v). Results of the first experiment showed that best rooting was obtained with NAA, followed by IBA. In the second experiment, dark treatments improved rooting percentage and root length. NAA was superior to IBA in root number. Higher IBA and NAA (3.0 mg/L) concentrations gave the best rooting. In the third experiment, induced shoots transferred to perlite gave better root number and rooting percentage followed by peatmoss: perlite mixture. Regardless of rooting medium, insignificant differences between 250 and 500 ppm NAA in root number and rooting percentage were obtained. In the quick dip method, NAA was superior to the in vitro root induction method. The highest rooting percentage (86.7%) was obtained with perlite at either 250 or 500 ppm, replacing by that the traditional in vitro rooting and obtaining plantlets that are more ready to grow under in vivo conditions.

610

Early Growth and Development of Pawpaw [*Asimina triloba* (L.) Dunal] Seedlings in the Greenhouse as Influenced by Shade and Root-zone Modification

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This experiment was designed to determine the optimal light level for growing pawpaw seedlings in the greenhouse. In addition, we wanted to determine if modifying the root-zone would positively impact pawpaw seedling growth and

development. Experimental treatments were imposed from seed sowing until the plants were destructively harvested. The experimental design was a split-plot, where blocking was done by position in the greenhouse. The main plot of the experiment was shade. This was accomplished by growing seedlings under a wooden frame covered with shade cloth to reduce incident light intensity received by the plant by 30%, 55%, 80%, or 95%. The control treatment was 0% shade or ambient greenhouse light level. The split-plot was root-zone modification. Half of all growing containers were untreated (control) while the other half were painted with SpinOut™, a commercially available product used to reduce root spiraling in nursery containers. There were 40 replicate seedlings per experimental treatment combination per block. Seedling shoot length and unfolded leaf number was recorded twice a week from seedling emergence until destructive harvest. Whole-plant leaf area was also determined. Leaves, stems, and tap and lateral roots were separated and dried to determine biomass partitioned to the respective organs. Up to 55% shade did not significantly reduce whole-plant biomass, while plants at 80% and 95% shade were stunted. Shade in the greenhouse is not required as was previously thought. Specific leaf mass and lateral root mass decreased as shade increased. Neither tap or lateral root dry weights were significantly affected by root-zone modification. New recommendations for container production of pawpaws in the greenhouse will be discussed.

611

Effect of *Cynodon dactylon* and *Amaranthus* sp. Leachates on the Growth of *Carya illinoensis* Seedlings

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Leachates of living *Cynodon dactylon* (L.) Pers. and *Amaranthus* sp. were applied to *Carya illinoensis* (Wangenh.) C. Koch. seedlings to compare effects on growth and elemental absorption. Water applied to the weed pot or control pot (no weeds present) leached through the pot and into a funnel with a tube attached, then directly into the corresponding pecan seedling pot. After 4 months of growth, pecan seedlings receiving weed leachates had less leaf area and were shorter than those watered through control pots. These results suggest that leachates from these two weed species inhibit pecan growth, independent of any competition effects.

121 ORAL SESSION 33 (Abstr. 612–617) Input/Output Management—Floriculture/ Foliage

612

Automated Irrigation Based on Soil Moisture Tension Reduces Run-off and Increases Productivity and Quality of Greenhouse-grown Cut Flower Roses

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Conventional irrigation practices of cut-flower greenhouse crops may result in application of excess water, resulting in runoff which may pollute the environment and contaminate drinking water supplies. A computerized irrigation control system based on soil moisture tension, originally designed for potted plants, was adapted for use in cut flower production. Tensiometers equipped with a high-flow ceramic tip and pressure transducers were effective in monitoring the soil moisture in the root zone of plants grown in ground beds and responded to rapid changes in soil moisture. The irrigation control system using these sensors, a computer, and custom-written software continuously monitored the moisture condition of the soil, initiated irrigation when the soil dried to a specific level, and turned off the water when an adequate amount was applied. When the system was installed in a greenhouse producing roses, water use decreased while productivity (stems harvested/m²) and stem length increased substantially. The observed increases in productivity and quality can result in significant increases in profitability for commercial rose producers.

613

Minimizing Irrigation and Fertilization in Greenhouse-grown Flowering Vinca

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The objective of this study was to determine which combination of three types of irrigation systems, three fertilization method, and four growing media produced optimum growth of flowering vinca, *Catharanthus roseus*. Irrigation systems used included ebb-and-flood, drip, and pulse; fertilization methods included slow release, prepackaged, and custom mixed; and the four growing media were peatmoss:perlite:vermiculite (1:1:1, by volume), peatmoss:rockwool (1:1, by volume), and 0.6-cm diameter shredded rubber or fabric from waste tires:vermiculite:peatmoss (1:1:2, by volume). Four replications of five plants each were used in each of the 36 treatment combinations. Plants were potted 29 and 30 May 1996 in 10-cm containers, grown for 10 weeks, and harvested 6 Aug. 1996. The drip-irrigated benches were irrigated once per day for 15 s. Pulse-irrigated benches were watered twice per day for 6 s. This resulted in the drip- and pulse-irrigated plants receiving a similar volume of water daily. Ebb-and-flood benches were filled once per day with drainage occurring 15 min after filling. Ending plant heights and dry weights indicated that those plants in the prepackaged fertilizer/drip or ebb-and-flood irrigation/shredded tire fiber growing medium were comparable to plants grown in the peatmoss:rockwool medium with the same fertilizer and irrigation methods.

614

Ebb-and-flow Irrigation in Bedding Plant Production

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The negative effects of nutrient runoff on the environment has come more to the forefront of greenhouse issues in the past few years. Alternative irrigation systems that reduce or eliminate runoff that are widely used in Europe have not yet gained much popularity in the southeastern United States, in part due to a lack of available information on their use. One such system is ebb-and-flow, which is a completely closed recirculating system, having no runoff whatsoever. In order to learn more about optimum growing practices using the ebb-and-flow system for bedding plants, marigolds and sunflowers were grown under a variety of conditions. After a 6-week period, pH of growing media of both marigolds and sunflowers decreased by 1, while EC increased by ≈ 1 dS/m. There were also significant differences in EC due to the different media types. The soilless medium with the highest percentage of vermiculite and lowest percentage of pine bark had the highest EC. Different types of fertilizer and fertilizer rates will be discussed, as well as interactions between fertilizer and media.

615

Effect of Fertilizer Source on Fe, Mn, and Zn Leaching, Nutrient Distribution, and Geranium Growth

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Improving the quality of water released from containerized production nurseries and greenhouse operations is an increasing concern in many areas of the United States. The potential pollution threat to our ground and potable water reservoirs via the horticultural industry needs to receive attention from growers and researchers alike. 'Orbit Red' geraniums were grown in 3:1 peat:perlite medium with microtube irrigation to study the effect of fertilizer source on geranium growth, micronutrient leaching, and nutrient distribution. Manufacturer's recommended rates of controlled-release (CRF) and water-soluble fertilizers (WSF) were used to fulfill the micronutrient requirement of the plants. Minimal differences in all growth parameters measured between WSF and CRF were determined. A greater percentage of Fe was leached from the WSF than CRF. In contrast, CRF had a greater percentage of Mn leached from the system than WRF during the experiment. Also, regardless of treatment, the upper and middle regions of the growing medium had a higher nutrient concentration than the lower region of medium.

616

Co-blended Composts for Production of Potted Poinsettia

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Production of 'Top White', 'Peterstar Pink', 'Lilo Red', and 'Red Success' poinsettias were evaluated in a treatment combinations that included 10 compost blends, three compost levels, and two commercial soilless substrates of Sunshine Mix 1 and Pro Gro 300S as controls. The compost feedstocks included PSG polymer dewatered biosolids (PSG), lime dewatered biosolids (CP), yard trimmings

(YT), poultry litter (PL), and municipal solid waste (MSW Bedminster). The PSG, PL, YT, and MSW were co-blended with CP on a 2:1 ratio (v/v), all other composts were co-blended on a 1:1 ratio (v/v). The compost levels of 33%, 50%, and 67% were mixed with peat:perlite (1:1, v/v). There were five replicates per treatment. Plants were fertilized once weekly with 200 mg·L⁻¹ N from 21N-2.2P-16.6K. Sunshine mix produced control plants that had greater canopy diameter and plant grade than Pro Gro mix. Plant height was reduced as compost level increased from 33% to 67%. Blends of PSG:PL at the 33% and 50% levels and PSG:YT at the 33% level produced premium-quality plants. Good-quality plants, similar to those grown in Sunshine Mix, were produced with the PSG or PL compost blended with immature MSW at the 33% level; PSG:PL blend at a 67% level; PSG:YT blend at the 50% and 67% levels; and PL:YT blend at the 33% level.

617

Comparison of Three Sprinkler Designs for Cold Protection in Shadehouses

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Water is an economical source of heat to prevent cold damage to certain crops; however, ways to reduce the quantity of this limited resource required for cold protection need to be developed. Rapidly rotating (6 rpm) wedge-drive impact sprinklers (conventional practice) were compared with a rotary action spray head and patented slow-rotating stream sprinklers for cold-protecting a subtropical crop [leatherleaf fern (*Rumohra adiantiformis* (Forst.) Ching)] growing in shadehouses. Treatments were applied in a 3 x 3 latin square design to nine 29 x 29-m post-and-cable shadehouses covered with woven polypropylene shade fabric designed to provide 73% shade. Temperatures in each shadehouse were monitored 45 cm above the soil surface using four constantan-copper thermocouples. Ambient temperatures and wind speeds were monitored using additional thermocouples and an anemometer at a nearby weather station. All sprinklers had 2.8-mm orifices, were operated at 0.25 Pa, and applied 0.5 (rotating stream, rotary) or 0.54 (wedge-drive) cm·hr⁻¹ of water. During an advective freeze with windspeeds up to 19 m·s⁻¹ and temperatures to -2°C, there were no temperature differences due to treatments. During a radiational freeze with readings below -2°C for over 12 hr and a low of -5°C, all three irrigation systems maintained thermocouples at about -1°C. No significant damage to mature fronds were detected. Percentage of immature fronds damaged was not affected by treatments and ranged from 11% for rotary to 43% for the wedge-drive sprinkler treatments. The two newer sprinkler designs (rotary action spray head and patented slow-rotating stream) provided satisfactory protection equivalent to the industry standard (wedge-drive) while using about 10% less water.

122 ORAL SESSION 34 (Abstr. 618-623)

Breeding & Genetics—Woody Ornamentals/Landscape/Turf

618

Application of DNA Markers to the Identification of Horticultural Plants

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The correct identification of horticultural taxa becomes more and more important for intellectual property protection and economic reasons. Traditionally, morphological characteristics have been used to differentiate among the horticultural taxa. However, the morphological characteristics may vary with plant age, cultural conditions, and climate. Modern technologies, such as DNA markers, are now employed in the identification of horticultural taxa. Currently, technologies of DNA sequencing (gene sequences) and DNA fingerprinting (RAPD, RFLP, SSR, and AFLP) are available for distinguishing among horticultural taxa. The literature and our personal experience indicate that the application of each technique depends on the taxon and ultimate goal for the research. DNA sequencing of a variety of nuclear or chloroplast encoded genes or intergenic spacers (rbcL, ndhF, matK, ITS) can be applied to distinguish different species. All DNA fingerprinting technologies can be used to classify infraspecies taxa. AFLP (the most modern technique) is the better and more-reliable to identify taxa subordinate to the species, while RAPDs can be employed in clonal or individual identification. Techniques of RFLP and SSR lie between AFLP and RAPD in their effectiveness to delineate taxa. Mechanics, laboratory procedures, and inherent

difficulties of each technique will be briefly discussed. Application of the above technologies to the classification of *Cephalo taxus* will be discussed in concert with the morphological and horticultural characteristics. Future classification and identification of horticultural taxa should combine DNA technology and standard morphological markers.

619

Inheritance of High Levels of Resistance to Microtubule-disrupting Herbicides in a Weedy Grass, and Molecular-tagging of the Genetic Locus

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Dinitroaniline herbicides exert their phytotoxic effect by interfering with tubulin dimer polymerization; thus, these and other anti-mitotic drugs destabilize cytoplasmic and spindle microtubules. The dinitroanilines are particularly effective on monocotyledonous species. A naturally occurring mutant of goosegrass [*Eleusine indica* (L.) Gaertn.], resistant (R) to the DNAs, and the widely distributed susceptible, wild-type (S) have been collected from a number of agricultural sites throughout the southeastern U.S. Pairs of these accessions were cross-pollinated to create F₁ individuals, from which F₂ and F₃ generations were developed through natural self-pollination. Analysis of the dinitroaniline herbicide response phenotype (DRP) has shown the F₁s to be susceptible, and the F₂ and F₃ to be segregating 3:1 for susceptibility and resistance, respectively (i.e., 3S:1R). This genetic data is consistent with the DRP being encoded by a single, nuclear locus. Random amplified polymorphic DNA (RAPD) analysis of a segregating F₂ population (N = 60), which identified 32 linked and 33 unlinked molecular markers, supports this hypothesis of simple Mendelian inheritance. Furthermore, this RAPD analysis coupled with restriction fragment length polymorphism (RFLP) analysis, localized the DRP locus to a single chromosomal region and identified two RAPD-markers, and at least one RFLP-marker, flanking the DRP locus. This information provides a starting point for map-based (i.e., positional) cloning of the resistance (*DRP*) and susceptibility (*DRP^s*) alleles.

620

Characterization of ENOD2 cDNAs in *Maackia amurensis* Rupr. & Maxim. (Amur Maackia)

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ENOD2 and other early nodulin genes are conserved among legumes studied to date and might function as markers for the potential of legumes to nodulate. Early nodulin genes have been characterized only among herbaceous legumes. We are interested in understanding the nature of ENOD2 in a nodulating, woody legume. A 561-bp MaENOD2 PCR fragment was used as a probe to screen a cDNA library from nodules ≈1 mm in diameter on roots of Amur maackia, the only temperate and horticulturally desirable leguminous tree species known to nodulate. Five cDNAs were selected for nucleotide sequence analysis. Sequences were determined by using automated dideoxy sequencing and analyzed for identity to other genes with the Genetics Computer Group (GCG) program. The cDNA clones show 68% to 74% identity at the nucleic acid level with ENOD2 genes of *Sesbania rostrata* Brem. & Oberm., *Glycine max* (L.) Merrill, and *Lupinus luteus* L. Southern and northern analyses are being conducted to investigate the possibility of a gene family and to show differential and temporal production of transcripts, respectively. These studies provide new information about nodulins of woody legumes and are being used to facilitate related research on molecular barriers to nodulation in the closely related, non-nodulating tree species *Cladrastis kentukea* (Dum.-Cours.) Rudd (American yellowwood) and *Sophora japonica* L. (Japanese pagodatree).

621

Alterations in Gene Expression during Exposure of Bermudagrass to Low, Non-lethal Temperatures

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Temperature is a limiting factor for plant growth. Warm-season turfgrasses can experience winter-kill when grown in the "transition zone." On the other hand, when properly cold-acclimated, these same plants can withstand otherwise lethal

temperatures. As part of our investigations into the biochemistry and molecular biology of cold acclimation in bermudagrass, total RNA from crowns (rhizome buds) isolated at different timepoints before and after chilling temperature exposure, was isolated by salt-buffer/phenol extraction, followed by LiCl precipitation and DNase treatment. Differential display reverse transcriptase polymerase chain reaction (DD-RT-PCR) was performed using specific- (dT₁₁NN) or variable- (dT₁₂VN) anchor primers (where V = dA, dG and dC and N = dA, dG, dC or dT) for first strand cDNA synthesis by RT. The ss-cDNAs were converted to double stranded molecules and PCR amplified using a randomly chosen 10-mer primer paired with the same anchor primer used for cDNA synthesis. The dCTP³² labeled cDNAs were fractionated on non-denaturing polyacrylamide gels. Individual bands exhibiting differential expression between treated and nontreated samples were identified for reamplification, cloning, sequencing and further characterization of the differential nature of their expression by reverse northern hybridization and RT-PCR. Only those excised bands able to be reamplified using the anchor:10-mer pair were selected for cloning. To date, 90 variable-anchor:10-mer or specific-anchor:10-mer pairs have been screened. Of these, ≈27 have exhibited possible differential expression with one or more bands. Nucleotide (and deduced amino acid) sequence information was used to search on-line databases for similarity/homology with previously reported gene or protein sequences.

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Development of DNA Isolation and Amplification Procedures for Sequence Comparisons Among Deciduous Azaleas

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Deciduous azaleas have been gaining popularity because of their showy floral displays and adaptability to adverse environmental conditions. However, an absence of distinguishing morphological characteristics, combined with the wide variability present in most species, has created difficulties in efforts to unambiguously identify the different species. Various DNA isolation protocols were tested in order to determine the most effective methods for isolation of DNA from 22 taxa of *Rhododendron* for subsequent PCR amplification. DNA yields from the various isolation methods varied widely. A minimum of 50 ng/μL of template DNA was necessary for PCR amplification under standard amplification conditions. Results indicated that the effect of tissue age on the efficiency of DNA isolation was taxa-dependent. For most species, extraction of DNA from freshly harvested young leaf tissue resulted in the highest DNA yields. However, DNA yields from *R. serrulatum*, *R. atlanticum*, and *R. viscosum* 'Lemon Drop' were highest when mature leaf tissue was used. Primers designed to amplify the internal transcribed spacer (ITS) region of the nuclear ribosomal genes and the *psbD*, *trnK*, and *16S* chloroplast genes were tested in various PCR reaction mixes in order to optimize reaction conditions for amplification. Primers to both the ITS and the *psbD* gene resulted in satisfactory amplification in the presence of 1.5 mM MgCl₂ and 50 ng template DNA.

623

Agrobacterium-mediated Transformation of Three Elite Hybrid Aspens

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Three elite hybrid aspen, *Populus grandidentata* x *P. canadensis*, *P. tremuloides* x *P. tremula*, and *P. tremuloides* x *P. davidiana*, have been transformed with *Agrobacterium tumefaciens* strains LBA4404 and EHA105 carrying kanamycin resistance and GUS genes. The leaves of micropropagated shoots were co-cultivated with *Agrobacterium* for 65 to 72 hr and then transferred to callus-induction medium with 80–120 mg/L kanamycin in the dark. After 2 weeks, the leaves were transferred to shoot-induction medium under 18-hr photoperiod. Regenerated shoots were verified for transformation by histochemical staining and PCR. Transformed shoots rooted and were transplanted to soil. The three hybrid clones differed widely in their medium requirements for regeneration and in their competence for transformation. The leaves of *P. grandidentata* x *P. canadensis* callused vigorously on a wide variety of media. In a typical transformation experiment, 30% to 60% of infected leaves produced putatively transformed calli (up to 10 calli per leaf). The origin of these calli and the frequency of shoot formation depended on the *Agrobacterium* strains. The calli from EHA105-infected leaves produced shoots within six weeks of co-cultivation and at high

frequencies (70% to 90%). However, the calli from LBA4404-infected leaves produced shoots more slowly and at much lower frequencies (5% to 10%). Delaying selection for 2 weeks was found to lower the transformation frequency. Putatively transformed calli were obtained from *P. tremuloides* x *P. tremula*, and *P. tremuloides* x *P. davidiana* hybrids at frequencies of only 2% to 3%. The calli regenerated from *P. tremuloides* x *P. davidiana* leaves were very small, but they continued to grow upon being transferred to shoot-induction media and have started to produce shoots. The calli from leaves of *P. tremuloides* x *P. tremula* were much larger and they produced shoots more quickly. This transformation protocol is currently being used to introduce rooting genes into these hybrids to improve their rooting from hardwood cuttings.

123 ORAL SESSION 35 (Abstr. 624–631) Postharvest Physiology—Fruits/Nuts

624

What Components of Chlorophyll Fluorescence are Related to Storage Scald in Apple?

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Chlorophyll fluorescence of three cultivars of apple, representing fruits that are considered highly susceptible ('Cortland'), moderate- to highly susceptible ('Red Delicious'), and resistant ('Empire') to superficial scald were studied in relation to scald development during storage. The preclimacteric harvested fruits from each variety were divided into two equal lots, lot one was treated with DPA (1000 ppm) and all the fruits (treated and untreated) were air-stored in separate bins at 0°C for 4 months. Chlorophyll fluorescence parameters, minimal fluorescence (F_o), maximal fluorescence (F_m) and the ratio of $(F_m - F_o)/F_m$, and various quenching components of variable fluorescence were measured at regular intervals during storage. The maximal level of fluorescence (F_m) at harvest varied between varieties; it was highest in 'Empire', followed by 'Red Delicious' and 'Cortland', respectively. DPA dip treatment seemed to have no influence on chlorophyll fluorescence at harvest. Decline in F_m was found to be related to scald development during storage. The data on fluorescence quenching pattern and kinetics in relation to development of storage scald will be discussed. Changes in O₂⁻ radical (a possible cause of apple scald) scavenging system during storage will also be presented.

625

Does Enhanced Removal of Active Oxygen Species Contribute to Superficial Scald in Apple Fruits?

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Apple fruits are highly susceptible to superficial scald, which is currently controlled by both chemical- and non-chemical-based technologies. The possible threat of withdrawal of diphenylamine (DPA) for the control of superficial scald has prompted us to investigate the biochemical and molecular aspects of scald resistance. We have selected genetic populations of a cross between 'White Angel' and 'Rome Beauty' that are resistant and susceptible to scald, and investigated whether the resistance of scald in these populations is due to the higher antioxidant-based defense systems. Cortical tissue of fruits (0–3 cm) was peeled and analyzed for conjugated trienes, H₂O₂, carbonyl groups, and antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and peroxidases (POX). Scald-resistant fruits at harvest had higher antioxidant enzymes and low levels of conjugated trienes, carbonyl compounds, and H₂O₂ levels compared to fruits that are susceptible to scald. Further, H₂O₂ levels rose in scald-susceptible fruits stored under low temperature with a concomitant increase in the production of conjugated trienes and carbonyl compounds, while no major changes were observed in scald-resistant fruits. Enhanced levels of H₂O₂ in scald-susceptible populations could be related to enhanced SOD activities and decreased activities of H₂O₂ degrading enzymes, suggesting that an imbalance between O₂⁻/H₂O₂ may have occurred. These results indicate that a coordination between SOD and H₂O₂ degrading enzymes in scald resistant populations may have minimized the influence of AOS on the oxidation of α-farnesene, protein, and, thereby, on scald. Hence, we have hypothesized that enhancing the potential of apple fruit to metabolize AOS develops resistance to superficial scald. [Supported in part by USDA Specific Cooperative Agreement 58-1931-5-017.]

626

Scald-related Volatiles in the Epicuticular Wax of Apple Fruit

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Volatile compounds produced by apple (*Malus domestica* Borkh) fruit partition into the cuticle and epicuticular waxes and may play an important role in superficial apple scald. Of these volatiles, α -farnesene, conjugated trienes, hydroperoxides, and 6-methyl-5-hepten-2-one have been identified as playing a crucial role in scald production. Volatiles from the epicuticular wax of four different apple cultivars have been analyzed by gas chromatography/mass spectroscopy. A correlation was found between scald incidence and 6-methyl-5-hepten-2-one content and the 6-methyl-5-hepten-2-one: α -farnesene ratio. α -Farnesene is the most-abundant volatile at the beginning of storage, whereas 6-methyl-5-hepten-2-one is present in minute quantities. These two volatile compounds appear to have an inverse relationship with respect to one another since the levels of 6-methyl-5-hepten-2-one increased and α -farnesene decreased prior to the onset of apple scald. This changing ratio may have been due to an autoxidative process resulting in the breakdown of α -farnesene to 6-methyl-5-hepten-2-one. Analysis of the volatiles emanating from the apple wax revealed a number of compounds associated with aroma that also partition readily into the fruit surface.

627

Reaction of Apple Skin following UV ExposureHarold N. Fonda*¹, John K. Fellman¹, X. Fan², and J.P. Mattheis²; ¹Dept. of Horticulture and Landscape Architecture, Washington State Univ., Pullman, WA 99164; ²USDA/ARS Tree Fruit Research Lab., Wenatchee WA 98801

In order to investigate biochemical events occurring at the surface of apple skin, UV light exposure was used to generate a skin-browning reaction in apples. 'Fuji' apple fruit that had been kept for 2 months in regular atmosphere storage at 0°C were exposed to short-wave UV light for 24 or 48 hr at 0°C or 23°C. After treatment, skin browning was monitored on fruit returned to 0°C storage or kept at room temperature under laboratory conditions. Fruit exposed to short-wave UV light at 0°C developed skin browning after 2 to 3 days at room temperature, whereas fruit held at 0°C did not show signs of skin browning until 7 days later. Short-wave UV exposure for 24 or 48 hr at 23°C resulted in skin browning that continued to develop on fruit kept at both room temperature and 0°C. When fruit were exposed to short-wave UV light for 72 hr at 0°C, a small amount of skin browning was already apparent. Long-wave UV light exposure for 48 hr had no observable effect on fruit treated at 0°C and then placed at room temperature. Our observations suggest that events that lead to browning are related to dispersion of energy absorbed by the hydrophobic molecules in the skin, a temperature dependent phenomenon.

628

Temporal Relationship between Ethylene and Ester Production during Maturation of Apple FruitJ.P. Mattheis*¹, D.A. Buchanan¹, and J.K. Fellman²; ¹USDA/ARS Tree Fruit Research Lab., 1104 N. Western Avenue, Wenatchee, WA 98801; ²Dept. Horticulture and Landscape Architecture, Washington State Univ., Pullman, WA 99164

Quantitative and qualitative changes in net production of volatile compounds by apples occurs during fruit development with a major transition to ester production occurring as fruit ripening begins. Ester production during fruit ripening is an ethylene-mediated response; however, differences in maturation patterns among apple cultivars led us to examine the relationship between ester production and onset of the ethylene climacteric in several commercial apple cultivars. Emission of volatile esters as a function of apple fruit development was evaluated for 'Royal Gala', 'Bisbee Delicious', 'Granny Smith', and 'Fuji' apple fruit during two harvest seasons. Apples were harvested weekly and analyses of harvest maturity were performed the day after harvest. Non-ethylene volatiles were collected from intact fruit using dynamic headspace sampling onto Tenax traps. Fruit from each harvest was stored at 1°C in air for 5 months (3 months for 'Royal Gala') plus 7 days ripening at 20°C, then apples were evaluated for the development of disorders. The transition to ester production occurred after internal ethylene exceeded 0.1 μ L for 'Royal Gala', 'Bisbee Delicious', and 'Fuji'. Ester emission by 'Granny Smith' apples remained low throughout the harvest period. Increased ester emission occurred after the optimum harvest date (as determined by the starch index and internal ethylene concentration) for controlled-atmosphere storage of 'Bisbee Delicious' and prior to optimum maturity for 'Royal Gala' and 'Fuji'. A relationship between the potential for development of superficial scald and ester production at harvest

was evident only for 'Bisbee Delicious' apples.

629

Effect of 1-MCP on Apple Fruit Ripening and Volatile ProductionJ. Song*¹, M.S. Tian², D.R. Dilley¹, and R.M. Beaudry¹; ¹Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824; ²Horticulture and Food Research Inst. of New Zealand, Private Bag 92169, Auckland, New Zealand

Aroma production by apple fruit is an important quality criterion and has been found to be a fruit-ripening-related process. 1-Methylcyclopropene (1-MCP), an effective ethylene action inhibitor, was used to study the relationship between volatile biosynthesis, ethylene action, and fruit ripening in 'Golden Delicious' apple fruit. Pre-climacteric fruit were treated with 1-MCP vapors at a concentration of 500 parts per billion (v/v) at 23°C. 1-MCP prevented the climacteric rise of ethylene production, respiration, and volatile production, while untreated fruits developed typical climacteric changes in ethylene production, respiration and volatile production. Applying ethylene at 15–20 parts per million for 24 hr 11 days after 1-MCP treatment could not overcome the effect of 1-MCP, suggesting that 1-MCP inhibited ethylene action irreversibly. Interestingly, when 1-MCP-treated tissue were fed butanol and butyric acid, they converted these compounds to their corresponding esters butylacetate and butylbutanoate. Thus precursor supply is apparently limiting and appears to be ethylene-dependent.

630

Effect of Modified-atmosphere Packaging on Aroma Profiles of Whole Apple Fruit

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The effect of polymers used in packaging on the aroma of the packaged product has been little explored. Using a package-in-a-jar system, we are able to simultaneously measure volatile production by plant organ (*Malus domestica* Borkh. cv. Golden Delicious) and the permeability of the packaging film to those volatiles. In this system, apple fruit were placed into a glass container or sealed in a low-density polyethylene (LDPE) package and subsequently placed into a glass container. Air or a modified atmosphere was slowly passed through the glass containers such that the O₂ level in the package was similar to that in containers with no package. The package and jar head spaces were sampled for CO₂, O₂, ethylene, and aroma volatile analysis by gas chromatography/mass spectrometry. The effect of temperature, atmosphere and film presence to some major volatile compounds was determined. When storage temperature increased from 0°C to 22°C the production rate of hexylacetate and 2-methyl butylacetate increased 11.27- and 17.15-fold, respectively. At 0°C, as O₂ decreased in concentration from 10% to 5% (v/v), hexylacetate and butylacetate declined significantly; however, 2-methyl butylacetate was not affected. This can be taken to indicate the production of 2-methyl butanol for 2-methyl butylacetate formation is not as O₂ concentration dependent as straight-chain alcohols. At the same O₂ concentration, non-packaged fruit evolved greater amounts of all volatiles than packaged fruit. The flux of α -farnesene, hexylacetate and 2-methyl butylacetate was 26.6-, 1.7-, and 1.4-fold higher, respectively, for fruit in glass container. The sorption of α -farnesene and some other volatiles into LDPE film is evidently considerable, altering the aroma profile of packaged produce relative to a flow-through system.

631

Using Hexanal Vapor to Inhibit Activity of *Penicillium expansum* in Inoculated Whole Apple Fruit

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Hexanal vapor is a natural, metabolizable fungicide that inhibits fungal activity and enhances the aroma biosynthesis in sliced apple fruit. Whole apple fruit were inoculated at two points per fruit with *Penicillium expansum* at a concentration of 0.5 x 10⁵ spore/ml and treated with hexanal vapors. Inoculated fruit were exposed to hexanal for 48 hr and kept for another 72 hr in hexanal-free air at 22°C. Treatments included 8.2–12.3 μ mol·L⁻¹ (200–300 ppm), 14.5–18.6 μ mol·L⁻¹ (350–450 ppm), and 24.8–28.9 μ mol·L⁻¹ (600–700 ppm), each with an air control. At a concentration of 200–300 ppm hexanal, there was no fungal growth during treatment, but lesion development was evident on 100% of the treated fruit following cessation of treatment. After 72 hr holding in air, lesion diameter was significantly smaller for treated fruit. When inoculated apple fruit were exposed to 350–450

ppm and 600–700 ppm hexanal vapors, the decay rate was 44.7% and 23.9%, respectively, while the decay rate of inoculated control apple fruit was 100% and 98%, respectively, after 72 hr holding in air. The development of aroma volatiles was investigated for both treated and untreated whole apple fruit. Hexanal was actively converted to aroma volatiles by 'Golden Delicious' fruit and there was no detectable hexanal emanations. The amount of hexylacetate, hexylbutanoate, hexylhexanoate, hexylpropionate, butylhexanoate, and hexyl-2-methylbutanoate were about 2- to 4-fold higher in treated apple fruit than in untreated apple fruit. 'Mutsu' apple fruit were treated with 350–450 ppm hexanal for 48 hr and processed into apple sauce within 4 hr. An informal sensory evaluation for processed 'Mutsu' apple revealed no apparent flavor difference between treated and control fruit sauce.

137 ORAL SESSION 36 (Abstr. 632–638) Culture & Management—Small Fruits/ Viticulture

632

Effect of the Split Trellis on Growth and Yield of Red Raspberry (*Rubus idaeus*)

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With the advent of new rotary-head mechanical harvesters, it is now possible to machine-harvest a wider raspberry canopy. In Spring 1996, a trial was established in a grower's field in Lynden, Wash., comparing raspberries trained to two top wires with a 70-cm spread (split trellis) to the conventional single top wire system. Within the split trellis, increases in leaf number per cane (97%), and leaf area per cane (55%) were not reflected in a concomitant increase in total leaf dry weight per cane (35%). Leaf dry weight per fruit weight was 11% less within the split trellis. These data suggest that the canopy is more efficient with this type of trellis. Increases in estimated yield per cane (49%) and projected yield per acre (50%) associated with the split trellis were due to increases in berry number per cane (47%). Fruit number per meter of lateral was 35% greater within the split trellis. Greatest enhancements to yield components were in the upper parts of the canopy where canes were tied over. Since there were no differences in lateral numbers or lateral lengths between the two systems, this increased productivity was due to increased floral expression, enhanced fruit set, increases through Spring bud initiation or any combination thereof. In both trellis systems, the longest laterals occurred on the middle third of the cane and decreased in length progressively towards the tip of the cane. Primocane lengths were shorter (20%) and diameters were smaller (10%) and more uniform in the split trellis system.

633

Field Assessment and Physiological Analysis of Cold Damage to the Red Raspberry Fruiting Cane and to Fruit Yield

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Two sets of field experiments have been set up in Lynden, Wash., to evaluate cold damage to red raspberry 'Meeker'. The locations represent newly established crops (field 1) and a field that suffered reoccurring cold damages in recent years (field 2), respectively. Temperature and moisture HOBOS were set up in the check and cold-damaged treatments of both of the fields to record the air and soil temperatures and air moisture. The cold-damaged treatments in both fields had significantly higher cane dieback and dead buds. Cold injury significantly reduced berry yield in field 1, but not in field 2, through an steep drop in berry number per cane, mainly due to a significant reduction in lateral number/cane. Cold damage reduced primary lateral number/cane, and increased secondary lateral number/cane in both fields. Secondary laterals were shorter in length and had lower berry number/lateral than the primary ones. It proved that cold damage also delayed initiation and development of secondary laterals, and resulted in more yield loss to the plant. The cold-damaged fruiting cane had lower gas exchange rates, leaf and stomatal conductance, and transpiration rates during fruit development in both fields. It also significantly reduced fluorescence parameters F_o , F_m , F_v , $T_{1/2}$, and F_q of the cold injury treatment in field 1. On a few cold days this spring, the HOBOS recorded a lower daily low temperature in the cold damaged area than in the check area.

634

Hydrogen Cyanamide Stimulates Early Foliation of 'Misty' Southern Highbush Blueberry

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Two-year-old, container-grown 'Misty' southern highbush blueberry plants were sprayed to drip with two concentrations of hydrogen cyanamide (HCN) (20.4 g·L⁻¹ and 10.2 g·L⁻¹) after exposure to 0, 150, or 300 hr of continuous chilling at 5.6°C. All plants were sprayed immediately after chilling and placed in a greenhouse for several weeks. The plants were moved outdoors during flowering to increase cross-pollination from nearby 'Sharpblue' blueberry plants. HCN sprays killed some of the more advanced flower buds on shoot terminals and on small-diameter wood from the previous spring growth flush. Significantly greater flower bud mortality occurred for the 20.4 g·L⁻¹ HCN sprays than for the 10.2 g·L⁻¹ sprays. Flower buds subjected to 0 hr of chilling were more susceptible to spray burn than flower buds receiving 150 or 300 hr of chilling. Very little flower bud death occurred with the 10.2 g·L⁻¹ HCN rate on plants receiving 300 hr of chilling. Vegetative budbreak was advanced for both HCN treatments compared to controls, regardless of chilling treatment. HCN-treated plants were heavily foliated at full bloom, while non-treated plants had very few to no leaves during bloom. HCN may be useful for stimulating vegetative growth in some southern highbush blueberry cultivars that suffer from poor foliation during flowering and fruit set.

635

Lowbush Blueberry Response to Phosphorus-containing Fertilizers: Assessment by Leaf Phosphorus Concentration and Content

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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 and stem nutrient concentrations and contents (concentration x weight). Samples of stems collected in July from three 0.03 m² quadrates per treatment plot indicated MAP and DAP had no effect on dry weight of stem tissue, but increased average dry weight of leaf tissue. Leaf nutrient concentrations and contents showed similar results; P and N were raised to higher levels by MAP and DAP than by TSP. TSP had no effect on leaf N concentration or content but raised leaf P concentration but not content, compared to controls.

636

Seasonal Frost Hardiness Changes in the Cranberry Plant

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In Wisconsin, the cranberry plant (*Vaccinium macrocarpon* Ait.) is protected from freezing temperatures by flooding and sprinkle irrigation. Due to the high value of the crop, growers typically overprotect by taking action at relatively warm temperatures. Our goal is to provide recommendations for improved frost protection strategies by studying seasonal hardiness changes in different parts of the cranberry plant (leaves, stems, buds, flowers, fruit). Stages of bud growth were defined and utilized in the hardiness determinations. Samples were collected from mid-April to mid-Oct. 1996 and cuttings were subjected to a series of freezing temperatures in a circulating glycol bath. Damage to plant parts was assessed by visual scoring and observation, ion leakage, and evaluation of the capability to regrow. The following results were obtained: 1) Overwintering structures, such as leaves, stems, and buds, can survive temperatures < -18°C in early spring, and then deacclimate to hardinesses between 0 and -2°C by late spring. 2) In the terminal bud floral meristems are much more sensitive to freeze-thaw stress than are the vegetative meristems. 3) Deacclimation of various plant parts occurred within 1 week, when minimum canopy temperatures were above 0°C, and when the most numerous bud stage collected stayed the same (bud swell). 4) Fruits >75% bluish can survive temperatures of -5°C for short durations. By collecting environmental data from the same location we are attempting to relate plant development, frost hardiness, and canopy temperatures (heat units).

637

Cold Tolerance of Cranberry Flower Buds Differs by Cultivar and Developmental Stage

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Cold tolerance of cranberry flower buds from four cultivars was evaluated using potted sods collected from commercial cranberry beds. The plants were evaluated weekly beginning at the spring dormant stage and continuing until the buds had elongated to at least 2 cm. The potted plants were placed in controlled temperature chambers at 5°C and the temperature was lowered 3°C/hr until the target temperature was reached. The plants were held at that temperature for 3 hr then slowly warmed. After 24 hr, damage was evaluated by microscopic examination of cross-sectioned buds. In the early spring, prior to leaf greening, all four cultivars were tolerant of -8°C. In the later part of the spring, cultivars with the smallest buds had greater cold tolerance than those with larger buds. Even when all cultivars appeared to be at the same developmental stage, e.g., bud swell, 'Ben Lear' and 'Stevens', were more sensitive than 'Early Black' and 'Howes'. At the 2-cm elongation stage, minimum cold tolerance of -1°C was reached for all four cultivars. New recommendations for protecting cranberry flower buds in the spring have been formulated based on this study.

638

Germination Characteristics of Thin-leaved Huckleberry (*Vaccinium membranaceum*)

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Seeds of *V. membranaceum* germinated in petri dishes fresh (undried), air-dried for 7 days, or cold-stored for 1 or 6 years exhibited similar germination vs. time curves. Dry storage at 0-4°C for 1 or 6 years did not reduce the percentage of germination compared to fresh seeds. Cold stratification at 0-4°C slowed germination by extending the initial lag phase compared to unstratified seed. Stratification for 28 to 56 days delayed germination by ≈2 weeks. This pattern held true for fresh (undried) seed, seed air-dried for 7 days, and seed cold-stored for 6 years. Surface sterilization for 20 or 30 minutes with a 0.5% aqueous solution of sodium hypochlorite reduced fungal and bacterial contamination of germinating seeds without adversely impacting germination. Treatment of *V. membranaceum* seeds with captan or mancozeb fungicide inhibited germination by extending the lag phase and reducing the germination vs. time slope of the exponential phase. Mancozeb-treated seeds exhibited a lower percentage of germination than did controls, and often developed necrotic radical tips.

138 ORAL SESSION 37 (Abstr. 639-644) Temperature Stress—Vegetables

639

Characterization of Ice Nucleation and Propagation in Bean (*Phaseolus vulgaris* cv. Bush Blue Lake) using Infrared Video Thermography

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Frost-sensitive plant species have a limited ability to tolerate ice formation in their tissues. Most plants can supercool below 0°C and avoid ice formation. Discrepancies exist about the role of intrinsic and extrinsic ice-nucleating agents in initiating ice formation in plants. Previous research has demonstrated the ability of infrared video thermography to directly observe and record the freezing process in plants (Wisniewski et al., 1997. *Plant Physiol.* 113:4378-4397). In the present study, the ability of droplets of a suspension of the ice-nucleating-active (Ice⁺) bacterium, *Pseudomonas syringae*, and droplets of deionized water, to induce ice formation in bean plants was compared. The activity of these agents were also compared to intrinsic ice formation in dry plants. Results indicated that the presence of the Ice⁺ bacteria in droplets ranging from 0.5-4.0 μL always induced freezing at a warmer temperature than droplets of deionized water alone (no bacteria) or intrinsic nucleators in dry plants. When droplets of Ice⁺ bacteria were allowed to dry, they were no longer effective but were active again upon rewetting. Droplets of water would often supercool below temperatures at which ice formation was initiated by intrinsic agents. When a silicon grease barrier was placed between the droplets of Ice⁺ bacteria and the leaf surface, the bacteria were no longer capable of inducing ice formation in the plant, despite the droplets being frozen on the

plant surface. This indicates that ice crystals must penetrate the cuticle in order to induce freezing of the plant.

640

Effect of Reduced Temperatures on Melon Transplant Subsequent Growth and Survival

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Delays in transplanting vegetable seedlings are often a problem due to cold, wet spring weather. This results in the production of overgrown transplants, which are more difficult to transplant and often do not survive. The objective of this study was to find a non-chilling temperature at which to short-term-treat transplants in order to slow down vegetative growth. 'Superstar' muskmelon and 'Royal Jubilee' watermelon seedlings were greenhouse-grown at 20°C during Mar. 1996. Fifty-cell trays of transplants were grown to the first true leaf stage and then held in a dark cooler at 7.5 or 12.5°C for 4 to 8 days. Control plants were kept in the greenhouse. Transplants were repotted into larger pots after the treatment. Preliminary experiments revealed that 8 days of 7.5°C was too severe of a temperature for watermelon and cantaloupe transplants. Six days of 7.5°C was effective in significantly reducing stem and leaf area growth without seedling death for both types of melons. Shorter durations at 7.5°C or the same duration at 12.5°C was less effective in retarding stem elongation. Surface area of the transplant leaves, after the reduced temperature treatment and subsequent growth, was much more sensitive to a drop in temperature and the length of temperature treatment. In 1997, these treatments will be repeated in the greenhouse and also in the field.

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Duration and Persistence of Heat Shock Induction of Chilling Tolerance in Cucumber Seedling Roots

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The effects of heat shock duration and persistence on the induction of chilling tolerance in cucumber roots were studied using total root growth, electrolyte leakage, and membrane peroxidation as injury indices after chilling. Heat shock reduced the chilling induced electrolyte leakage, decreased membrane peroxidation as measured by MDA content, and resulted in a greater total root growth after chilling compared to the control. Heat shocks at 40°C, applied to 36 hr germinated seedlings for time periods from 1 to 15 hr, all resulted in an increase in chilling tolerance in a time-dependent manner. The heat shock induction of chilling tolerance is most effective when heat shock was imposed immediately before chilling, but the effect is persistent even 32 hr after heat shock when seedlings are held at 25°C before chilling. The possible mechanism of heat shock effect and its persistence will be discussed in relation to heat shock proteins and antioxidant enzyme systems.

642

Effects of Chilling and Ethanol Treatments on the Antioxidant Systems of Cucumber Seedling Roots

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Previous experiments have shown that soaking 24-hr-old cucumber seedlings in ethanol leads to an increase in chilling tolerance. Seedlings were immersed in a 500-mM ethanol solution for 2 hr prior to chilling, rinsed, and placed in chilling immediately after treatment. All seedlings (except the control group) were treated for 2 hr after a 24-hr germination period at 25°C and a second group was held for 3 hr to allow the ethanol-induced chilling tolerance to dissipate. At this time, the seedlings were retreated with a second ethanol treatment identical to the first. The induction of chilling tolerance seen in both treatment groups was measured as an increase in root growth and decreases in lipid peroxidation and electrolyte leakage after exposure to chilling temperatures (2°C). Although ethanol treatment does clearly enhance chilling tolerance, the mechanisms by which it does so are unclear. Some hypotheses have suggested that ethanol acts as an anaesthetic, preventing a membrane phase change from a liquid to a gel-like state. Other evidence indicates that ethanol is a scavenger of the hydroxyl radical, working in concert with enzymatic-reducing systems and antioxidants to directly prevent damage caused by active oxygen species. Because enzymatic reducing systems and antioxidants have been shown to combat stress, the activities of three H₂O₂-scavenging enzymes (catalase, glutathione reductase, and ascorbate-specific

peroxidase), along with the relative concentrations of reduced and oxidized forms of glutathione and ascorbate as affected by both chilling and ethanol treatments will be discussed in relation to chilling susceptibility.

643

Effect of Centrifugal Force on the Chilling Sensitivity of Cucumber Seedlings

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The cessation of protoplasmic streaming is one of the first observable effects of chilling in sensitive plant tissue. If the lack of protoplasmic streaming contributes to the development of chilling injury, then impeding protoplasmic streaming at the chilling threshold temperature should induce chilling injury symptoms in tissue that would normally not exhibit symptoms at that temperature. A centrifuge was constructed to subject entire germinating cucumber (*Cucumis sativus* L., cv. Poinsett 76) seeds to centrifugal forces of up to 20 *xg* at 2.5, 10 and 12.5°C. Subjecting cucumber seeds with 5-mm-long radicles to high centrifugal forces (18 *xg*) at a marginal chilling temperature of 10°C for up to 3 days had no significant effect on subsequent radicle elongation of the entire population. In one experiment, spun seedlings were 7.4 ± 0.52 cm long, while the controls were 6.1 ± 4.3 cm long after 48 hr at 25°C. When analyzed by individual seed, the spinning treatments had no effect on high-vigor seedlings, while an 18 *xg* treatment significantly improved subsequent radicle elongation of low vigor seedlings. The effect of increased centrifugal forces on the respiration, metabolism and chilling sensitivity of cucumber seedlings will be discussed.

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Effects of Low Oxygen and High Carbon Dioxide Atmospheres on the Chilling Sensitivity of Cucumber Seedlings

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Crops with origins in tropics and subtropics undergo physiological injury when subjected to nonfreezing temperatures below 12°C. Application of heat and chemical shocks to tissue prior to chilling induces chilling tolerance. This study was undertaken to investigate the effects of low oxygen and high carbon dioxide atmospheres on subsequent chilling tolerance. Cucumber seedlings (*Cucumis sativus* L., cv. Poinsett 76) with radicles 8 to 12 mm long were subjected to 0% to 21% oxygen and/or 0% to 20% CO₂ atmospheres for 0 to 72 hr at 2.5 or 15°C. After chilling, they were placed at 25°C for three additional days. Radicle growth was used to assess chilling injury. Modification of the individual germination plates was necessary to ensure seedling exposure to the desired atmospheres. Chilling injury was reduced by exposure to oxygen levels below 1% and to carbon dioxide levels above 5%. Effects of brief exposures were small in comparison to prolonged exposures during chilling. Seed to seed variability was high and obscured some results. The effects of the various atmospheres were greater with the less vigorous seedlings.

139 ORAL SESSION 38 (Abstr. 645–650) Sustainable Agriculture–Vegetables

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The Influence of Organic Fertilization and Different Plant Densities on Physiological Traits and Production of Nopal (*Opuntia* spp.) under Plastic Tunnels

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The response of physiological traits of four genotypes of *Opuntia* spp (AN-V1, AN-V3, AN-V5, and AN-TV6) to organic fertilization with two levels of thickness and different plant densities (10, 20, 30, 40, and 50 plants/m²) under plastic tunnels were studied in the Universidad Autónoma Agraria "Antonio Narro" in 1995 and analyzed at CIBNOR, La Paz, Mexico. The main goal of this work was to screen *Opuntia* genotypes for yield and photosynthetic efficiency. The experiment was established as a randomized blocks design with three replicates. Response variables were dry weight (DW), crop growth ratio (CGR), rate of crop growth (RCG), relative growth rate (RGR), leaf area index (LAI), and net assimila-

tion rate. The annual average temperature in the study site was 19.8°C. Hottest months were July and August, with temperature values as high as 39°C. The lowest temperatures were recorded in December and January, with temperatures as low as -13°C. Annual rainfall was 365 mm. Soils in the study region show a generalized low fertility. According to our results, genotype AN-V1 showed the best photosynthetic features with 30 plants/m²; genotype AN-TV6 showed no differences for 40 and 50 plants/m². The highest values for CGR and RCG were observed under the highest level of organic fertilization (16-cm thickness). Genotypes AN-V3 and AN-V5 evidenced the highest RCG. Other results suggest that AN-V3 and AN-V5 showed the highest value for LAI, for a density 50 plants/m², and genotypes AN-V1 and AN-V3, with a density 40 plants/m², had the highest RGR. The studied *Opuntia* genotypes appeared to be promising crops for marginal semiarid regions.

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The Effect of Four Composts on the Establishment of Vesicular–Arbuscular Mycorrhizae in Soilless Media

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The beneficial use of vesicular–arbuscular mycorrhizae (VAM) in mineral soils is well-documented, but little is known about the effect of soilless mixes on mycorrhizal colonization of roots. Previous research indicates that mycorrhizal colonization is affected by pH, soluble salts, phosphorus levels, cation exchange capacity, percent organic matter, and some peats. No other research has been published, to our knowledge, on the role of commonly used horticultural composts and mycorrhizal establishment. This study examined four different composts for their effect on VAM establishment using onion roots as an indicator. The composts used in the study were vermicompost, spent mushroom compost, yard waste compost, and processed manure fiber. Plant growth parameters, phosphorus (P) levels and rate of desorption, and microbial populations were analyzed in relation to the percent of VAM colonization of the roots. Significant differences were found in percent VAM colonization between composts. The primary factors influencing VAM colonization were the initial levels of P in the blends and the rate and amount of P released. The experiment raised questions about the balance between mineralized P and organic P in composts and their effect on VAM fungal spore germination.

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Duration of Composting Affects Compost Characteristics of Importance to Agriculture

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A recently enacted state law requiring California cities to reduce their solid waste flow to landfills has greatly increased the composting of yard and landscape wastes. Currently, much of this material is being composted for less than 16 weeks, some for as little as 4 weeks, before agricultural use. A study was conducted to document the effects of composting method and duration on the physiochemical and biological characteristics of green waste compost. At each of four commercial composting facilities, two windrows of municipal green waste were sampled at 3-week intervals over a 15-week composting period. Each sample was analyzed for pH, NH₄-N, NO₃-N, and total N and C. Phytotoxicity was measured by a tomato seed bioassay. N mineralization/immobilization behavior was evaluated in a 2-week aerobic incubation of a 10% compost/90% soil blend at 30°C. The growth of vinca plugs (*Vinca minor* cv. 'Pink Cooler') in a 50% compost/50% perlite mix was also evaluated. At all sites, the initial green waste was similar, with 1.1–1.5% N and C/N ratio of 20–28. Rapid mineralization of carbon in the first 6- to 9-weeks reduced C/N ratios to 14–18, with little change thereafter. Phytotoxicity decreased through 9 to 12 weeks, then stabilized. Net N immobilization was observed throughout the compost period, but decreased with increased composting time. Vinca growth increased with increasing compost age, up to 9 to 12 weeks. In summary, at least 12 weeks of composting was required to produce material of sufficient quality for typical agricultural uses.

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Integration of Cover Crops and Strip-tillage Systems for Vegetable Production

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Five on-farm trials were conducted in the Willamette Valley of western Oregon

in 1996 to evaluate the potential for integrating winter-annual cover crops and rotary strip-tillage in vegetable production systems. Two kinds of rotary strip tillers were used to till strips into killed winter cover crops or wheat stubble. Strip-tillage systems were compared to the "standard tillage" practices of the participating growers. In two sweet corn trials, yield of sweet corn was reduced \approx 1 MT/ha in the strip-tillage treatments, compared to the standard tillage practices used by the growers. In these trials, the number of tillage operations was reduced by four to five passes with the strip-tillage system. In two other sweet corn trials, corn yield was reduced by \approx 4.5 to 5.6 MT/ha in the strip-till treatments compared to the standard tillage treatments. In a transplanted broccoli trial, the strip-tillage and standard tillage treatments produced comparable yields. Possible factors reducing crop yield in the strip till systems include reduced soil temperature at planting and during early growth, soil moisture depletion in the undisturbed cover crop areas, soil compaction, nitrogen immobilization by the cover crop, weed competition, and possible glyphosate/microbiological interactions. Although an economic analysis of this project has not yet been completed, a rough estimate of tillage costs at \$25/40 per pass per ha suggests that, in the field with only a 1 MT/ha yield reduction, the reduction in tillage costs would offset the yield reduction in corn (valued at about \$88/MT). If yield reducing factors can be understood and a predictable, manageable system of strip-till vegetable production developed, there is a potential to dramatically reduce tillage costs and enhance soil quality through conservation of soil organic matter and biological diversity.

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Integrating Watermelon and Forage Crops

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Watermelon growers are advised to grow melons in a given field no more than 1 year out of 4. Bermudagrass pastures are abundant in the southern U.S., but ranchers are reluctant to destroy a pasture for 1 year and plant it with melons if they must then re-establish a sod. A project was designed to develop a system for growing watermelon in a permanent pasture with only a minimal amount of tillage, and without destroying the established forages in the pasture. The approach is to compare and evaluate several techniques for growing watermelons in strip-tilled areas within a permanent pasture. These techniques include cultivation, plastic mulches, and herbicides applied to 2-m strips separated by untilled bermudagrass. Research was done in 1996 at two university research centers in Oklahoma and Texas. The treatments with greatest watermelon yields, in decreasing order, were black polyethylene mulch, hand-weeded control, photodegradable mulch, biodegradable mulch, cultivation plus sethoxydim, sethoxydim alone, cultivation alone, and the weedy check. At harvest, 63% of the area in the cultivation alone treatment, 40% of the area in the plastic mulch treatment, and 1% of the area in the sethoxydim treatment were covered with a regrowth of bermudagrass. Forage was also collected from row areas of plots. Forage amounts, in decreasing order, were from cultivation alone, weedy check, sethoxydim alone, photodegradable mulch, polyethylene mulch, biodegradable mulch, cultivation plus sethoxydim, and the clean control.

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Cooperative Farmer–Scientist Evaluations of Biologically Integrated Soil and Pest Management Practices

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In Fall 1995, 12 row crop farmers in conjunction with Univ. of California, NRCS and private agency advisors established the West Side On-Farm Demonstration Project to conduct demonstrations of soil and pest management options aimed at sustained profitability and environmental stewardship in the western San Joaquin Valley of California. Monitoring of soil physical, chemical, and biological properties is done in side-by-side on-farm comparisons of plots amended with organic inputs and unamended plots. Intensive monitoring of beneficial and pest insects is carried out within each comparison block, and the data generated is used to guide pest management decision-making at each site. Yields and soil characteristics of the amended plots did not differ from those of unamended plots after the first year. The on-farm context and the cooperative farmer–scientist interactions of this project facilitate the development of timely and relevant research directions to be pursued beyond the core set of monitoring activities.

140 ORAL SESSION 39 (Abstr. 651–655) Computer Technology Applications in Extension Horticulture

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The NewCROP Electronic Network

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NewCROP (New Crops Resource On-line Program) is an Internet resource (<http://www.hort.purdue.edu/newcrop>) developed by the Indiana Center for New Crops and Plant Products to deliver instant topical information on the subject of fiber, energy, and specialty crops. NewCROP includes CropSEARCH (an index to food and feed crops of the world, including taxonomic information, uses, and economic importance), FactSHEETS (in-depth articles on selected crops), NewCROP Import–Export (importation permits, phytosanitation certificates, quarantine and inspection information), Organizations (listings of crop organizations, societies, and interest groups), FamineFOODS (includes about 1250 species that are consumed in times of food scarcity), and FarmMARKET (listing locations of United States farmers' markets). The web site also includes new crop bibliographies, directories of new crop researchers, announcements of pertinent up-coming symposia and crop conventions, the New Crop Center newsletters, and activities of the Indiana Center for New Crops. A search engine is provided for quick information retrieval from the system. An electronic bulletin board, NewCROP LISTSERV is maintained for posting queries and messages to subscribers. We are planning to incorporate material from three books (>1930 pages and 6000 index entries) derived from New Crops symposia and published as *Advances in New Crops* (1990), *New Crops* (1993), and *Progress in New Crops* (1996). The NewCROP digital information program is interlinked with FAO's EcoCROP system and the Australian New Crops Programme, as part of a developing world-wide crop information network.

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NurseryWeb—An Information and Communication Page for the Nursery Industry

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Electronic information systems that take advantage of new technological developments on the Web are a key towards fulfilling the mission of the extension educator; i.e., to help individuals, families and communities put research-based knowledge to work in improving their lives. Webpages are one key to achieving this goal, but vertical searches using search engines are tedious and inefficient. There is a need for a) rapid and easy access to verifiable information databases and b) the coordination of good information resources that are already available on the Web in an horizontal format. NurseryWeb was developed as an open information resource within a frames environment that enables users to gather information about a variety of nursery-related material; e.g., cultural information, diagnostic criteria for disease and pest identification, data on integrated pest management and marketing data. In addition, a password-protected communication resource within the page provides nurserymen with conferencing and direct email connections to nursery extension specialists through WebChat™, as well as providing time-sensitive data, alerts, and links to professional organizations. A number of critical issues remain unresolved—e.g., the integrity of information links, data and picture copyright issues, and software support. Nonetheless, the ease of use, availability of information in remote areas at relatively low cost, and 24-hr access assures that this type of information provision will become dominant in the future.

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Electronic Support of California Cooperative Extension for Fruit and Nut Crops

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For California pomology, it is ideal to communicate and disseminate information electronically because of its large size and diversity of fruit and nut crops. In support of statewide extension, the Fruit & Nut Research and Information

Center's World Wide Web site (<http://pom44.ucdavis.edu>) focuses on providing information and links for temperate, subtropical and tropical fruits and nuts and keeping all interested persons well informed about University of California research and outreach activities. The Internet has been proven ideal for its user friendliness and rapid dissemination of current information. The Center supports this electronic change for growers and industry by collaborative projects with industry and involving Internet education and demonstrations at short courses, symposia, and educational days throughout the state. By this outreach to fruit and nut crop industries, the needs of the growers can be addressed. Also, it is important to address interdisciplinary cooperation and efficiency in the Agricultural Experiment Station and Cooperative Extension programs, especially in view of the recent reduction in staff and resources. By creating electronic listserv groups for each crop through the Center, extension specialists and farm advisors have the ability for increased communication. A more visible and active focal point—both within and outside the University—for research and outreach activities related to fruit and nut production, handling, processing, marketing and consumption has been created since the Center was established in Dec. 1995.

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Large Trees for Kentucky Landscapes—An Interactive Extension Publication Available on the World Wide Web

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An interactive computer version of a traditional Extension educational publication was developed for delivery over the Internet. *Large Trees for Kentucky Landscapes* is a 40-page publication describing suggested species adapted to Kentucky conditions. It is illustrated with numerous color photographs. This type of Extension publication has a limited distribution because it is relatively expensive to publish. The digital version of this publication allows for inclusion of additional information and illustrations. It was designed to be interactive with the user selecting the species and the information about that species from a screen menu. The user also has the option to print a one page informational sheet on that species. The initial audience for this digital version of the publication is the county Extension agent and Division of Forestry personnel, but it may also be useful at retail horticultural outlets.

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Using a Digital Camera to Assist in Problem Identification by County Extension Field Staff using Electronic Mail

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A Casio QV-10 digital camera was used to photograph images. A portable of desktop computer was used to convert the images to a digital image file and attached them to an electronic mail message sent from field extension staff to campus-based horticulture specialists. Images were examples of insect, disease, or cultural problems for diagnosis, plant identification questions, or an overview of a lawn or landscape. Electronic transmission allows immediate identification for a low cost, enables the specialist to see what is being described, and results in images that can be stored for news releases, newsletters, or problem warnings. Limitations exist for resolution and size of objects photographed and these will be described and demonstrated along with other problems and limitations encountered. Cameras are presently available in all five area extension centers and in several individual county extension offices. Two cameras are available for testing and demonstration purposes by individual agents. Transmission from a cellular phone from a remote location is possible, but has not been tested as of this writing. A campus-based "horticulture response center" was established to provide immediate responses to questions from field staff.

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Preplant Fumigation of Reset 'Lisbon' Lemon Trees

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A field study was conducted near Mesa, Ariz., in a mature lemon grove with re-

set 'Lisbon' lemon trees (*Citrus limon*) on a Carrizo citrange rootstock to determine the effects of stump removal and preplant soil fumigation on reset tree growth and development. Treatments consisted of resets planted with or without tree stumps and in addition with or without preplant Vapam. Pretreatment soil samples average 2.1 propagals of *Phytophthora* per gram of soil; however, after Vapam treatments, *Phytophthora* was not detected in the treated plots. In subsequent soil sampling for 2 years, *Phytophthora* was detected in only one plot treated with Vapam. Tree growth and vigor was greatest for resets that had stumps removed and preplant Vapam followed by resets with stumps present and preplant Vapam based on visual ratings and trunk diameter measurements. In addition, resets without stumps were more vigorous than resets where stumps were present.

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Isolates of Arbuscular Mycorrhizal (AM) Fungi Alter Citrus Leaf Gas Exchange during Soil Water Deficit Stress and Recovery

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Four AM fungal isolates (*Glomus* sp.) from disparate edaphic conditions were screened for effects on leaf gas exchange of 'Volkamer' lemon (*Citrus volkameriana* Ten. and Pasq.) plants of similar size under conditions of increased soil water deficit stress and recovery from stress. Mycorrhizal and non-mycorrhizal plants were grown in 8-L containers for 10 weeks under well-watered conditions in a glasshouse and then subjected to three consecutive soil-drying episodes of increased severity (mean soil water tension reached -0.02, -0.06, and -0.08 MPa, respectively). Gas exchange measurements were made on the last day of each soil-drying episode. Plants were irrigated after each soil-drying episode, and measurements were repeated on the following 2 recovery days, when soil remained moist. All measurements were made at mid-day with a LI-COR 6200 portable photosynthesis system. The effect of AM fungi on leaf gas exchange fluxes varied depending on the isolate and the intensity of soil water stress. Leaf gas exchange fluxes always were highest for plants colonized by *Glomus mosseae* (Nicol. & Gerde.) isolate 114C, except during the third soil-drying episode, when all mycorrhizal plants had similar, and lower, gas exchange fluxes compared with non-mycorrhizal plants. During recovery from the third soil-drying episode, *Glomus mosseae* isolate 51C had lower leaf gas exchange fluxes compared with all other plants. Our results show that AM fungi can alter leaf gas exchange fluxes of citrus, under conditions of optimal P nutrition, in an isolate-specific manner.

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Phosphorus-induced Leaf Abscission in Olive and Citrus Explants

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Previous studies, in which the role of phosphorus in abscission of olive leaves was examined in the presence of ethylene biosynthesis inhibitors, have suggested that phosphorus induces abscission directly, without involvement of ethylene. In the present study, this possibility was further explored by comparing the effects of an ethylene biosynthesis inhibitor, aminoethoxyvinylglycine (AVG), and an ethylene action inhibitor, 2,5-norbornadiene (NBD), in olive [*Olea europaea* (L) cv. Manzanillo] and citrus [*Citrus sinensis* (L.) Osbeck cv. Shamouti]. In olive, leaf abscission was always induced in the presence of KH_2PO_4 , with or without AVG and NBD (alone or in combination), but was more pronounced when KH_2PO_4 was applied alone. In citrus, the effect of KH_2PO_4 alone on the induction of leaf abscission and ethylene production was much stronger than that observed in olive. However, in the presence of NBD, KH_2PO_4 did not induce leaf abscission in citrus during the first 60 hr. Similar results were obtained when NBD was replaced by AVG, but, in this case, abscission was inhibited for only 48 hr. In both cases, ethylene was detected after the inhibitory period had ended. The results obtained with citrus indicate that the observed effect of KH_2PO_4 on the ethylene-independent induction of leaf abscission in olive is not a general phenomenon and may differ in different species.

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Finite Dose Diffusion of Urea through Isolated Citrus Leaf Cuticles

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Recent interest in reducing nitrate levels in ground water has stimulated the

re-examination of foliar application of urea on citrus trees. Because the cuticle is the primary barrier to foliar uptake, we examined the diffusion of ^{14}C -urea through isolated citrus leaf cuticles. Cuticles were enzymatically isolated from leaves of the four youngest nodes (1 month to 1 year old) of pesticide-free grapefruit trees. The diffusion system consisted of a cuticle mounted on a receiver cell containing stirred buffer solution. Urea (1 μL) was pipetted onto the cuticular surface, and buffer solution was sampled periodically through the side portal of the receiver cell. The time course of urea diffusion was characterized by lag (time to initial penetration), quasi-linear (maximum penetration rate), and plateau (total penetration) phases. Apparent drying time was less than 30 min. Average lag time was about 10 min. The maximum penetration rate occurred about 40 min after droplet application and was about 2% of the amount applied per hour. Rewetting stimulated further penetration. The total penetration averaged about 35% and tended to decrease with leaf age. Dewaxing the second node cuticles by solvent extraction significantly increased maximum penetration rates (30% of the amount applied per hour) and total penetration (64%).

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A Survey of Cold Protection Methods for Florida Citrus

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During Summer 1996, a disproportionate systematic sampling procedure was used to obtain an initial sample of 955 citrus growers from the mailing lists of extension agents in 27 counties. Of these, 451 usable responses were returned (67% response rate), providing an expected error of $\pm 4.3\%$ with a 95% confidence interval. Surveyed growers obtained weather information during the 1995–96 winter from multiple sources, including the National Weather Service (NWS) (48%), commercial radio/TV (48%), Extension offices (18%), private meteorologists (9%), and other sources (10%). After the NWS discontinued agricultural freeze forecasts in Apr. 1996, growers indicated they would rely on commercial radio/TV (72%); private meteorologists (20%), and their County Extension Office (32%) for weather reports. When deciding which cold protection method to use, respondents adopted Extension (35%) and consultants' recommendations (30%), assessed the costs and benefits of cold protection (32%), and assessed risks based on grove history (38%). Cold protection methods used by percent respondents included: flooding groves (22%); grove heaters (2%); wind machines (2%); permanent overhead irrigation systems (2%); ground microsprinklers (76%); in-tree microsprinklers (18%); tree wraps (13%); and tree wraps or covers with microsprinklers (6%). Seventy-three percent of growers reported that their cold protection methods were very effective for a freeze with minimum temperatures of -2°C for at least 4 hr, with 12% and 3% reporting cold protection measures being very effective at -7 and -9°C , respectively.

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The Effect of Soluble and Slowly Soluble Phosphorus Supply on the Growth of Three Citrus Rootstocks in a Composted Pine Bark Substrate

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Pine bark and peat-based substrates have been shown to have low-phosphorus (P) fixation capacity and high leach-potential, similar to that occurring in high-organic soils lacking in inorganic colloids. A long-term greenhouse experiment was conducted where three rootstock species of varying growth rate, *Citrus jambhiri* Lush.(RL), *Citrus reshni* Hort. ex Tan. (CM), and *Poncirus trifoliata* L. x *Citrus sinensis* L. (Osbeck) (CC), were grown in 3-L containers in composted pine bark, amended with three forms of P. Two slowly soluble forms (Calmafos and MagAmp) and soluble single superphosphate were incorporated at 0 (control), 200, 400, and 800 g P/m³, in a completely randomized block design (n = six plants). A split fertigation treatment of P at 50 mg·L⁻¹ vs. No P was superimposed on the design (n = 3). Despite significant ($P > 0.01$) differences in P availability in the substrate after 380 days, particularly between liquid P ($\mu = 65 \text{ mg}\cdot\text{L}^{-1}$) vs. no liquid P ($\mu = 15 \text{ mg}\cdot\text{L}^{-1}$), differences in leaf analysis of seedlings after 235 days showed little significance (2.2 vs. 2.7 mg·g⁻¹). To avoid excessive leaching of P from pine bark substrates, it therefore appears that slow-release forms of P are adequate to maintain relatively high growth rates of citrus stock without supplemental P fertigation.

142 ORAL SESSION 41 (Abstr. 662–667) Controlled Environments–Vegetables

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Influence of Nodule Development on the Long-term Photosynthetic Response of Beans to Elevated CO₂ and Temperature

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The widely observed reduction in photosynthetic (P_n) capacity following long-term exposure to elevated CO₂ is believed to result from an imbalance in source–sink status. We hypothesized that nitrogen fixation in root nodules would provide a strong sink for photosynthate and lead to a sustained positive photosynthetic response to elevated CO₂. Bean plants (*Phaseolus vulgaris* L., cv RedKloud) were grown in poly chambers at one of four combinations of temperature (35/21 or 26/15°C day/night), and CO₂ (350 or 700 ppm). Half the plants in each chamber were inoculated with *Rhizobium* and fertilized with a complete nutrient solution lacking nitrogen; control plants received a similar solution with nitrogen. Total nitrogenase activity (acetylene reduction assay; 8 weeks after planting) of excised whole root systems was stimulated (up to 4-fold) by elevated CO₂, but this response was only significant for 26/15°C-grown plants. Inoculated plants also accumulated more biomass (10%) than control plants. Nodule abundance and size were significantly higher in high CO₂-grown plants than ambient CO₂ plants, but the P_n capacity of inoculated plants was only slightly greater than that of control plants. Averaged across other treatments, high CO₂-grown plants accumulated more biomass (42%) and had higher P_n rates (50%) than ambient CO₂ plants. Treatment effects on leaf carbohydrate levels and P_n acclimation to CO₂ were not consistent. The results suggest that the higher total nodule activity was due to increased nodule number and size in proportion with increased plant size under high CO₂, rather than an increase in nitrogenase activity per nodule. It is also evident that plants with symbiotic nitrogen fixation capability can benefit from elevated CO₂, even with reduced input of inorganic nitrogen.

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Optimization of Intracanopy Lighting for Hydroponically Grown Cowpea in Controlled Environments

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A major source of power consumption in controlled-environment crop production is plant-growth lighting. Methods developed to minimize this source of power consumption will reduce the negative environmental impact of crop production through more-efficient management of non-renewable resources. One such method uses "intracanopy lighting," in which the plants are allowed to grow through multiple levels of low-intensity lamps to irradiate the understorey that normally is shaded when traditional overhead lighting is used. Early results with cowpea (*Vigna unguiculata* L. Walp 'IT87D-941-1') indicate a significant reduction in net power consumption within a given growth area or volume while enhancing the harvest index (HI = percent edible biomass). Incorporation of mylar reflectors and manipulation of lamp geometries for more-efficient use of available photosynthetically active radiation, while maintaining low power consumption are the focus of present experiments. Photosynthetic rates by leaves of different ages and positions within the canopy are measured as a way of determining lighting efficiency. The productivity parameters HI, edible yield rate (EYR = gDW x m⁻² x day⁻¹), yield efficiency rate (YER = gDW edible x m⁻² x day⁻¹ [gDW non-edible]⁻¹), energy conversion efficiency (ECE = EYR x [kW·h]⁻¹), and energy partition efficiency (EPE = YER x [kW·h]⁻¹) express the costs of edible biomass production in terms of the spatial, temporal, energetic, and non-edible biomass penalties. [Research supported in part by NASA grant NAGW-2329.]

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Effects of Photosynthetic Photon Flux, Photoperiod, and CO₂ Enrichment on the Growth and Morphogenesis of Lettuce Plug Transplants

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Artificial lighting is widely used in controlled environment plant production to enhance plant growth and quality. However, high light intensity with artificial light-

ing is costly, and often causes increase of leaf temperature and, thus, leaf burn. We investigated the effects of photosynthetic photon flux (PPF) and photoperiod on the growth and morphogenesis of lettuce plug transplants under ambient and enriched CO₂ levels. Three days after seeding, the plants were cultured under four PPF levels (100, 150, 200, and 300 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$), two photoperiods (16 and 24 hr), and two CO₂ levels (400 and 800 $\mu\text{mol}\cdot\text{mol}^{-1}$) for 18 days in growth chambers. Light source was fluorescent lamps. The air temperature around the plants was kept at 20°C. The results showed that dry weight of the plants increased linearly as PPF and daily integrated PPF (product of PPF and photoperiod) increased under both CO₂ levels. At the same daily integrated PPF, higher CO₂ level and longer photoperiod led to higher dry weight of the plants. CO₂ enrichment increased significantly dry weight of the plants. The ratio of T/R and specific leaf area of the plants decreased quadratically as daily integrated PPF increased under both CO₂ levels. The ratio of leaf length to leaf width of the plants decreased quadratically as PPF increased under the two photoperiods and CO₂ levels.

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Influence of Ambient UV Radiation on Growth and Flavonoid Concentration of 'New Red Fire' Lettuce

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The influence of ambient UV radiation on growth and flavonoid concentration of *Lactuca sativa* L. ('New Red Fire' lettuce) was examined. Plants were grown outdoors for 31 days from seed in window boxes covered with one of three different UV filters—UV transparent tefzel (10%T, 245 nm), UV-B-absorbing polyester (10%T, 319 nm), or UV-A- and UV-B-absorbing Lumar (10%T, 399 nm). Plants were grown in plastic pots filled with vermiculite and subirrigated with nutrient solution. Lettuce plants grown in the absence of solar UV-A and UV-B radiation showed a significant increase in leaf number and biomass of tops and roots as compared to those grown under ambient UV-A and UV-B. They also had a lower concentration of flavonoids and other UV-absorbing substances at 270, 300, and 330 nm (on both an area and on a dry-weight basis). These findings should be of interest to researchers involved in protected cultivation because the transmission of UV-B radiation is greatly attenuated by standard greenhouse glass. Our results also have implications for human nutrition, since bioflavonoids are important as antioxidants.

666

Stomatal Density and Index of Five Species of Crop Plants Grown at Elevated and Super-elevated CO₂

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The effects of elevated CO₂ on stomatal density and index were investigated for five crop species currently being studied for NASA's Advanced Life Support program. Lettuce (cv. Waldmann's Green) and radish (cv. Giant White Globe) were grown at 400, 1000, 5000, or 10,000 $\mu\text{mol}\cdot\text{mol}^{-1}$ CO₂, tomato (cvs. Red Robin and Reimann Philip 75/59) were grown at 400, 1200, 5000, or 10,000 $\mu\text{mol}\cdot\text{mol}^{-1}$ CO₂, and wheat (cv. Yecora Rojo) and potato (cv. Denali) were grown at 400, 1000, or 10,000 $\mu\text{mol}\cdot\text{mol}^{-1}$ CO₂ within controlled-environment growth chambers using nutrient film technique hydroponics. Leaf impressions were made by applying clear silicone-based RTV coating to the adaxial and abaxial leaf surfaces of three canopy leaves of each crop at each CO₂ treatment. Impressions were examined using a light microscope, whereby the number of stomatal complexes and epidermal cells were counted to calculate stomatal density and stomatal index. Results indicate that stomatal density increased for lettuce and radish at 10,000 $\mu\text{mol}\cdot\text{mol}^{-1}$ CO₂, whereas tomato density was highest at 1200 $\mu\text{mol}\cdot\text{mol}^{-1}$ CO₂. Potato had the lowest density at 1000 $\mu\text{mol}\cdot\text{mol}^{-1}$ CO₂, and there was no effect of CO₂ on density for wheat. Stomatal index correlated with density for lettuce and tomato; however, stomatal index for radish, potato, and wheat was not influenced by CO₂. This suggests that there may be a species-specific CO₂ response to epidermal cell size that influences stomatal density and stomatal index.

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Sodium Recycling through Plants for Bioregenerative Life Support

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As humans explore the solar system, life support will need to be increasingly self-sufficient. Growing higher plants and using recycling technologies can im-

prove self-sufficiency. Sodium is an essential mineral for humans, but not typically for plants. Recycling sodium back to humans through food crops may reduce the need for sodium supplements in the human diet. However, if sodium from waste streams is added to the plant system in greater quantities than it is removed, then plant toxic levels may result. The recommended daily sodium requirement is 3000 mg per person. Based on a 20-m² growing area per person, 150 mg·m⁻² sodium would need to be removed each day. Most crops will not remove enough salt when grown at very low sodium levels; however, when grown in 20 mM sodium, plant uptake may meet the 3000 mg/d human sodium requirement without affecting yields. We grew four different salad crops (lettuce, radish, spinach, and table beet) hydroponically and calculated plant uptake rates and partitioning with 0, 20, 40, or 80 mM sodium supplemented nutrient solutions (corresponding to ≈1.4, 4.0, 8.0, and 13.0 dS·m⁻¹ electrical conductivity). Sodium at 40 and 80 mM reduced edible yields. Sodium replaced tissue potassium in most cases, whereas calcium and magnesium concentrations were much less affected, particularly at 20 mM sodium. This data will be used to model sodium flows within a bioregenerative life support system and determine the feasibility of sodium recycling using food crops.

150 ORAL SESSION 42 (Abstr. 668–674) Breeding & Genetics—Vegetables

668

Environmental Effects and Postharvest Flux of Antiplatelet Activity, Pungency, and Solids in Onion (*Allium cepa*)

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Onion is a species within the *Allium* genus with great culinary importance. Onion extract contains organosulfur compounds that influence pungency and inhibit blood platelet aggregation. Antiplatelet activity has the potential of reducing cardiovascular disease. Onions are typically held in postharvest storage for up to 160 days, during which time volatile organosulfur compounds may be affected. A study was conducted to evaluate antiplatelet activity, pungency, and percent solids during cold storage of onions grown in replicated plots in Wisconsin and Oregon in 1994 and 1995. Organosulfur compound concentration and antiplatelet activity were also measured in progeny derived from crosses of inbred lines contrasting for pungency grown during 1995 and 1996 in Wisconsin. For the first study, bulbs were evaluated for antiplatelet activity, percent solids and pungency at 40-day intervals after harvest. Significant differences were detected for these traits among years, states, dates of sampling, and lines. During the 120-day postharvest period in 1994, antiplatelet activity increased by 25% and 80% for Oregon and Wisconsin, respectively, averaged over all lines. During the same period in 1995, antiplatelet activity decreased by 35% and 4% in the two locations. For three out of four lines, antiplatelet activity was 4.6% higher for Wisconsin than Oregon. Averaged over states, antiplatelet activity was 9.7% higher in 1994 compared to 1995. Pungency was positively correlated with antiplatelet activity in Wisconsin. Broad-sense heritabilities were calculated for antiplatelet activity and organosulfur compound concentration. These data demonstrate that environmental factors influence postharvest flux of antiplatelet activity and pungency in onion.

669

Developing Methodology for Evaluating Sweet Corn Tissues for Allelochemicals Restricting European Corn Borer Larval Development

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European corn borer, *Ostrinia nubilalis* Hübner, can severely affect sweet corn quality. Selection techniques in field experiments have improved ear feeding resistance associated with morphological features and/or allelochemicals. The isolation and identification of allelochemicals that detrimentally affect *O. nubilalis* may improve breeder selection for host plant resistance, thus reducing the need for insecticide application. A laboratory bioassay was used to detect chemical resistance factors in silk and kernel tissues of 10 variously resistant sweet corn genotypes. Ground lyophilized tissue from field-grown plants was added to a nutritionally complete larval diet before infestation with *O. nubilalis* neonates. Larval weights on a 10-day basis and time to pupation were recorded to estimate

larval development. Tissue and genotype main effects affected ($P \leq 0.05$) 10-day larval weight and time to pupation. Silk tissue ($P \leq 0.05$) reduced 10-day larval weight and increased the time to pupation compared with kernel tissue and the cellulose control, which did not differ. Silk tissue reduced larval weight by 65% and increased time to pupation by 4.0 days compared with the cellulose control. Genotypes variously affected ($P \leq 0.05$) larval growth and development, reducing 10-day larval weight up to 51% and increasing the time to pupation up to 4.2 days when comparing the best genotype for each developmental stage with the cellulose control. Silk tissue of some genotypes may contain allelochemicals that decrease the rate of larval growth and development. The status of allelochemical detection in silk tissue will be discussed.

670

An Analysis of the Seed Coat Pigments in Eight Different Genotypes of *Phaseolus vulgaris* L.

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Dry bean (*Phaseolus vulgaris* L.) seed coat color is determined by the presence and relative amounts of phenolics, flavonoids, and anthocyanins present in the lumen of epidermal cells. Some of these chemicals may interact with proteins of the cotyledon to form complexes that render beans hard to cook and digest. Eight genetic loci control seed pigment chemistry. When all eight loci are dominant, a shiny black seed coat results, but recessive substitutions at one or more loci yield colors ranging from white, yellow, and brown to dark violet. In order to relate Mendelian genes for seed coat color to the pigments formed, we studied eight genetic stocks that had recessive substitutions at one or more color-determining loci in an otherwise all-dominant genetic background. Seed coat from each genotype was extracted exhaustively with hexane, EtOAc, MeOH, MeOH:H₂O 1:1, and H₂O 100%. Silica gel thin-layer chromatography (TLC) (solvent system CHCl₃:MeOH 4:1) analysis of the MeOH fraction showed that one genotype had no phenolic compounds and two had only simple phenols. Once flavonol glycoside was present in relatively large amounts in four of the genotypes, but absent in genotypes with anthocyanins. Cellulose TLC (2-dimensional, Butanol:Acetic Acid:H₂O 4:1:5 first dimension, 1% HCl second dimension) of the anthocyanin-containing genotypes showed that the presence of one flavonol and three anthocyanidin-3-glycosides (UV spot color and color shift with NH₃). The relative importance of the seed coat chemicals in digestibility and their antioxidant will also be discussed.

671

Location of Four Morphological Markers (*dgs*, *blu*, *arg*, and *y*) in a Molecular Linkage Map of Common Bean

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The development of a complete linkage map including both morphological and molecular markers is important to understand the genetic relationships among quantitatively and qualitatively inherited traits in common bean. The objective of this study was to identify RAPD markers linked to genes for four morphological traits using bulked segregant analysis and to map the markers to a molecular linkage map previously constructed in common bean. Three segregating populations were evaluated. Two BC₂F₂ populations with *dgs* (dark green savoy leaf) and *blu* (blue flower) induced mutant was developed with a Florida breeding line 7-1404 and 5-593 as the recurrent parent. In addition, a BC₃F₂ population with the *y* (yellow wax pod) and the *arg* (silvery green pod) mutants was developed from the Lamprecht line PI 527858 and 5-593 as the recurrent parent. RAPD markers linked in coupling to the morphological traits were detected to be 4.1 cM, 4.3 cM, 7.3 cM, and 12.3 cM distant from the *dgs*, *blu*, *y*, and *arg* genes, respectively. The linked RAPD markers were mapped in the molecular linkage map previously constructed using recombinant inbred population of the cross PC-50 x XAN-159. In this linkage map, we observed a linkage between the C locus and *blu* gene whose location was not previously known. In addition, a linkage between an abaxial leaf pubescent gene and *dgs* gene was observed. These results indicate that integrating morphological markers and molecular markers can result in a more complete genetic linkage map in common bean.

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Comparison of Genetic Diversity between Nuña and Other Andean bean (*Phaseolus vulgaris*) Populations

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Nuñas are a type of common bean (*Phaseolus vulgaris*) that possess the unusual characteristic of popping or expanding their cotyledonary tissue when heated. Numerous landraces of nuña beans were domesticated in the Andean region of South America (Peru, Bolivia, and Ecuador) and have been grown and consumed in this region since antiquity. The practical consideration in the domestication of nuñas in the high Andes was likely due to the greater energy efficiency in cooking toasted vs. boiled seeds. The *Phaseolus* germplasm bank at CIAT (Centro Internacional de Agricultura Tropical) has developed a core collection of Andean beans that includes numerous nuña landraces. Based on the wide range of phaseolin types observed among nuña landraces, it has been hypothesized that nuñas may represent a greater source of genetic diversity compared to other landraces and cultivars of common bean. Eighty nuña accessions and 120 non-popping common bean accessions were randomly sampled from the CIAT Andean germplasm core collection. The 200 accessions were characterized for 140 mapped RAPD markers. The objectives of our research were to 1) understand the genetic structure of nuña bean accessions relative to other Andean common beans, and 2) to measure the genetic distance and genetic diversity between nuña and other Andean bean populations.

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Genomic Analysis of Chromosomal Regions Introgressed from Tepary Bean Associated with CBB Resistance in *Phaseolus vulgaris* L.

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One of the highest levels of common bacterial blight (CBB) resistance identified in *Phaseolus vulgaris* is found in XAN-159, which was developed for leaf resistance to CBB through six generations of pedigree selection of progenies derived from the interspecific cross [(Pinto UI 114' x PI 319441) x *P. acutifolius* PI 319443] x 'Masterpiece'. A RAPD genetic linkage map was previously constructed in a recombinant inbred population derived from the common bean cross PC-50 x XAN-159 for identification of genomic regions associated with bacterial disease resistance in XAN-159. To confirm that chromosomal regions associated with CBB resistance in XAN-159 were introgressed from tepary bean, we investigated the parentage of each genomic interval in XAN-159 by studying the genomic constitutions of the four different parents involved in the pedigree. The results indicate that all genomic regions associated with CBB resistance contain intervals derived exclusively from tepary bean. The uniqueness of marker polymorphisms associated with resistance to CBB in XAN-159 will allow the application of marker assisted selection for these resistance genes in most populations of common bean.

674

RAPD Marker Facilitated Analysis of Genetic Diversity among *Capsicum* Genetic Resources from the Asian Vegetable Research and Development Center

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Significant effort has been made in the collection of *Capsicum* germplasm throughout the world for maintenance by genebanks. The largest *Capsicum* germplasm collection is held by the Asian Vegetable Research and Development Center (AVRDC), consisting of 6844 accessions and eight species. The paradox of any germplasm collection is that, as the number of accessions and the probability of preserving genetic variability increases, the ability of users to efficiently utilize this resource decreases. Genetic variation can be quantified using RAPD molecular marker allele frequency and allelic variation to understand the genetic structure and variation within and among populations. The comprehensive *Capsicum* collection held at the AVRDC provides an opportunity to sample a range of germplasm representative of the variability that exists in available *Capsicum* germplasm. Accessions were sampled from the AVRDC collection to represent the range of genetic variation available in *Capsicum* 1) based on cluster analysis using morphological traits among 1500 accessions and 2) based on pedigree information from the *Capsicum* breeding program. Our objectives include understanding the structure and magnitude of genetic diversity among these AVRDC accessions

and comparing the genetic diversity within sub-populations of these accessions. RAPD fingerprints of these accessions were collected using markers dispersed over numerous linkage groups based on a genetic map we have constructed. RAPD band frequencies and RAPD band diversity were used to test differences among and within sub-populations. The understanding of the distribution of genetic variation among and within these sub-populations will be useful for prioritizing collection, conservation, and sampling of these genetic resources.

151 ORAL SESSION 43 (Abstr. 675–680) Culture & Management—Fruits/Nuts (Subtropical/Tropical)

675

Long-term Effects of Nitrogen and Drip Irrigation Water Levels on Almond Yields

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Five rates of urea-N each at two water levels (0.6 & 1.0 ET_c) were applied to three varieties (Butte, Carmel, and NonPareil) of almonds [*Prunus dulcis* (Mil) D. A. Webb] planted in 1981 on a 3.65 x 5.47-m spacing (550 trees/ha) on Ar buckle gravelly loam (Fine-loamy, mixed, thermic Typic Haploxeralf). Trees were drip-irrigated to basins (three per tree) ≈7 cm deep and 30 cm in diameter, located 76 and 183 cm on either side of the trees in the tree row. N rates ranged from 0–57, 0–198, 0–454, 113–907, 170–1361, 227–1814, 227–1814, 170–1361, 113–907, 113–907, 113–907, 0–907, 0–907, 0–907 and 0–907 g per tree, respectively, during 1982–1995 and were applied on a monthly basis in four to six increments beginning in April. Almond meat yields were >1500 kg·ha⁻¹ in 1984 and as high as 3800 kg·ha⁻¹ during the 12-year period for the 1.0 ET_c water treatment and optimum N rate. Nitrogen response was generally in the 600–1000 kg·ha⁻¹ range, with water treatment response in the 200–500 kg·ha⁻¹ range. The three varieties generally responded to higher N and water rates in the order Butte > Carmel > NonPareil. Leaf analyses (three to six each year) were used to monitor treatment effects and evaluate need for other nutrients.

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A Management Strategy for Mango Production Beyond the Year 2000

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Mango (*Mangifera indica* L.) currently ranks fifth, along with apple, among fresh fruit imported by the United States, with more than 142,000 MT imported in 1995. Imports have doubled in the past 5 years and are projected to increase by 20% to 30% by the year 2000. Mexico supplied >80% of the imported volume in 1995, with the remaining 20% supplied by Brazil, Ecuador, Guatemala, Haiti, Nicaragua, Peru, and Venezuela. Individual production areas (countries) have traditionally controlled a market, defined by time of year, resulting in a near 12-month supply of mangos in the United States in the past few years. However, market share among producing countries is rapidly changing as individual producers and production regions extend their season through the use of different available microclimates, bloom manipulation, and new cultivars. With this extension of production season in each region, there is now significant market overlap and traditional regional windows have been shortened or eliminated. Producers in all regions must now make timely management decisions to assure their future profitability. A holistic management scheme involving attention to fruit quality, cultivar selection, volume consistency, and marketing is presented. Such a management plan is key to an individual region's success in establishing and holding a given market window.

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Yield and Root Growth Responses of Papaya to Partial Root Volume Irrigation by Drip or Microsprinkler Irrigation Systems

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'Tainung 2' papaya seedlings were transplanted on 30 Jan. 1996 and irrigated with one, two, or three drip irrigation lines per row in one study and with 90°, 180°, or 360° microsprinkler spray patterns in a second study to determine the

reproductive and vegetative growth responses to irrigation design. Variable irrigation duration was used to supply a homogeneous amount of water to each plant in the drip irrigation study. The trench profile method was used in the drip irrigation study, and a monolith method was used in the microsprinkler study to determine root distribution at the end of the dry season (30 May to 2 June). All fruits were harvested and weighed on 26 Aug. Roots proliferated underneath the drip lines during the dry season, and root concentration on the profile walls was inversely related to the number of drip lines. Root concentration underneath one drip line was 3.7 times greater, underneath two drip lines was 2.3 times greater, and underneath three drip lines was 1.9 times greater than root concentration in the non-irrigated zones. Roots also proliferated in the wetted zones of the micro-sprinkler spray patterns. Mean fruit weight and total harvested fruit weight did not differ among the irrigation treatments within each study. The results indicate that papaya roots are highly morphoplastic and proliferate in wetted zones under partial root volume irrigation. One drip line per row supplied ample irrigation coverage under the conditions of this study.

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Responses of Olive Trees to Low Soil Temperatures

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Responses to low soil temperatures at winter days of high evaporative demand were studied in 20-year-old (field) and 1-year-old potted (controlled conditions) olive (*Olea europaea* L. cv. Picual) trees in 1996 and 1997. Low soil temperatures apparently affected tree water status as evidenced by low water potentials and stomatal conductance. Low night (2 and 5°C) but ambient day (above 10°C) temperatures did not affect stomatal conductance (g_s), leaf (Ψ_l), and xylem (Ψ_x) water potentials of potted olive trees. Tree Ψ_l and Ψ_x decreased when exposed to low night and day temperatures (8°C), but g_s was not affected. Water potential of those trees recovered very rapidly when the soil temperature was raised above 10°C at midday. When the trees were exposed to soil temperatures below 8°C for 3 days, Ψ_l, Ψ_x, and g_s immediately decreased. After the first day, g_s and Ψ_x started to recover while g_s was maintained at low levels, thus allowing for tree rehydration. Root hydraulic resistance (r_{root})—a major part of whole plant resistance—increased immediately in response to soil temperatures below 10°C relative to that of control trees. The relationship between Ψ_x and r_{root} indicated that the root system apparently plays a major role in the control of tree water status in response to low soil temperatures. During the winter months, olive tree water uptake seems to be primarily limited by low soil temperatures, even though soil water content is normally adequate due to high seasonal rainfall.

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Seasonal Fluctuation of Promoters and Inhibitors of Adventitious Root Formation in 'Nabali' Olive Shoots

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Four fractions from known dry weights from buds or leaves of 'Nabali' olive shoots—nonacidic ethylacetate (F 1), acidic ether (F 2) and acidic-n-butanol (F 3) were obtained for several sampling dates. A fourth fraction (F 4) from F 1, F 2, and F 3 was established. The four crude fractions were bioassayed for adventitious root formation using mung bean cuttings. In another extraction, fractionation by paper chromatography was performed to identify promoters and inhibitors using the R_f values and mung bean bioassay. The results indicated absence of rooting inhibitors in buds and leaves of 'Nabali' olive in mung bean bioassay in all four crude extracts and their fractions located at the various R_f values. However, rooting promoters from buds and leaves were detected by mung bean bioassay in all crude extracts. F 1 contained rooting promoters located at R_f 0.5 and 0.6 throughout the period from 20 Nov. to 2 Apr.; these promoters were found to be highest in buds sampled 23 Feb. and in leaves sampled 4 Dec. and 4 Feb. F 2 from buds and leaves showed neither promoting nor inhibitory activities. F 3 (from leaves or buds) contained promoters of rooting located at R_fs from .4–0.7 throughout the sampling periods. However, F 3 from buds on 9 Dec., 23 Feb., and 2 Apr.; and from leaves on 4 Feb. gave significantly highest root-promoting activity. F 4 from buds and leaves showed root-promoting effects from November to April. The promoting effect of F 4 was greatest in buds and leaves sampled 9 Dec. and 4 Feb., respectively.

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Somatic Embryogenesis and Plant Regeneration from Roots

of *Punica granatum* L.

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Somatic embryogenesis from apical meristem, cell elongation zone, and cell differentiation zone of roots of *Punica granatum* L. var. Ganesh was obtained. The basal medium used was Gamborg's B5. 2,4-D induced white globular callus in root tip explants, which on further subculture to medium containing 0.5 mg/L BAP, produced somatic embryos from the outer surface of the callus. Direct somatic embryogenesis occurred from all the three zones of the root in presence of 2 mg/L kinetin. BAP induced embryogenic callus in elongation and cell differentiation zone segments of the roots, which, on further subculture onto the same medium, produced somatic embryos. NAA caused rhizogenesis in all the three root segments. Differentiation of somatic embryos into plantlets took place on B5 medium supplemented with 0.01 mg/L NAA + 0.5 mg/l BAP + 2 mg/L kinetin.

158 ORAL SESSION 44 (Abstr. 681–686) Culture & Management–Nursery Crops

681

The Effects of Three Nursery Production Methods on Tree Growth Rates

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Ninety trees are being used and have been in the field since 1994. The three species studied include: *Fraxinus pennsylvanica* Patmore (Green Ash), *Quercus macrocarpa* (Bur Oak), and *Pinus nigra* (Austrian Pine); 30 of each species. Each species has been harvested in three different nursery production methods including balled and burlapped, plastic container, and fabric container. During the 1996 growing season, the following data was recorded for each tree, growth increments, caliper size, and tree heights. For the two deciduous species, both dry weights and leaf area were recorded. Some sap flow measurements were taken using a non-intrusive stem heat balance method, on the same tree species with varying production methods. All three species showed the greatest growth increments and heights for those trees planted in fabric containers. In regards to trunk caliper size, *Pinus nigra* showed that the balled and burlapped, and fabric containers had larger calipers than those planted in plastic containers. Fabric container trees were larger in caliper than plastic container trees, which was larger than the balled and burlapped on *Quercus macrocarpa*. The plastic container and balled and burlapped resulted in greater calipers on *Fraxinus pennsylvanica* than the fabric containers. *Quercus macrocarpa* also showed that both leaf area and dry weight were greatest for trees planted in fabric containers, followed by the other production methods. Trees in plastic containers exhibited the greatest leaf area and dry weight for *Fraxinus pennsylvanica*. Overall, the fabric container trees in all three species illustrated the highest-quality trees, followed by those planted in plastic containers, and then balled and burlapped. Minimal data was recorded for transpiration rates in 1996 and will be further investigated in 1997.

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Pot-in-pot Production and Cyclic Irrigation Influences Growth and Evapotranspiration of 'Okame' Cherry

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A study was conducted with *Prunus x incamp* 'Okame' to evaluate the effects of a pot-in-pot production system compared to a conventional above-ground system and cyclic irrigation on plant growth and water loss. Plants were grown in #7 (26-L) containers with a 8:1 pinebark:sand (v/v) substrate. Cyclic irrigation provided the same total volume of water, but was applied one, three, or four times per day. Final plant height and stem diameter, shoot and root dry weight, total biomass, and root:shoot ratio were all increased for plants grown pot-in-pot compared to above-ground. Multiple irrigation cycles increased stem diameter, shoot dry weight, and total biomass, compared to a single irrigation application. Multiple irrigation cycles decreased the root:shoot ratio. Evapotranspiration was influenced by production system, irrigation, and date. Amount of water lost as leachate was influenced by irrigation and date. Cyclic irrigation resulted in a two-fold decrease in leachate volume. Soluble salts and nitrate-nitrogen in the leachate were influenced by an interaction between production system, irrigation, and date.

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Implications of Genotypic Selection and Production Practices on Root Regeneration Potential and Field Establishment of Container-grown Trees

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Transplant studies were conducted on *Taxodium distichum* L., *Platanus occidentalis* L., *Quercus shumardii* Buckl., *Fraxinus velutina* Torr., and *Chilopsis linearis* (Cav.) Sweet seedlings grown in 2.2- to 9.1-L black plastic containers. Effects of half-sib family selection on post-transplant root regeneration potential (RRP) and field establishment were investigated with *P. occidentalis*. *Taxodium distichum*, *Q. shumardii*, and *P. occidentalis* were used to determine seasonal variation in relationships among RRP characteristics and measures of successful transplant establishment. Post-transplant effects of avoidance of circling root development vs. remediation practices were investigated with *Q. shumardii*. Effects of container media composition on field establishment and RRP of container-grown plants were studied using *F. velutina* and *C. linearis*. Impacts of rotation time on RRP and field establishment were investigated with *T. distichum*. Rates of RRP were the measure most consistently linked to improved post-transplant shoot growth of *P. occidentalis*. Utilization of locally adapted genotypes and avoidance of summer transplant were important in establishment of *P. occidentalis* and *T. distichum*. Increased small diameter root regeneration was linked to reduced water stress during transplanting of *Q. shumardii*. Physical characteristics of the container media impacted initial post-transplant growth of *F. velutina* and *C. linearis*.

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Growth After Mechanical Root Pruning of Herbaceous Perennials under Increasing Levels of Water Stress

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Perennials grown in 5.7-cm containers received two root treatments (mechanical root-pruned and non-pruned) prior to field planting. During the 1996 season, the two root treatments and five irrigation treatments, (0%, 25%, 50%, 75%, 100%) ET_0 (reference crop evapotranspiration), were tested on *Delosperma cooperii*, *Delosperma nubigenum*, *Polygonum affine*, and *Veronica liwanensis* and evaluated on the basis of plant growth and visual ratings. No significant change in height occurred in any species for both root or irrigation treatments. No significant change in width or density occurred in *D. cooperii*, from root treatment; however irrigation treatments below 50% resulted in a significant decrease in width. Significant decreases in width also occurred in all species from irrigation treatments. Mechanically root-pruned plants resulted in a significant decrease in density of *D. nubigenum*, *P. affine*, and *V. liwanensis* and a decrease in width in *P. affine*.

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Monitoring Chemical Properties of Growing Media with Small Soil Solution Samplers

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Hydrophilic polymer tubes (2.5 mm OD, 1.4 mm ID, 10-cm length, 0.1-mm pore diameter) attached to PVC hose were used to extract solution from soilless media at container capacity and analyzed for pH, EC, NO_3^- -N and NH_4^+ -N. Media chemical properties were also analyzed by the Saturated Media Extract (SME) and Pour-Through (PT) methods. Extraction and analyses were conducted in peat : vermiculite (PV) and peat : perlite (PP) media irrigated for 1 week with Hoagland solution at 0.25, 0.5, 1, 2 and 4x. A 10-mL syringe was used as the vacuum source (48.1 ± 0.5 kPa) for the solution samplers (SS), yielding ≈ 2 –5 mL of solution over a 3-min period. Simple correlation coefficients for EC, NO_3^- -N and NH_4^+ -N between SS and SME and PT were high (>0.99). When measured by PT, these chemical properties were similar to SS (within 1% to 6%), whereas SME values were much lower than SS (12% to 15% and 35% to 38% in PV and PP media, respectively). Correlation coefficients for pH were lower than in other chemical properties, particularly in the PV medium. With an estimated life of ≈ 6 months in soil, SS are excellent monitoring tools for mineral nutrition research and horticultural crop production.

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Influence of Stratification, Temperature, and Light on Seed Germination of Selected Provenances of Atlantic White Cedar

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Cones 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 collected Fall 1994 (Alabama, North Carolina, New Jersey, and Connecticut), Winter 1995 (Massachusetts), or Fall 1995 (Florida). Cones were dried for 2 months, followed by seed extraction and storage at 4°C. Seeds were then graded and stratified (moist-prechilled) for 0, 30, 60, or 90 days. Following stratification, seeds were placed at 25°C or an 8/16-hr thermoperiod of 30°/20°C with daily photoperiods of 0, 1, or 24 hr. Germination was recorded every 3 days for 30 days. Temperature, stratification, and light had significant effects on germination. However, responses to these factors varied according to provenance. Averaged over all treatments, the Alabama provenance exhibited the greatest germination (61%), followed by the Florida provenance (45%), with the remaining provenances ranging from 20% to 38%. However, there were specific treatments for each provenance that resulted in germination > 50%. The three southern provenances (Alabama, Florida, and North Carolina) required 30 days of stratification for maximum germination. They did not exhibit an obligate light requirement, but photoperiods ≥ 1 hr increased germination greatly over seeds in darkness. In contrast, the northern provenances (New Jersey, Connecticut, and Massachusetts) had an obligate light requirement. These provenances only required 30 days stratification with continuous light for maximum germination. When subjected to a 1-hr photoperiod, seeds from the northern provenances required longer durations of stratification for maximum germination. Regardless of the length of stratification, the New Jersey provenance required a 24-hr photoperiod to maximize germination. When averaged over all treatments, total germination for each provenance was greater at 30°/20°C than 25°C (43% vs. 31%).

159 ORAL SESSION 45 (Abstr. 687–693) Micropropagation–Floriculture/ Ornamental Horticulture

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Micropropagation, Decontamination, Transcontinental Shipping and Hydroponic Growth of *Cattleya* while Sealed in Semi-permeable Membrane Vessels

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Two varieties of *Cattleya* orchids (*C. Loddigessi* 'Elen' x *C. Loddigessi* Alba 'Extra' and *Brassolaeliocattleya*. Mem. 'Helen Brown' Sweet Afton) were micropropagated in sealed, three-dimensional polypropylene vessels with microporous, semi-permeable membrane films to allow diffusion of water, dissolved nutrients, and gas to plant material inside the vessels. During tissue culture on sugar-containing media, chance contaminants were eliminated on the vessels outer surface using 5% bleach solution. Proper decontamination treatment did not effect carbohydrate content or subsequent growth of tissues contained within the vessels. Plantlets remaining in membrane vessels were shipped (7 days at 14–30°C) from Japan to the United States in the dark in a plastic tray and arrived without changes in fresh or dry weight of whole plantlets. However, shoot dry weight did increase significantly. Sucrose, glucose, and fructose reserves established on sugar-containing media were greater in root than shoot tissue and were largely expended during shipping concurrent with increased shoot dry weight. It is likely carbohydrate catabolism provided energy for these CAM plantlets to continue carbon fixation, resulting in positive net carbon assimilation in the dark shipping environment. Changes in starch concentrations during shipping were not significant. Plantlets grew photoautotrophically in hydroponic culture in the greenhouse, following transport in the same sealed membrane vessels. Carbohydrate concentration of plantlets following hydroponic culture was not significantly different than after the shipping process. Sealed-membrane vessels for micropropagation, decontamination, shipping and greenhouse growth were useful for culture of *Cattleya* to facilitate scale-up of materials handling and international commerce of tissue-cultured plants.

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Micropropagation of Wetland Plants: *Sagittaria latifolia*

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Many wetland plant species used for aquascaping and wetland revegetation projects are collected from donor wetland sites for planting elsewhere. Increased demand for wetland plants has lead to over-collection and subsequent environmental damage to these donor sites. Micropropagation provides an ecologically sound alternative to field collection and allows for production of under utilized wetland species and genotypes that are either slow-growing or difficult to propagate using conventional methods. *Sagittaria latifolia* Willd. (Duck-potato), a rhizomatous herbaceous wetland species, was established in vitro from surface-sterilized lateral and terminal rhizome shoot-tips cultured in liquid basal medium consisting of half-strength Murashige and Skoog mineral salts, 0.56 mM myo-inositol and 1.2 μ M thiamine supplemented with 87.6 mM sucrose. Prior to multiplication, responsive Stage I cultures were indexed for cultivable bacteria and fungi. Shoot multiplication occurred in vitro through formation of multiple node rhizomes bearing terminal shoots. Duck-potato exhibited a high sensitivity to relatively low benzyladenine (BA) levels. Maximum rhizome and shoot production occurred from single shoot explants initially cultured on agar-solidified BM supplemented with 4.0 μ M BA for 28 days. However, repeated subculture on BM supplemented with greater than 2.5 μ M BA resulted in increased mortality, reduction in multiplication rate, or production of dormant corms. Consistent shoot multiplication (four to five shoots/explant) was possible in the presence of 1.5 μ M BA. Maximum (100%) acclimatization and rooting was attained by direct sticking of Stage II microcuttings in soilless growing medium contained in 38 cell plugs. Production of salable plants bearing multiple rhizomes was possible within 6 weeks post-transplant. Preliminary observations indicate that corm formation in *Sagittaria latifolia* may be mediated by photoperiod.

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Flowering Patterns of Reverse Pinwheel Chimeras Produced during In Vitro Culture of *Saintpaulia ionantha* 'Silver Summit'

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The pinwheel flowering African violet 'Silver Summit', a periclinal chimera, has bicolor flowers with violet-blue 93B corolla segment margins and white 155B central stripes. Several off-types were produced during in vitro culture of 'Silver Summit', the two of greatest potential value having reversed color patterns with violet-blue stripes and white margins. The off-types varied in color, one with deep violet-blue stripes (DR, dark reverse) and the other with lighter stripes of the same color (LR, light reverse). Unexpanded inflorescences of both off types were cultured on Murashige and Skoog medium containing 0.1 mg/L benzyladenine and 0.1 mg/L naphthaleneacetic acid. Plantlets resulting from expansion and multiplication of the dormant buds in the inflorescences were removed, acclimated, and grown on to flowering. Thirteen LR inflorescences produced 55 plants; 51 were true to type and four had solid violet-blue flowers (non-chimeral). Thirteen DR inflorescences produced 64 plants; only eight were true to type, 17 produced solid violet-blue flowers, 38 produced flowers with mixtures of the DR chimeral pattern and solid violet-blue flowers, and one was solid white flowering. To visualize the chimeral arrangement of the meristems of the off-types, flower patterns of all plants were recorded and "floral maps" were constructed. Floral maps of LR were constant from plant to plant and varied little as the plants aged, indicating LR to be a stable periclinal chimera. Floral maps of DR were highly variable from plant to plant, and changed considerably over time indicating that the DR meristems were less stable.

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Effect of Different Organic Compounds and Medium Consistency on Temperate Orchid (*Orchidaceae*) Micropropagation

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The effects of organic compounds most commonly used for orchid micropropagation and the physical condition of the medium were investigated for the development of young temperate orchid protocorms. Separate experiments were conducted with five different temperate orchid species: *Dactylorhiza fuchsii*, *Dactylorhiza maculata*, *Dactylorhiza majalis*, *Orchis morio*, and *Ophrys lutea*. Small 2- to 4-mm-wide protocorms were placed in baby food jars (three per jar) containing 50 ml modified FAST medium (Szendrak and R. Eszki, 1993) supplemented with one of eight treatments in a split-plot design with five replications. Both the liquid medium (gyrotary shaker, 125 rpm) and the gelled medium (8 g agar/L) were supplemented with one of the following compounds: 2 g peptone/L;

100 ml coconut water/L; 1 g casein+1 g lactalbumin/L; and 10 g glucose/L as a treatment with a defined compound. All treatments were kept in the dark at 25°C. The number of protocorms/jar were counted weekly over a 6-week-long period and the size and fresh weight of protocorms were measured at the end of the 6th week. In most cases, the liquid medium increased proliferation and the size of the protocorms. However, generally after the 4th week on liquid medium, the development of the protocorms often stopped, but it continued on the gelled medium till the end of the experimental period. The media supplemented with the undefined organic compounds showed a much better effect than the medium supplemented with glucose. Generally peptone and coconut water led to the best development of protocorms, but this varied with species. The development of protocorms into plantlets was normal in all cases.

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Seasonal Effects on ex Vitro Growth and Corm Formation in Micropropagated *Sagittaria latifolia* Ecotypes

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Commercial micropropagation of wetland plants used for habitat restoration provides an alternative to field collection and facilitates production of difficult-to-propagate species and possibly selection of ecotypes that are physiologically adapted to specific habitat conditions. Knowledge of the degree of ecotypic variation within and between wetland populations is very limited. The feasibility of screening ecotypic differences in growth of micropropagated wetland plants, following acclimatization, was examined using *Sagittaria latifolia* Willd. (Duckpotato), a highly variable rhizomatous herbaceous wetland species that is widely distributed in southeastern Canada and the eastern United States. Plants were obtained from populations in Rhode Island, North Carolina, South Carolina, and Florida. Stage I cultures of each *Sagittaria latifolia* ecotype were established from surface-sterilized rhizome shoot-tips cultured in a liquid basal medium (BM) consisting of half-strength Murashige and Skoog mineral salts, 0.56 mM myo-inositol and 1.2 µM thiamine supplemented with 87.6 mM sucrose. Stage I cultures were indexed for cultivable bacteria prior to clonal multiplication of each ecotype by rhizome production on agar-solidified BM supplemented with 1.1 µM benzyladenine (BA). At 4-week intervals for 24 months, Stage II microcuttings of each ecotype were acclimatized and rooted in soilless growing medium under intermittent mist for 10 days. Plantlets were transferred to a shadehouse (50% sunlight reduction) and maintained under prevailing environmental conditions. Plant height, leaf length and number, rhizome number, corm number and weight, and flowering were determined 6 weeks post-transplant. Significant seasonal differences in leaf growth, rhizome production, corm formation and flowering were observed between ecotypes. During the growing season, induction of corm formation occurred progressively earlier in the more northern ecotypes.

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Studies on in Vitro Culture of the Australian Fan Flower, *Scaevola*

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Plants of genus *Scaevola* (family, *Goodeniaceae*), commonly known as "fan flowers," are mostly endemic to Australia. Commercially popular species are *Scaevola aemula*, *S. albida*, *S. striata*, and *S. phlebopetala*. These plants are used as ground covers in Australia and as hanging baskets, window boxes, and garden bed plants in Europe and America. Two aspects of in vitro culture of *Scaevola* are reported here: micropropagation and direct shoot regeneration. A number of commercially available cultivars of *S. aemula*, *S. phlebopetala*, *S. striata* and wild-collected *S. phlebopetala*, *S. glandulifera*, *S. hookeri*, and *S. ramonissima* were used for micropropagation experiments. Micropropagation medium contained salts, vitamins, L-cysteine, sucrose, and agar. Tissue-cultured shoots were rooted in hormone-free medium. A high survival percentage (>95%) was obtained when plants were transferred to soil under glasshouse conditions. Results on in vitro shoot induction and regeneration response of leaf, stem, root, node, and flower explants of two horticulturally important species of the Australian fan flower, *Scaevola aemula* and *Scaevola striata* are also presented. Of all the explants tested, node explants of these species were the first to respond in tissue culture. Maximum number of shoot induction and regeneration was achieved from node explants of *Scaevola aemula* and node and stem explants of *Scaevola striata*. More than 95% of the regenerated shoots were rooted on the medium supplemented with 4 mg/L

of IBA. The significance of above findings in assisting breeding program for new horticultural desirable cultivars of Australian fan flowers will be discussed.

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Multiple Shoot Formation from Somatic Embryo Explants of Eastern Redbud (*Cercis canadensis* L.)

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Somatic embryos from Eastern redbud show a high degree of malformation during development and a low conversion rate to seedlings. This problem is common with somatic embryo systems, especially with legume species. A procedure for multiple shoot formation from somatic embryo explants of Eastern redbud was developed that bypasses the need for germination to recover plantlets. Somatic embryo explants cultured on DKW medium containing benzyladenine (BA) and thidiazuron (TDZ) produced more shoots than either treatment alone. The highest number of shoots (3.3 to 3.4 shoots per explant) was obtained from partially desiccated and wounded explants treated with a combination of 5 or 10 M BA and 0.5 or 1.0 M TDZ for 20 days before being transferred to the same medium without TDZ. The number of shoots formed was increased from 1.5 to 3.2 shoots per explant by cutting through the cotyledonary node prior to culture. In addition, the frequency of explants forming shoots was increased by desiccation of somatic embryo explants to ≈50% moisture and by using somatic embryos with two well-formed cotyledons as explants.

160 ORAL SESSION 46 (Abstr. 694–699) Breeding & Genetics—Fruits/Nuts

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Introgession of *Fragaria* Species using a Streamlined Synthetic Octoploid System

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Fragaria species from the center of diversity have not been integrated into octoploid commercial strawberry cultivars because of ploidy level differences. Even though traits such as disease resistance, enhanced flavor, cold hardiness, and vigor are known to exist in the diploid, tetraploid, and hexaploid species, they cannot be easily used for breeding. The synthetic octoploid method circumvented introgression difficulties by combining lower ploidy species and doubling to the octoploid level. Although easily crossed to cultivars, the use of synthetic octoploids has been minimal as it has been extremely difficult to create them. By working to improve bottlenecks of the original system, improved methodology has been developed and 170 synthetic octoploids have been produced. This represents more than a 100-fold increase in efficiency. The following factors played a major role in improving the system: wide germplasm base; use of *F. vesca* as a common genome; embryo rescue; 5% colchicine applied in vitro by dropper method for 24 hours followed by a quick rinse and continuous light in a 18C growth chamber. *F. vesca*, *F. nilgerrensis*, *F. nubicola*, *F. viridis*, *F. orientalis*, and *F. moschata* have been incorporated into synthetic octoploids in this study.

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Nursery Selection for High Early Fruit Yield in Subtropical Strawberries

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Development of new strawberry cultivars for winter fruit production in Florida entails growing of hybrid seedlings in a nursery in the summer of the first year for runner plant production. Two runner plants are taken from each seedling and planted in the fruiting field in the fall. An experiment was conducted to see if it is possible to predict which genotypes in the nursery will have the highest early season fruit yield. Seedlings from 24 families from a 6 x 4 factorial mating design were grown in a nursery. From each family, daughter plants of 20 seedlings with the highest vigor and 20 randomly picked seedlings were then evaluated in the fruiting field. Plants from selected (high-vigor) seedlings were more vigorous, but had fewer crowns and runners, than unselected plants. More inflorescences were counted in selected plants than in unselected plants during the second week of January. This could account for higher early yield (yield at the end of January)

and total yield (yield at the end of March) in selected than in unselected plants.

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Growth Response to Orchard Replant Disorders in Some New *Malus* Rootstocks

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Orchard replant disorder (ORD) is a widespread soilborne disease complex that causes stunting and poor establishment of replanted fruit trees. Chemical and cultural control of ORD provide effective, but short-term, control. More-sustainable strategies would involve ORD-resistant rootstocks not yet identified in apple. We tested 'Bemali', G11, G13, G30, G65, G189, G210, and G707 clones from the apple rootstock breeding program at Geneva, N.Y., for their response to ORD in a composite soil collected from New York orchards with known replant problems. Clones were tested in the greenhouse in steam-pasteurized (PS), or naturally infested field soils (FS) with about 900 *Pratylenchus penetrans* and 150 *Xiphinema americanum* per pot. Plant dry mass, height, root necrosis, and nematode populations were determined after 60 days under optimal growing conditions. Stunting, reduced plant dry mass, and root necrosis were more severe in FS than in PS for most of the clones ($P \leq 5\%$), but G30 and G210 were substantially more tolerant to replant disorder than smaller ones, but this tolerance might not be sustained in fields with greater or more prolonged nematode infestations. There is sufficient variation in apple rootstock resistance or tolerance to ORD to suggest that genetic resistance may be identified and developed for better management of orchard replant problems.

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Colchicoid Identification of Sections of Shoot Apices in Apple in Vitro

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Plant mutation induced with colchicine, disturbance of chimeras has long been unsolved. Authors used embryo culture in vitro induced with colchicine for inducing genome of embryonic cells of diploid apple to be doubled, cell doubled differentiated into adventitious shoots, and then were culture into plantlets. By morphological preselection, plants induced hundreds of genotypes had been obtained. To identify ploidy variation of three histogenic layers of shoot apices, sections of shoot apices of 284 plants were identified. Two-hundred-forty-nine tetraploid plants were selected. Entire mutants accounted for 98%, chimeras 2%. This proved that induction in vitro could indeed eliminate disturbance of chimeras and was a new induction technique simply and effectively. Accurate rate of morphological preselection was confirmed by 87.7% by sections of shoot apices. The identification of ploidy of mutated plants of apple in vitro induced with colchicine, the method of combining morphological preselection with sections of shoot apices had advantages over that of chromosome count. First, the method is simple, saving time and labor, with a high success rate and reliable results. Second, whether the mutated plants were chimeras and chimera structures could be known. Main criteria of identifying ploidy by sections of shoot apices are the size of cells, nuclei, and nucleoli and numbers of nucleoli of three histogenic layers of shoot apices. Morphological characters of tetraploid were dumpy, thick, and strong stem with short internodes; small petiole angle; broad-round thick leaves with dark green color; round leaf base; thick and sharp-pointed sawteeth; protruding and clear main vein.

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In Vitro Conservation of Wild Pear (*Pyrus syrica*) in Jordan

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Some factors that affect the in vitro conservation of wild pear (*Pyrus syrica*) microshoot cultures were studied. Sorbitol and mannitol at 0.2 to 4.0 M reduced growth significantly and extended the subculture intervals to 5 months when cultures were kept at 15°C. Increasing sucrose to 12% in the medium was not highly effective and the subculture intervals did not exceed 3.0 months. After 2 years of maintaining cultures on slow-growth medium, cultures grew slowly when transferred to fresh control medium. Shoots started to proliferate after three subcultures (6.0 weeks apart) on medium containing 1.0 mg/L BA and 0.1 mg/L NAA. New microshoots were rooted on medium containing 2.0 mg/L IBA and rooted microshoots gave 90% survival when acclimatized ex vitro under intermittent mist.

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Somatic Embryogenesis in Commercial Crops—An Overview

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Many researchers regard somatic embryogenesis as a system of choice for in vitro propagation of superior varieties of crops such as coffee, mango, datepalm, and rose. While there are advantages, commercialization has not been possible so far in coffee, mango, and rose. The work highlights some reasons for this and feasible alternatives. We have established somatic embryogenesis in four elite Indian arabica coffee genotypes. Plantlets (3500) of all the four varieties are now being field-evaluated. The cost of producing these propagules is 15 times the seedling cost at present. A major constraint is the long time (6 months) needed to reach the five-leaf stage in vitro prior to release for acclimatization. This period can be reduced to 2 months using ex- vitro development after the two leaf stage. There are many reports of somatic embryogenesis in mango. Results on establishing free-living plantlets have not been encouraging. We found a number of abnormalities in the shape of the somatic embryos in cv. Rumani. However, except for the "rod"-shaped ones (that lacked cotyledonary expansion), all embryos germinated satisfactorily (75% rooting). We have encouraging results in reducing the time required to generate suitable plantlets for field acclimatization and in standardizing the procedures for grafting. Our laboratory has developed methods for ex vitro germination of mature embryos in datepalm, which yield more numbers of free-living plantlets (50%–60%) in only 3 months with an average of four leaves per plant. This compared favorably with in vitro germination that takes 6 months and produces plantlets with one or two leaves only. A novel protocol for obtaining somatic embryogenesis in rose from petal derived calli was developed by us (Murali et al., 1996). The number of embryos induced was too low for commercial application. [Murali et al., 1996. Euphytica 91:271–275].

38 Colloquium 1 (Abstr. 700–705)

Water Management and Water Relations of Horticultural Crops

700

Water Conservation in the Urban Landscape

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As populations become increasingly urbanized, landscape water conservation becomes more important. Landscape water consumption can increase municipal water use up to 4-fold during the growing season, and account for half the total yearly water use. Landscape water conservation is important in decreasing peak summer water demand to reduce the strain on delivery systems, and to reduce total demand so that development of new sources can be forestalled. Potential water savings from existing landscapes can be estimated by comparing historical usage gleaned from water meter readings to plant water needs estimated from reference evapotranspiration. Estimating water needs for turf is straightforward because of the few species involved and the uniformity of turf landscapes. Estimating water needs of woody plants is more difficult because of the heterogeneity of woody plants and how they are used, and woody plants respond to evaporative demand differently than turfgrass. Many woody plants will actually use less water as reference evapotranspiration increases due to stomatal closure induced by high leaf-air vapor pressure gradients. Landscape water is then conserved by either applying water more effectively in scheduling when and how long to irrigate based on estimating water use again from reference evapotranspiration, or by replacing areas in turfgrass with plants more-adapted to the existing conditions. Encouraging water conservation by end users is the final and largest challenge. Automated irrigation systems makes wasting water easy, while conserving water takes more effort. Education is the key to successful landscape water conservation.

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Water Management and Citrus Tree Response to a Humid Climate

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Four decades ago, irrigation in much of the southeastern U.S. was considered

not sensible economically because of normal rainfall in excess of 1200 mm in some areas. More-recent research has shown that irrigation makes definite economic sense because it can increase production substantially. This is especially true in Florida citrus, where irrigation can increase yield by up to 60%. Drip and microsprinkler irrigation have become popular, and these methods of partial root-zone coverage affect tree water potential and yield. Growing environmental concerns about possible nitrate and pesticide leaching to the groundwater have led to greater emphasis on irrigation management in an area of highly variable rainfall. Rapidly growing population has brought about increased competition for water and greater restrictions on agricultural water use. Reclaimed water, once considered a disposal problem, is now being promoted as a partial solution for periodic water shortages. Discussion will focus on tree response to different irrigation management systems and how agriculture is dealing with greater irrigation restrictions.

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Rescuing Irrigated Desert Agriculture

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From its birth in British India in 1847, modern irrigated desert agriculture has grown in just more than a century to produce one-third of the world's crops. Until the techniques of civil engineering were wedded to the ancient art of irrigation on the plains of the Punjab, most crops were rain-fed, except in areas such as the Nile Valley, where reliable seasonal floods made irrigation practical. Today, in contrast, we have made the desert bloom, giving ourselves fresh produce year-round and making the difference between survival and starvation in much of the developing world. Without irrigation, it would not have been possible to farm the high-yielding seeds of the Green Revolution, which greatly reduced the threat of famine in Asia and Latin America. But now, after a century of heavy irrigation, serious side effects are beginning to appear. Soils are becoming salinized by the cycles of wetting and drying in an arid climate, and wildlife has been poisoned by toxic drainage pumped from beneath irrigated fields where it has built up over time. These side effects have caused some to predict that the bounty of modern desert agriculture may not be sustainable, but others see hope of reducing the side effects through vastly improved water management.

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Effects of Water Stress on Vegetative Growth and Productivity of Fruit Trees

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Generally, water stress reduces yield in annual crops. However, for mature fruit trees, this relationship may not hold in many situations, thus providing the opportunity for saving water without losing production. Indeed, even an increase in productivity may be achieved as we better learn how to manipulate processes within the tree through moderate water stress. Several areas of research have shown promising results. The reduction of irrigation after harvest of early maturing peaches and plums has demonstrated substantial savings of water with no loss of production. Peaches can suffer fruit quality problems such as doubling and deep suturing, but these can be overcome with well-timed irrigations in the previous late summer. Water stress imposed before harvest has also shown some promise. Reports from Australia have demonstrated significant increases in yield and fruit size in peach and pear, although researchers in other locations have generally been unable to replicate these results. The timing and/or rate of stress development appear to be critical factors. Under the right conditions, stress can alter the allocation of resources between vegetative and fruit growth. Before implementation of these practices can be achieved, further research will need to focus on developing good tools for measuring stress in the trees, obtaining a better understanding of adaptation of trees to rapid- and slow-developing stress, documenting the effects of stress on vegetative and fruit growth during different times of the season, and understanding the interaction of stress with other factors such as fruit load.

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Leaf and Root Growth in Relation to Water Status

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Of all the plant processes examined, leaf growth and canopy development is the most sensitive to water stress. The consequent reduction in cumulative

radiation interception by the plant leads to a smaller biomass as well as reduced transpiration, usually without altering radiation-use efficiency or water-use efficiency of the canopy. Sensitivity of leaf growth to the growth medium or aerial environment of the plant will be illustrated. A way to quantify the consequent and often marked impact on productivity will be discussed. In contrast with the high sensitivity of leaf growth to water stress, root growth is more resistant. This allows at least the partial maintenance of root growth as the stress intensifies. The result is a more thorough extraction of soil water while transpiration is restricted by the smaller leaf area. The possible mechanisms for the differential sensitivity of leaf and root growth to water stress will be evaluated. Emphasis will be placed on processes underlying cell enlargement. Recent data, obtained with the pressure microprobe that measures turgor pressure in individual cells, will be presented to illustrate the contrasting responses in growth, cell wall extending ability, and solute transport to the growing cells when the plant adjusts and accommodates to changes in water status.

705

Deficit Irrigation in Prunes: Getting More with Less Water

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Prunes trees are believed to be relatively tolerant of water stress, and because prune fruit are dried, a low fresh to dry weight ratio of the fruit will reduce energy requirements for fruit drying and will represent an economic benefit to the grower. In previous research, we found that, under some orchard conditions, irrigation deprivation was associated with a number of economically beneficial effects, including a lower fresh to dry weight ratio of the fruit, increased return bloom, and final saleable crop yield. Analysis of these results was complicated by the effects of irrigation on alternate bearing, and the fact that tree water stress could be substantially different under different soil conditions for the same level of irrigation deprivation. Taking these factors into account, however, indicated that economic yield in prune could be maintained or increased by managing trees at a moderate level of water stress. An experiment was established to determine whether midday stem water potential could be used to guide irrigation and achieve a target level of water stress during the growing season, and whether a moderate level of water stress would be economically beneficial to prune production. By managing prune trees at a moderate level of water stress (midday stem water potential reaching about -1.5 Mpa by the end of the season) over 3 years, an average savings of 40% in applied irrigation water was obtained. Modest increases in return bloom, and an improved fruit dry to fresh weight ratio, occurred in moderately water stressed trees, although overall yield was not changed. The substantial savings in water, without reducing yield, should represent a net economic benefit to growers, depending on the price they pay for water.

88 Colloquium 2 (Abstr. 706–713) The Carbohydrate Economy of Horticultural Crops

706

Carbohydrate Supply as a Limiting Factor for Citrus Fruit Growth and Productivity

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Carbohydrates fulfill several roles in plants; as building stones, as a source of energy, and also, as recently demonstrated, as modulators of gene expression. Primary, photosynthetic production of carbohydrates (as well as their release from tree reserves) is linked with the carbohydrate-consuming processes through complex feedback and feedforward regulatory loops. With horticultural productivity as the goal, maximum resources must be diverted toward reproductive processes. Persistence of viable vegetative structures must be secured, however, to enable the function of tree systems and ensure the tree's potential for future years. Thus, in the carbohydrate resource allocation of fruit trees, a delicate balance must be maintained between the vegetative and reproductive needs. Flowering, fruit set, and fruit enlargement have been identified as three distinct, critical stages within the annual course of yield formation in citrus. While each of these stages has its own, salient developmental features, all require considerable amounts of energy and their occurrence is dependent, at least to some extent, on the availability of

carbohydrates. Whereas flower bud differentiation may require only a threshold level of carbohydrates, floral development and anthesis consume large amounts of carbohydrates due to the very large number of flowers per tree and their high rates of respiration. Fruit set is more closely linked to carbohydrate levels. Fruitlet abscission acts as a self-thinning, feedback mechanism to adjust the tree's fruit population to the carbohydrate supply. This mechanism does not operate properly in certain mandarin cultivars, resulting in alternate bearing. The acquisition of fruit size appears to be most directly correlated with the availability of photosynthate. Elimination of alternative sinks by extreme thinning and girdling brings about tremendous increases in fruit size. The fruit's vascular system also expands in response to the increase in photosynthate availability. A dynamic model has been constructed to provide a quantitative analysis of citrus trees' carbon balance during the annual productivity cycle.

707

Effects of Atmospheric CO₂ Enrichment and Root Restriction on Photosynthesis and Dry Matter Partitioning in Tropical Fruit Crops

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Banana (*Musa* sp.), mango (*Mangifera indica*), and avocado (*Persea americana*) plants were grown in controlled-environment glasshouses in ambient (350 μmol CO₂/mol) and enriched (700–1000 (mol CO₂/mol) atmospheric CO₂ concentrations. At each CO₂ concentration, plants were either exposed to sink-limiting (root restriction) or non-sink-limiting conditions (no root restriction). Total carbon assimilation and dry matter accumulation were generally greater for plants in the enriched CO₂ environment than for plants grown in ambient CO₂. However, plants grown in the enriched CO₂ environment were less efficient at assimilating carbon than plants grown in ambient CO₂. There was a downward regulation of net CO₂ assimilation due to root restriction that resulted in less dry matter accumulation than in non-root-restricted plants. This may explain the lower net CO₂ assimilation rates often observed for tropical fruit trees grown in containers compared to those of field-grown trees. Atmospheric CO₂ enrichment generally did not compensate for reductions in net CO₂ assimilation and dry matter accumulation that resulted from root restriction.

708

Measurement and Modeling of Carbon Balance of Apple Trees

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Apples have very high record yields (about 140 tons/ha sustained) that demand large amounts of carbon to be produced and partitioned into both fruit and vegetative structures. Even though large quantities of dry matter can be produced, profitability depends on the management of the carbon production and partitioning to produce the optimal balance of yield and fruit quality. The productivity is mostly related to moderate photosynthesis rates per leaf area, long leaf area duration, high seasonal radiation interception, relatively low respiration, and very high harvest index. Due to the perennial nature and large size, few good estimates of seasonal carbon balance are available. Models have been developed, but are not well-validated yet, but general seasonal trends are apparent. Daily net CO₂ exchange begins negative with early spring growth, reaches zero near bloom, peaks about 6 to 10 weeks after bloom, then gradually declines until leaf fall. The demand of the fruit appears to increase exponentially during cell division, then levels off to a relatively constant demand until harvest. Experiments and modeling suggests that if fruit development is limited by carbon availability, the probability increases in heavily cropping trees, and will occur at about 2 to 4 weeks after bloom and before harvest. Best carbon balance appears to occur in relatively cool temperatures and in very long seasons.

709

Developmental and Environmental Control of Dry Matter Partitioning in Peach

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For the last several years, research in my laboratory has been focused on studying the developmental and environmental control of dry matter partitioning in peach trees based on the concept that plants grow as collections of semi-autonomous, but interacting, organs. This concept assumes that plant genotype, triggered by

developmental and environmental signals, determines current organ specific growth potentials and that environmental conditions dictate conditional growth capacity and respiration (both growth and maintenance) requirements of each organ at any specific time. Dry matter partitioning at any given time is then determined by the availability of resources to be partitioned, the conditional growth capacity and maintenance requirements of each organ, and the relative ability of each organ to compete for the resources. In this presentation, I will demonstrate how developmental patterns of various organs influence dry-matter partitioning within the tree over time, how organ number can influence the amount of dry-matter partitioned collectively to an organ type, and propose an hypothesis for how environmental conditions may influence partitioning on a diurnal basis.

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Photoassimilate Production and Distribution in Stone Fruit

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Resource partitioning between individual sink organs is dependent upon the supply of carbon from current photosynthesis and reserves, the relative ability of the translocation system to deliver resources to the sinks, and the strength or competitive ability of the sinks. To comprehend photoassimilate distribution in *Prunus*, one must have a general understanding of habitat, growth patterns, and changes in sink demand over the life cycle and seasonal development of the plant. In this review, we describe assimilation rates for the major *Prunus* species and general dry matter allocation patterns, with emphasis on environmental and biological factors that effect photosynthesis, partitioning, and control. The following factors will be covered: annual growth, changes with tree age, environmental and biological factors that effect photosynthesis, genetic factors, water, light, fruiting, and pruning.

711

Modification of Carbohydrate Content in Developing Tomato Fruit

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The carbohydrate economy of developing tomato fruit is determined by whole-plant source-sink relationships. However, the fate of the imported photoassimilate partitioned to the fruit sink is controlled by the carbohydrate metabolism of the fruit tissue. Within the *Lycopersicon* spp. there exists a broad range of genetic variability for fruit carbohydrate metabolism, such as sucrose accumulation and modified ratios of fructose to glucose in the mature fruit and increased starch synthesis in the immature fruit. Metabolic pathways of carbohydrate metabolism in tomatoes, as well as natural genetic variation in the metabolic pathways, will be described. The impact of sink carbohydrate metabolism on fruit non-structural carbohydrate economy will be discussed.

712

Regulation of Mannitol Dehydrogenase: Relationship to Plant Growth and Stress Tolerance

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Increasing salinity of agricultural soils may ultimately limit the sustainability of food production in some areas of the world. Work from our laboratory and the labs of others demonstrates that mannitol, a six-carbon sugar alcohol, is important as a stress-related metabolite in some plants. Mannitol helps plants resist the damaging effects of stressful growth environments, such as drought, high soil salinity, and perhaps attack by microorganisms that cause plant diseases. In the long run, we hope to genetically engineer plants to produce and use mannitol for increased productivity and tolerance to environmental stresses. Basic information about how plants regulate those genes important to mannitol metabolism is of critical importance to this long-term goal. Our laboratory discovered an enzyme, mannitol dehydrogenase, that is the first critical biochemical step in mannitol use in vascular plants. Later, we cloned the gene for this enzyme. We discovered that hexose sugars "turn off" the expression of this gene. So, as long as adequate sugars are available for energy, maintenance, and growth, the production of the mannitol-using enzyme is repressed. After the sugars are gone, mannitol dehydrogenase is produced very rapidly, and this allows mannitol to be used metabolically. This

type of gene regulation is ideally designed to help plants cells conserve mannitol as long as possible, which in turn allows the cells to retain stress tolerance as long as possible.

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Aspects of Carbohydrate Partitioning in Ornamental Geophytes

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Ornamental geophytes comprise a large and diverse group of plants characterized by underground storage organs that serve the obvious function of reserve storage and subsequent supply during early stages of shoot growth. Relative to many agronomic and horticultural crops, the fundamental physiological bases of carbon metabolism, partitioning, and utilization in geophytes are unclear. One reason is diversity in organ morphology (bulb, corm, tuber, root, rhizome, etc.), storage carbohydrate (starch, fructan, glucomannan, etc.), and growth habit (e.g., synanthous vs. hysternthous flowering). Knowledge of factors that control accumulation and mobilization of carbohydrate reserves may lead to manipulations that considerably improve the quality and culture of these crops. We are utilizing a variety of techniques and experimental systems to study selected internal and external controls or influences on geophyte carbohydrate metabolism and partitioning. Specific examples to be discussed include bulb storage temperature effects on starch and fructan metabolism in *Tulipa*, effects of carbon source and dormancy breaking treatments on starch and glucomannan metabolism in in vitro-grown *Lilium* bulblets, photoperiod control of fructan accumulation in *Dahlia* seedlings, and biochemical and molecular features of soluble and wall-bound invertases in developing *Lilium longiflorum* flower buds.

157 Colloquium 3 (Abstr. 714–723) Implementing HortBase: Horticulture Global Information System for Decision Support

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HortBase: A Global Information System for Decision Support

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HortBase, a global electronic information system to support horticultural decisions in classroom, distance education, life-long learning, and Extension, incorporates three innovative concepts: 1) Three-dimensional-team creation of individual electronic information files (subject, communications, and information science authors collaborating from start-to-finish to create the file). Team-creation respects, utilizes and develops professional strengths and resources of each team member. 2) Nation-wide, or even world-wide, distribution of the workload and costs of creation, review, revision, and distribution of the individual electronic information files, rather than redundant individual efforts and expenditures, enables us to do more as a group and to specialize individually. And, 3) National peer review by each file creators' professional society (ASHS, ACE, and ASIS respectively) enhances information quality, continued professional development of the authors, and wider acceptance and use of the information. Capabilities of electronic information systems facilitate, indeed require, this new approach to information development and delivery. For additional information, <http://forages.css.orst.edu/HortBase/>.

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ASHS Strategic Planning and HortBase

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The ASHS Strategic Plan, Key Result Area One: Enhance Internal Services, identifies various aspects of communication with and enhancing services for the

membership. Strategy Three calls for the development of "an information highway through advanced communication technologies." Strategy Four seeks to "enhance services for international members" and Strategy Five and Six addresses increasing the involvement of graduate and undergraduate students and increasing the value of membership to diverse members. There are various other aspects of the Strategic Plan dealing with promoting horticulture and horticulture information dissemination that are impacted by HortBase. How the development and implementation of HortBase will help ASHS reach these objectives will be discussed.

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National Electronic Information Systems–Agricultural Databases for Decision Support

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A number of factors have emerged in recent years, grown in importance, and are now converging rapidly to create a window of opportunity for all of us. These factors constitute six separate, but related and important, categories: 1) Decreasing staff in the nation's Cooperative Extension System; 2) increasing complexity of agricultural production technologies; 3) increasing concerns of society; 4) opening of markets globally; 5) increased need for accountability; and 6) rapid progress in computerized information and communication technologies. These factors concurrently are causing greater sharing of expertise and resources across states, institutions, and departments; more cooperation with the private sector; improved openness and communication on issues of interest to the community; greater awareness of our role in the world; and a willingness to consider new approaches. One of these approaches involves the development of comprehensive national decision support resources for producers and those who work with producers in an educational, advisory or service role. This program, which has evolved over the past 10 years, is Agricultural Databases for Decision Support (ADDS). ADDS projects may be developed for any commodity, clientele, or major issue area. Products already available include the National Dairy Database and the National Pig Information Database. Several additional projects are underway and more will be added as interest warrants. The ADDS hallmark applies to those projects that follow the philosophy and meet the criteria agreed to by the greater community of developers and users. ADDS uses the sophisticated search and retrieval mechanism and multimedia capabilities of commercially available software. This software is applied to a cooperatively developed national resource of peer-reviewed materials that are selected by experts for their usefulness.

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A Horticulturist's Perspective of Agricultural Databases for Decision Support

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Agricultural databases have existed in one form or another from time immemorial. However, their usefulness to horticulturists has not been the greatest. Many databases exist today that one can use to research developments in agriculture. However, none exists that allow a horticulturist to rapidly focus on a subject with the assurance that the information is accurate. Accuracy of information, especially that which can readily be used by Extension horticulture specialists and agents, is not guaranteed. The Cooperative Extension System (CES) through several state specialist and the National Program Leader at USDA developed a list of current and available Extension literature on three distinct subjects during the early 1980s. These lists were compiled by the Specialists and were placed in an electronic format (bulletin board) available through the nascent CES electronic network. This effort was abandoned 3 years after inception due to lack of use by CES staff. One of the reasons for not using these lists so as not to reinvent the wheel was that electronic communication at that time was very expensive. Other reasons were that it was cumbersome and did not include text. There was no quality assurance of any kind. In the case of this primitive database in horticulture, personal contacts were much more useful and convenient. Indeed there are many databases that have horticultural subjects included and many more are being created. These are only marginally useful to us in horticulture. There is a shining nova in our horizon today. HortBase offers the best chance we in horticulture, and especially in Extension horticulture programs, have of being able to use data (written and hopefully in other media) that meet our specific requirements. HortBase will be a peer-reviewed accumulation of our experiences and experiments whether in the classroom or in the field. It has a great potential to become one of our best tools for program development and delivery. We in horticulture, whether at the society, national, state, region, or county level, must

help in the development and maintenance of this rising star so that it truly reaches its full potential.

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The Role of ASHS in Implementing HortBase

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The American Society for Horticultural Science (ASHS) is the largest and most prestigious world-wide professional scientific society for the horticultural science community. Research presented in the serial publications of the Society is peer-reviewed under a well-organized and rigorous system that provides independent review of the research and assures that the scientific information published is validated. The Executive Committee and Board of Directors of ASHS are firmly committed to the HortBase concept of information dissemination, and are supportive of the Society's proposed role as the validator of HortBase information for use in extension and teaching. The presentation will discuss the role of the scientific society, specifically ASHS, in implementing HortBase.

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ASHS Publications Department Role in Implementing HortBase

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The ASHS Publications Department's primary function is to organize and manage the Society's peer-review system and distribute the horticultural information that meets the requirements for dissemination. As Web and other electronic information distribution systems come on-line, the functions of the department will not change, but the methods to achieving the final product will change. Issues such as the security of electronic peer-review and controlled methods of information dissemination are at the forefront of discussions among scientific publishers, and the role of established scientific society publication departments on how best to implement the changes brought about by Internet in the distribution of this information will be discussed. A comparison of the "traditional" methods of peer review and the future of peer review will be compared, and the synergism of the changes will also be addressed.

720

Integrating the Web into Existing Extension and Educational Technology

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Recent studies by academic, extension, and private foundation "think tanks" have reaffirmed the land-grant philosophy as an important component of American society in the 21st century. According to Bill Campbell's dictum, successful land-grant systems will have more closely integrated educational, research, and extension programs characterized as more ACCESSIBLE, AFFORDABLE, and ACCOUNTABLE than current models. The World Wide Web affords the land-grant professional an information delivery/teaching system that conforms to Campbell's three As. Web technology is evolving rapidly, necessitating continuous and rapid adaptation by information providers. The availability of low-cost, user-friendly Web access through home TVs promises to upset the existing paradigms of extension information delivery through county offices and undergraduate instruction exclusively in the campus classroom. Some land-grant professionals have adopted Web technology as a tool to deliver educational programs and coursework; however, the vast majority have not. Most faculty continue to distribute information in a printed form, citing as justification the very steep learning curve and time involved in formatting materials for electronic delivery. We have emphasized the need for life-long learning to our clientele and students; we must heed our own advice. The transition from a paper-based, county-centered extension delivery system and campus classroom-oriented undergraduate educational system is being facilitated by satellite and compressed video conferencing, and Web server networks. Faculty must develop the ability to integrate appropriate technology into their own programs, since it is clear that the "efficient" land-grant systems of the future will not provide them with the support personnel to do it for them.

721

The CD-ROM-World Wide Web Hybrid

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A large horticultural database and an electronic retrieval system for extension

education programs were developed using compact disk-read only memory (CD-ROM) and World Wide Web (WWW) as the medium for information delivery. Object-oriented database techniques were used to organize the information. Conventional retrieval techniques including hypertext, full text searching, and expert systems were integrated into a complete package for accessing information stored in the database. A multimedia user interface was developed to provide a variety of capabilities, including computer graphics and high-resolution digitized images. Information for the CD-ROM was gathered from extension publications that were tagged using the Standard Generalized Markup Language (SGML)-based document markup language (International Standards Organization, 1986). Combining funds from the state legislator with grants from the USDA, and other institutions, the CD-ROM system has been implemented in all 67 county extension offices in Florida and is available to the public as a for sale CD-ROM. Public access is also available to most of the database through the WWW.

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Developing, Converting, and Maintaining Information-rich Resources on the Web

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"Sustainable Practices for Vegetable Production in the South," 174 pages long, including 250 references, was written as a traditional college textbook. I will be discussing my experiences converting it to a web document and simultaneously releasing web and print versions. I will also discuss some of the issues we will confront if we depend on the web for delivering and receiving information. These issues are: 1) There are no conventions for websites comparable to those that have evolved for print documents. At the same time, users expect sites to function certain ways. 2) Consistency between parts of the website is more difficult to maintain than in a print document, but is critical in order to correctly orient the user. 3) The optimal size and structure of the information "chunk" or subdivision is unclear—Should it be a whole chapter or article, a single paragraph, or a functional unit of facts that does not have a name or correspond to anything in print media? 4) How do you let a person accessing any one part of your website know about all the other parts and how they fit together—You can flip through a book to view it, but a person following a link to a page on your site is like the blind person touching the elephant's trunk—they can not visualize the whole. 5) There is no one intuitively obvious or logical place to put references and footnotes because of the subdivision of information into "chunks" or functional facts. 7) There is no obvious starting or stopping point in making revisions. 8) People accessing the site will send messages and ask questions. 9) Meaningful evaluation of usage and usefulness is difficult.

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HortBase: Providing a Foundation for Education

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Technology allows educators to convey information be conveyed more flexibly and visually. How to access and make use of technological teaching tools is the challenge facing educators. HortBase provides the framework for educators to create and access educational chunks. How to make use of the information in HortBase in distance teaching is a three-step process. 1) Before assembling the teaching material, the educator must decide on who the target audience is and what information to convey. Audiences on campus have higher expectations of how they learn, as they are used to live teaching and guidance, and often do not have a clear idea of what they want to learn. Off-campus audiences have lower expectations and are more focused on the information they want. 2) The educator then decides how much of the information to bring into digital form oneself and what to draw from elsewhere. Pieces of digitized information can be created by scanning existing images into the computer or created on computer with drawing programs. Once digitized images can be manipulated to get the desired look. This is a very time-consuming step, so much effort can be saved by taking created "chunks" from HortBase. 3) Finally, what medium and tools to use must be decided. Course content can be presented with slide-show software that incorporates digitized slides, drawing, animations, video footage with text. Lectures can then be outputted to videotape or broadcast via over an analog network. Alternatively, the digitized information can be incorporated into interactive packages for CD-ROM or the World Wide Web.

45 Workshop 4 (Abstr. 724–725) Changing Directions for Horticultural Commodity Education

724

Curriculum Adjustments at Michigan State

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At Michigan State Univ., the Dept. of Horticulture curriculum has been restructured simultaneously both toward and away from specialization. The traditional commodity orientation has been eliminated in the main track Horticulture option. At the same time, a new highly structured Landscape Design–Construction and Management option has been created. Both of these changes were made in response to industry needs. Additional optional Specializations in Environmental Studies, Agribusiness, and Biotechnology also are available. These require students to take 18–20 credits from specified course lists. These credits may be part of the required courses for the Horticulture major, or may be in addition to that requirement.

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Sustainable Agriculture—Another Method of Attracting High-quality Students

N.G. Creamer*; Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695

While enrollment is dropping in many commodity-based curriculums, one key program area of interest to many students is sustainable agriculture. Some land-grant universities are initiating undergraduate and graduate programs, or concentrations in Sustainable Agriculture, to meet this student demand. Many smaller colleges (for example, Delaware Valley College, Slippery Rock Univ., and Warren Wilson College) are also offering a focus in this area as well. These programs often include an experiential learning component through internships and other hands-on activities. Examples of some of the courses being offered include Principles and Practices of Sustainable Agriculture, Agricultural Ecosystems, Sustainable Agriculture Processes in Plant Horticulture and Animal Husbandry, and Fertility Considerations in Regenerative Agriculture. In this presentation, I summarize ongoing programs nationwide, and discuss the impact these programs are having on student enrollment.

61 Workshop 8 (Abstr. 726–731) Aroma Generation by Horticultural Crops: What Can We Control?

726

Factors that Influence Biosynthesis of Volatile Flavor Compounds in Apple Fruits

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Volatile ester molecules are important contributors to the perception of fruit taste. Biosynthesis of volatile compounds occurs via several biochemical pathways. Ongoing studies have concentrated on alcohol acetyl transferase, the terminal step in the acetate ester synthesis pathway. Our studies on volatile biosynthesis in apples have revealed several interesting phenomena. First, the nature and amount of volatile compounds are cultivar- and strain-dependent. Studies with 'Delicious' show a relationship between amount of peel coloration and flavor volatile content of tissue. Second, it is possible to manipulate the preharvest growing environment to influence the content of some volatiles in the fruit. Third, generation of volatiles is closely linked to the onset of climacteric ripening. Other experiments show the response of apples to different storage conditions with regard to volatile ester synthesis. In some cultivars softening apparently provides ester precursor molecules, leading us to speculate that there are glycosidically bound intermediates that are liberated by the action of cell-wall degradation.

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The Composition of Strawberry Aroma as Influenced by Cultivar, Maturity, and Storage

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The aroma of fresh strawberries is composed of a mixture of volatile compounds with no single compound responsible for the characteristic strawberry aroma. Volatiles produced in strawberries are predominately esters, although alcohols, ketones, and aldehydes are also present in smaller quantities. The major volatiles contributing to aroma include ethyl butanoate, 2,5-dimethyl-4-hydroxy-3(2H)-furanone, ethyl hexanoate, methyl butanoate, linalool, and methyl hexanoate. There are qualitative and quantitative differences in volatile composition between cultivars. Headspace concentration of volatiles from 5 cultivars were 0.4, 1.7, 5.6, 5.8, and 14.3 mol·m⁻³ for 'Honeoye', 'Cavendish', 'Micmac', 'Kent', and 'Annapolis', respectively. During fruit maturation on the plant, aroma volatile synthesis coincides with color formation, and continues to increase until the fruit is over-ripe. Volatile concentration increases about 4-fold in the 24-hr period required for fruit to ripen from 50% red to fully red on the plant. Volatile composition continues to change after harvest and is affected by storage temperature, atmosphere composition, and light. The concentration of ethyl esters increases while methyl esters remain constant in fruit held at 0°C, but, when fruit are warmed to 15°C, the reverse is true. Holding strawberries in 10 to 20 kPa of CO₂ may increase concentrations of ethyl esters in the fruit. Light increases the production of volatiles in stored strawberries. Methods to control strawberry aroma will be discussed.

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The Biochemistry and Control of Cell Disruption-dependent Aroma Generation by Tomatoes

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More than 400 volatile components have been identified in tomato fruit, of which only 10–16 are likely to be important contributors to tomato flavor/aroma based on odor threshold data. Tomato volatiles are grouped as lipid-derived, carotenoid-related, amino acid-related, lignin-related, or of uncertain origin. These flavor components are either present in intact fruit or formed after blending due to mixing of previously compartmentalized enzymes and substrates. Lipid-derived volatiles are the biggest group containing *cis*-3-hexenal and hexanal, which are quantitatively the major volatile compounds in tomato fruit. *cis*-3-Hexenal and -ionone have the highest odor thresholds among tomato volatile compounds so far identified. Most of these compounds increase during ripening (or the enzymes, substrates and conditions develop that result in increased levels after blending) and appear to be related to ethylene production. Biosynthetic pathways have been established or suggested for most of the important flavor components, of which lipid degradation is the best-understood. Linoleic and linolenic acids are oxidized to hydroperoxides by lipoxygenase, which are then cleaved to volatile C₆ aldehydes (hexanal and *cis*-3-hexenal, respectively). There are two membrane-associated lipoxygenases (tomloxA and B), of which tomloxB appears to be fruit-specific and increases during ripening. Alcohol dehydrogenase (ADH) has been demonstrated to catalyze the interconversion of *trans*-hexene-2-al and -2-ol and of *trans*-hexene-2-al, hexanal and hexanol. The enzyme product of the *Adh2* gene is induced by 3% O₂, and is developmentally expressed in fruit aside from anoxic induction. Naturally occurring mutants and genetically engineered tomatoes with reduced ethylene production, color and/or retarded ripening patterns show changes in volatile concentrations.

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Modifying Flavor and Aroma from Cut Onions and Other *Alliums*

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World-wide, onions are the most important member of the vegetable *Alliums*. Members of this group are primarily consumed because of their unique flavors and aromas. *Allium* aroma is dominated by organosulfur compounds arising from the enzymatic decomposition of S-alk(en)yl-L-cysteine S oxide (ACSO) flavor precursors following tissue disruption. Primary products from the decomposition of the four ACSOs are sulfenic acids, including the lachrymator, pyruvate, and ammonia. The sulfenic acids, however, are short-lived and disassociate rapidly into thiosulfonates, which, in turn, are unstable and randomly rearrange or dis-

sociate over time. The thiosulfonates each have unique sensory qualities and are responsible for the flavor notes of fresh cut *Alliums*, while of the degradation compounds can contribute to off-flavors and bitterness. ACSO concentration affects ultimate flavor and aroma intensity, while ACSO composition determines among species flavor differences. Controlling sulfur uptake and sulfur metabolism that terminates in ACSO synthesis is one method of controlling ultimate flavor and aroma intensity. Cultivar difference in the ability to absorb and metabolize sulfur have been identified. Sulfur availability, plant growing temperatures, and irrigation intensity also influence sulfur absorption and metabolism, and can be manipulated. Differences in alliinase concentration and the efficiency at which alliinase decompose the ACSO substrates also affect aroma generation. Difficulties, however, exist in controlling alliinase activity. Alliinase has been cloned and anti-sense constructs have been made, but an efficient vectoring system has yet to be developed for the *Alliums*.

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Synthesis of Volatile Flavor Components in Food Crops during Cooking

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Using the sweetpotato as a model, we identified precursors of critical flavor volatiles by fractionating, based upon solubility, raw roots into major groups of constituents. Volatile thermophyllic products from the individual fractions were analyzed and compared to those from non-extracted root material. Volatile components were separated and identified using GC-MS and quantified using internal standard methodology. Mechanisms of synthesis of flavor volatiles via thermophyllic reactions will be discussed, as will postharvest treatments that can modulate eventual aromatic properties of cooked plant products.

731

A Genetic Approach for Investigating the Chemistry of Cooked Flavor and Aroma in Sweet Corn

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Investigating the chemical constituents that determine human preferences for cooked vegetable flavor and aroma is complicated by experimental limitations. Several to many biochemicals interact with each other and with textural properties to influence perception of eating quality. This is particularly true for volatile compounds associated with aroma, where differences in concentration, volatility, reactivity, chemical stability, thresholds of perception, and duration of receptor bonding generate transient stimuli that are integrated into the sensory evaluation of quality. This paper describes methodology that can isolate, identify, and quantify the effect of chemical constituents that influence flavor and aroma using populations segregating for genes controlling eating quality. A $F_{2,3}$ population derived from a cross between two sweet corn inbreds that differed in kernel characteristics associated with eating quality were assayed for variation in chemical, physical, and sensory characteristics. Because most aromatic constituents of sweet corn are generated during cooking, kernel tissue samples were autoclaved and analyzed by gas chromatography. Panel variation in sample preference were found to be controlled by three overlying factors—taste, texture, and aroma—the relative importance of each being 45.1%, 30.5%, and 24.4%, respectively. DNA marker technology was employed to generate a linkage map of this population that was sufficiently saturated with probes to allow for the identification and mapping of genes controlling each characteristic. This information improves selection methodology in a breeding program aimed to develop germplasm with superior eating quality.

97 Workshop 14 (Abstr. 732) Technology Transfer to Developing Countries

732

Using HortBase

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How can HortBase and other electronic information systems benefit horticulturists in developing countries? If Nation-wide distribution of the workload and costs of creation, review, revision, and distribution of individual information files to produce an electronic information system for decision support can be achieved in the U.S., can this collaboration occur world-wide? The European Agricultural Multimedia Network (<http://www.stoas.nl/mmnet/>), established in 1995, is an international network of more than 37 European institutes and organizations that are active in agricultural education. Its goals are to exchange knowledge and ideas and foster cooperation in development and exchange of agricultural education and extension multimedia products. EUROPEA, created in 1993, is a network of about 500 agricultural colleges and institutes in Europe to optimize transnational cooperation in development of distance education and lifelong learning and to provide an international dimension to students. The international membership of ASHS coupled with global communication technology facilitates global collaboration on information development and access.

112 **Workshop 17 (Abstr. 733–734)
Health and Nutritional Components of Horticultural Food Crops**

733

Genetic Improvement of Vegetables for Enhanced Cancer Chemoprevention

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Extensive epidemiological evidence suggests that carotenoids (including vitamin A), ascorbate (vitamin C), tocopherols (including vitamin E), and glucosinolate breakdown products exert anticarcinogenic effects in a range of human tissues. Consumption of fresh and processed vegetables with enhanced levels of these phytochemicals could reduce human risk of cancer. The vitamins play a major role as antioxidants, offering protection against cancer by preventing or reversing oxidative damage to DNA and other cellular components. Cruciferous vegetables contain glucosinolates (GSs), which, during mastication, are hydrolyzed by the enzyme myrosinase into bioactive breakdown products (BBPs), including sulforaphane. BBPs appear to induce synthesis of drug metabolism enzymes resulting in increased detoxification rates of carcinogens. This paper describes an interdisciplinary investigation designed to develop vegetable cultivars that offer chemoprotection from cancer at doses commensurate with a normal American diet. Initial work has focused on surveying sweet corn and *Brassicaceae oleraceae* germplasm for variation in vitamin and glucosinolate content in conjunction with in vitro and in vivo bioassays to determine which compounds and concentrations optimize chemoprotectant activity. Segregating populations from crosses between sweet corn and Brassica lines that vary in vitamin and GS concentrations will be assayed for chemical content and chemoprotectant activity, and genetically characterized using DNA marker technology to identify and map genes controlling these traits. This information will improve selection methodology in a breeding program aimed to develop brassica and sweet corn germplasm with enhanced cancer chemoprevention.

734

A New Look at the Bioactive Properties of Anthocyanin-rich Horticultural Crops

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The bright red pigmentation in edible, anthocyanin-rich fruits and vegetables is a definite bonus in terms of market appeal. As a result, breeders have worked consistently to intensify anthocyanin levels or alter composition in crops. The positive links between consumption of crops and food products containing natural anthocyanin pigments, and reduced incidence of cardiovascular and other chronic diseases, have been established anecdotally and more recently validated in research trials including those from our laboratory group. The protective events, most attributed to the potent antioxidant properties of anthocyanin pigments and associated phytochemicals, place anthocyanin-rich crops in the category of "Functional Foods," yielding health protection unrelated to nutritional value. In vitro bioactivity assays have identified components from these crops capable of blocking the initiation stages of carcinogenesis, while a completely separate class of phytochemicals and sets of assays establish efficacy against the promo-

tion stages of tumorigenesis. Animal models for carcinogen-induced damage to mammary gland and skin DNA subsequently demonstrate the in vivo potency of the same target compounds. Similarly, to establish cardioprotective properties, demonstrations of ability to inhibit platelet aggregation, relax vascular muscle tissue, and reduce total serum cholesterol are demonstrated in a series of in vitro assays, and via animal models and human studies. While activity-directed fractionations seek to identify specific responsible compounds, it is increasingly evident that bioactivity is drastically attenuated once specific compounds are isolated, and the synergistic interaction of associated phytochemicals in horticultural crops is prerequisite to realizing health benefits. These complications have slowed the establishment of effective minimum "dosages," but all the more strongly promote consumption of the crops.

113 Workshop 18 (Abstr. 735–738) Time and Method of Nutrient Application in Fruit Orchards on Nutrient Distribution in the Soil and Tree Performance

735

Effects of Fertigation and Ground Application on Nutrient Movement and Tree Response in Eastern Soils

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Distribution of nutrients was evaluated in samples collected at various depths and distances from drip emitters after 8 years of application. Nutrients applied to soil surface influenced levels mainly in top 40 cm of the soil profile, while fertigation resulted in movement to depth of 80 cm within the wetted zone. $\text{NO}_3\text{-N}$ was increased in 0- to 40-cm depths by soil surface application, but below 40 cm by fertigation. Fertigation increased P in wetted zone to a 40-cm depth. Surface-applied K increased levels in the 0- to 20-cm zone, while fertigation increased K to the 80-cm depth. Zn and Cu were increased to 80 cm by fertigation. Growth and yield indicate soil surface application of fertilizers plus drip irrigation to be comparable to fertigation in most experiments. Fertigation of mature trees on M.7 with K + B for 3 years did not show consistent positive effects on fruit size or color. Responses associated with fertigation appear to be largely attributable to irrigation unless soil nutrient supplies are inadequate.

736

Effect of Fertigation and Ground Application on Nutrient Movement and Tree Response in Western Soils

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Traditionally, broadcast or foliar fertilizer applications sufficed to improve the nutrition of many irrigated, deciduous fruit orchards in western North America. Recent developments, including adoption of low-pressure, micro-irrigation systems and planting at higher densities (especially for apples), have increased interest in controlled application of fertilizers directly with irrigation waters (fertigation). The possibility of using fertigation to synchronize fertilizer application and plant nutrient uptake seems attractive as environmental concerns to minimize leaching of nutrients (especially N) to groundwater increase. Recent fertigation research in western North America will be reviewed and compared to traditional fertilizer application methods to assess the potential of fertigation to overcome inadequate nutrition. Emphasis will be placed on the use of soil solution monitoring to assess changes in soil NPK status. Tree response will be illustrated by studies in high-density orchards where N, P, K, Ca, B, or Zn have been fertigated.

737

Fate of Labeled Nitrogen, Zinc, and Boron in Fruit Orchard Systems

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Nitrogen, boron, and zinc are the major deficiencies encountered in Oregon tree fruit production. Much of our current management strategies are based on

studies evaluating the uptake and plant mobility of labeled N, Zn, and B. Because mature trees differ from young plants, most of our experiments are conducted on fully bearing trees. Nitrogen strategies emphasize applying minimal amounts to avoid excess vigor and poor fruit quality. Our goal is to produce moderately vigorous trees with low fruit N, while still maintaining adequate tree reserves for early spring growth. Labeled ^{15}N studies suggest that the later N is applied, the less is partitioned into leaves and fruit, with more N incorporated into storage tissues. Postharvest foliar applications of urea can also produce high bud N levels in combination with moderate vigor and low fruit N. Partitioning differences from various timings also result in different utilization efficiencies, especially if one considers N losses from pruning. Early N applications may have smaller efficiencies because pruning losses are greater. Although plant B is thought to be immobile, foliar-applied B is rapidly mobilized out of the leaf. Postharvest foliar B applications are an excellent way to ensure that buds have adequate B levels the following spring. Unlike N and B, Zn is not mobilized out of the leaf where it is applied. Sprays directly to young tissues in the spring are the only practical ways of increasing Zn levels.

738

Nutrient Demand-driven Macronutrient Uptake in Fruit Crop

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Our understanding of the quantities and seasonal patterns of nutrient uptake by mature fruit trees has been limited by the difficulties in working with the large woody biomass of these organisms, tree-to-tree variability, and the resolution to distinguish between recently acquired nutrient from the nutrient background of the tree. We have coupled the use of stable isotopes of nitrogen (N) with periodic whole-tree excavations and nutrient analyses during the year. Vegetative growth, reproductive growth, and nutrient storage in perennial tree parts during tree quiescence represent nutrient sinks. Data obtained using mature pistachio, prune, and walnut trees indicate that macronutrient accumulation in metabolic sinks is associated with increases in tree macronutrient uptake. These data are consistent with the concept that sink removal of phloem-mobile nutrients from vascular circulation may provide the stimulus to further uptake of the nutrient(s) sequestered. We propose that the recognition of those patterns can be used to increase the efficiency of tree nutrient recovery and utilization.

144 Workshop 20 (Abstr. 739–742) Horticulture: Its Role and Impact on Youth

739

Introduction and Overview of Opportunities in Interdisciplinary Research in Children's Gardening

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Studies in human issues in horticulture have focused on how gardens affect the self-development typically in non-traditional or special populations. As the science of people-plant research expands, many populations are being investigated, including youth. As we study the effects of horticulture on self-development of youth, it is important to cross the boundaries between technical horticulture and disciplines such as psychology and education. Tools that have been used traditionally in these other disciplines have been adapted to study the effects of gardening on children. Two major areas of research will be reviewed, including: 1) The effects of gardening and school ground landscaping on the self-development, environmental attitudes and horticulture knowledge of mainstream school children, and 2) The evaluation of horticulture programs established for at-risk youth and juvenile offenders.

740

Conducting Horticultural Research with Youth: Research Issues and Methodology

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Conducting research with human subjects involves many of the same issues involved with conducting any type of research. As horticulturists, we are aware

of the range of variability that can be introduced when working with living organisms. This variability can come from environmental influences as well as genetic variation. These can be major factors when conducting research with people as well. Research with people also introduces complicating interactions between the researchers and the subjects. When working with humans as subjects, federal regulations must be considered; these regulations are even stricter when the research involves youth. These additional factors, which should be considered when designing studies to understand the impacts of plants and plant programs on youth, will be discussed.

741

Researching the Benefits of Children's Gardening using Computer Technology

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The kinderGARDEN website (<http://aggie-horticulture.tamu.edu/KINDER/index.html>) was developed as part of the Aggie Horticulture network. Its focus was to help incorporate fun garden activities into the home and school lives of children. The page has grown to include pages on school gardens, community gardens, botanical gardens, and a fun page for kids. The site focuses toward providing information on activities and curricula developed for children. A survey, designed to investigate the perceptions of parents and teachers working with youth in gardening situations on the benefits of children gardening, is included on the site. Adults who work with children in any type of gardening situation can respond to the survey via e-mail. Questions on the survey relay information about the type of gardening situation in which the children participate, how many children are involved, the types of crops grown, the relationship of the adult to the child, and what kinds of benefits the adults observe in the children. Results and conclusions of the survey instrument will be presented. The positive aspects and drawbacks of this research technique will be discussed.

742

Funding Opportunities for Children's Gardening Research

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The benefits of horticulture to our society have long been known. Just recently, we are beginning to see the valuable role that horticulture can have on impacting youth. However, research into this area has been limited. As this avenue of horticulture is growing, so is the need to continue and establish substantial research into this area. One important obstacle to overcome is funding. While a desire to pursue the effects of horticulture on youth exists, too often a lack of financial support has limited the depth and scope of research. Finding and establishing funding allows the researcher to explore and allocate the resources necessary to continue reputable research. This workshop will explore various funding opportunities for research in the area of children and gardening. Areas of discussion will include sources for funding as well as generating a proposed idea, refining your idea, documenting the need, and establishing uniqueness of your study. This talk will focus on finding and establishing funding for children's gardening research—a much needed necessity to help document and establish the benefits and importance of youth gardening programs.

145 Workshop 21 (Abstr. 743–749) Metabolism, Action, and Use of BAS-125 in Apples

743

The Effect of BAS-125W on Apple Tree Growth, Fruit Quality, and Fireblight Suppression

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In 1995, BAS-125W applied at 125 to 500 mg/liter 23 days after full bloom (AFB) to 'Starkrimson Delicious'/MM 106 and MM111 reduced average shoot weight and length of the longest shoots in the top and scaffold limbs by 50%

at the highest rate. The number of nodes on the lower 40 cm of each shoot was increased by 1.8 times by the growth retardant. The number of pruning cuts, pruning time, and pruning weight per tree was reduced by 30%, 20%, and 29%. Fruit diameter, color, soluble solids, starch, fruit weight, and fruit number per tree were not altered by BAS-125 W. Growth suppression appeared to be greater on trees with heavier crop loads. In 1996, BAS-125W applied at 250 mg/liter 8 days after full bloom was more effective than when applied 19 days AFB to 'Starkrimson Delicious'/MM 106 and MM111. Multiple applications of two, three, and four sprays to the same trees at 3-week intervals further reduced shoot growth with each application. Four applications reduced shoot weight by 72%, shoot length by 60%, and basal shoot diameter by 25%, and the number of pruning cuts, pruning time, and pruning weight per tree was reduced by 75%, 55%, and 80%, respectively. Thinning activity of NAA, Sevin, or Accel was not affected by tank mixed sprays with BAS-125W when applied to Gala/M.27 trees 20 days AFB. Tank mixing BAS-125W with combinations of Vydate + Accel or Carbaryl + Accel + Oil did not alter fruit thinning of Fuji/M.27 (at 10 mm fruit diameter). In one experiment, BAS-125 may have potentiated thinning by ethephon and NAA 10 days AFB in another experiment. BAS-125 W sprays at petal fall + 1 and 2 weeks later significantly suppressed % infection by fireblight, *Erwinia amylovora*, in inoculated shoots. In addition, BAS-125W reduced canker length in the first-year growth in shoots inoculated 2 weeks after treatment.

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BAS-125, A Promising Vegetative Growth Control Chemical for Bearing Apples

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Handgun applications on bearing spur 'Red Delicious' evaluated both timing and concentration. At season's end, single 250-ppm applications at petal fall (PF), PF+7, +14 or +21 days reduced growth by 47% to 67%. Concentration of 125, 250, and 375 ppm @ PF+7 were all effective (45% to 55% reduction). Number of pruning cuts, pruning weight, and pruning time were all reduced. Applications at PF+0, +7 and +14 days increased fruit set, and, as a result, fruit weight trended lower. Airblast applications to 'Top Red Delicious' applied at PF+3 weeks using 125, 250, and 500 ppm showed good initial growth suppression, but considerable regrowth in August and September. Yet, pruning weight and tree row volume were reduced with no fruit set or quality differences. Multiple, low-rate applications starting at PF on 'Granny Smith' were very effective (60-70% reduction). Total application concentrations of 250 ppm were more effective than 500 ppm. The earlier the application sequence was started, the better the growth suppression. Two years of successive 200-ppm applications to the same trees in five separate plots involving three varieties showed an average 32% reduction in year 1 and a 56% reduction in year 2.

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Controlling Floral Initiation and Vegetative Growth of Apple with Prohexadione Calcium (BAS-125W), an Experimental GA-biosynthesis Inhibitor

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Early fruit production and control of tree size are important factors in the economic viability of high-density apple orchards. A horticultural tool permitting growers to induce terminal budset should provide greater control over the balance between vegetative growth and reproduction, increasing orchard production and profitability. With this goal, the experimental GA-biosynthesis inhibitor, BAS-125W, is being evaluated for effects on enhancing floral initiation and controlling tree size in young orchards. In nursery stock, the effect of inducing earlier terminal budset is also being studied for influence on storage carbohydrates and performance after planting. Studies in 1996 showed that 250 ppm BAS-125W induced terminal bud set on actively growing second-leaf 'Macoun', 'Delicious', and 'Fuji' trees. Seven application dates from 17 June to 9 Sept. were compared to determine how time of treatment would effect degree and distribution of flowering the following year. Terminal budset typically occurred 2 weeks after application, with shoot growth resuming in 4 to 5 weeks. At two dates, treatment of growing tips only was compared with entire tree application to distinguish the direct effect of GA-inhibition on floral initiation from the effect of redistributing photosynthate. Treatment from 17 June to 29 July significantly reduced total annual shoot growth compared to the

untreated controls, while later treatments had no significant effect on shoot length. Treatments of nursery stock with BAS-125W on 1 Sept. accelerated terminal bud set by at least 7 days compared to untreated controls of both 'Fuji' and 'Golden Delicious'. Effects of treatments on flowering and tree growth in 1997 will be discussed.

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Mode of Action, Metabolism, and Uptake of BAS-125W, Prohexadione Calcium

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Prohexadione calcium, or BAS-125W, is a plant growth regulator being developed for registration in the United States by the BASF Corporation and Kumiai Chemical Industry Co. Ltd. Prohexadione calcium inhibits the biosynthesis of gibberellin by blocking dioxigenases, which require 2-oxoglutarate as a co-substrate. The result is a decrease in cell elongation and reduced vegetative growth. Gibberellin levels are reduced in the plant for 3 to 4 weeks following application of this growth regulator. Prohexadione calcium does not persist in the plant or directly effect vegetative growth the following season. Prohexadione calcium is absorbed by the plant foliage and uptake is generally complete within 8 hr following application. Results indicate that translocation within the plant is predominantly by acropetal movement, while basipetal movement is limited. Preliminary research has shown prohexadione calcium to have a short half-life in the environment; to have no negative effects on non-target organisms; and to offer little risk to users or consumers. Rates of 125 ppm a.i. to 250 ppm a.i. have typically provided effective vegetative control of vigorous apple trees. Generally, as the vegetative vigor of a tree increases; the rate of prohexadione calcium needed for effective vegetative control has to be raised. Vegetative vigor is influenced by numerous factors including: fruit load, location, variety, rootstock, age, pruning, and training system. Earlier applications at 2 to 5 inches of new shoot growth have provided more-effective control of vegetative growth than later applications. Due to its short-term effect and lack of persistence, prohexadione calcium can be a flexible tool in developing user specific growth management strategies.

747

The Use of BAS-125 for Apple Production in the Mid-Atlantic Region

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The Mid-Atlantic region consists of the states of Pennsylvania, Maryland, West Virginia, Virginia, and New Jersey, and produces about as many apples as New York or Michigan. The climate in this region in the summer often has warm days and relatively warm nights. Light intensity can often be reduced by clouds from tropical air masses, and this is usually accompanied with high relative humidity. Most orchards are not irrigated, and rainfall can vary widely. The predominant cultivars are 'Delicious', 'Golden Delicious', 'Rome', and 'York Imperial'. With these cultivars and this set of climatic conditions, excessive vegetative growth and fluctuating return bloom are common problems. This climate and apple variety assortment are markedly different from more northerly apple production regions in the U.S. The need for an effective growth-control chemical has been obvious for years. The development of BAS-125 appears to have made this a possibility and has caused much interest among pomologists and growers that are aware of this chemical. Research was conducted from 1994 to 1995 on 'York Imperial',

'Delicious', and 'Spartan', and was reported in HortScience (31:191). Research in 1996 dealt with 'Law Rome' and 'Golden Delicious'. On 'Law Rome', treated shoots were \approx 24 cm in length, while untreated shoots were 38 cm in length. On 'Golden Delicious' this compound controlled shoots to \approx 29 cm in length, while untreated shoots had about 39 cm of total shoot growth. BAS-125 can effectively reduce shoot growth, which will improve the light regime in mid-Atlantic apple tree canopies. This should result in savings in pruning, increased fruit quality, and increased cropping levels due to enhanced fruit bud production.

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Thinning and Growth Control of Apples Treated with BAS-125 10W

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BAS-125 10W is a new plant growth retardant that was evaluated on 'McIntosh' apples to control excessive vegetative growth. When applied at concentrations between 0 and 375 ppm, it significantly reduced terminal growth. As a result, light penetration into the tree was increased and fruit at harvest had more red color, and more were graded into the US Extra Fancy category. BAS-125 increased fruit set; thus, fruit were smaller, but firmer, at harvest. Treated fruit were firmer and had less decay following 20 weeks of regular air storage. Several different thinning strategies were employed to thin BAS-125-treated 'Delicious' trees. In one experiment, the best thinning treatment was a combination spray containing 10 ppm NAA plus carbaryl at petal fall followed by 8 ppm NAA when fruit size averaged 10 mm. The best treatment in another experiment was a Wilthin application at 80% bloom followed by 8 ppm NAA plus carbaryl at petal fall. Recommendations for the successful use of BAS-125 10W in the Northeast will be discussed.

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Registration of Prohexadione Calcium (BAS-125W) for Use on Apples

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A U.S. Environmental Protection Agency (EPA) voluntary program encourages the registration of pesticides that represent reduced risk to human health and the environment. A "reduced risk" designation for a pesticide depends on how its use will affect human health and the environment, pesticide resistance, and pesticide management. Prohexadione-Ca is a bioregulator being developed by BASF Corporation to control vegetative growth in apples with the effect of improving fruit production. BASF will petition the EPA to register prohexadione-Ca as a reduced risk pesticide in 1997 based on the following properties associated with its use: Prohexadione-Ca exhibits a very low mammalian toxicity and a low propensity for crop residues. Prohexadione-Ca rapidly dissipates in soil as a result of microbial metabolism and causes no detrimental ecological effects. There is no other hazard associated with the compound and no health risk for user or consumer is indicated. The use of prohexadione-Ca reduces the incidence of fireblight (and helps control this disease). The use of prohexadione-Ca reduces tree row spray volumes of other pesticides up to 25%. With these beneficial characteristics, prohexadione-Ca will fit exceptionally well into an Integrated Pest Management (IPM) program, providing another "reduced risk" justification for the registration of prohexadione-Ca. The current situation of accepting prohexadione-Ca as a reduced risk pesticide and its registration status will be discussed.