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
Teryl R. Roper* and Armand R. Krueger, Dept. of Horticulture, University of Wisconsin–Madison, Madison, WI 53706
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
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 was 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 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.

Root Distribution of ‘Gulfcoast’ Southern Highbush Blueberry

James T. English; Apartado Postal No. 125, Caborca, Son.

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.

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 10^6 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 10^6 colony forming units/g dry wt, floral injury occurred at a warmer temperature than to flowers that had lower bacterial densities.

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 a pan type A. The crop coefficients (Kc) 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.
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 broadleafes, number of annual grasses, or total number of weeds emerging. Landscapers emerged in greater numbers after daytime or night cultivation using green tractor lights (48/m²) than after 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 perennial's and evaluated on the basis of weed control, phytotoxicity, and effect on plant growth. The herbicides and rates were: Naptropane (Devrinol 10G), 0.72 and 1.44 kg a.i./ha; Oxadiazon (Ronstar 2G), 0.06 and 0.42 kg a.i./ha; Oxadiazon + Oryzalin (Rout 3G), 0.54 and 2.16 kg a.i./ha; Oxyfluorfen + Pendimethalin (Scott's OH II), 0.54 kg a.i./ha; Oxyfluorfen + Oryzalin (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; Oxylufen + Oryzalin (Rout 3G), 0.54 and 2.16 kg a.i./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, Diastus gratianopolitanus, Gaillardia x 'Baby Cole', Pennstemon x 'Husker's Red', and Phlox subulata 'Emerald Blue'. Phytotoxicity symptoms (visual defects and less height) were apparent with Oryzalin on Pennstemon (at both rates) and on Phlox (0.72 kg a.i./ha). Weed control was significantly less with Trifluralin and Naptropane 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 Prodimine 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. Prodimine was evaluated for postemergence control of chamberbitter and phytotoxicity to containerized ornamentals. On 20 June 1995, prodimine at 0, 1.88, 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. Prodimine 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
Concentration-dependent degrees of chlorosis and necrosis. Plants were more fresh mass production and chlorophyll fluorescence. A completely randomized treatments, and their potential to produce much vegetative growth. Species included: Plant species were chosen based on their aesthetics, tolerance to wetland conditions, and their potential to produce much vegetative growth. Derived Herbicides Control of Canary Grass and Nutsedge Weeds with Microbially Atrazine, Simazine, and Metalaxyl Residues in Water formulation. This project was done under a low rainfall year, 1995, and it should be reassessed with the new Velpar DF formulation and irrigation. Tolerance of Selected Ornamentals for Phytoremediation of Atrazine, Simazine, and Metalaxyl Residues in Water C. Wilson, T. Whitel, and S. Klain; Dept. of Environmental Toxicology, Clemson Univ., P.O. Box 709, One TIWET Drive, Pendleton, SC 29670; Dept. of Horticulture, Clemson Univ., Clemson, SC 29634 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 tolerateances 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 μmol/m²·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 μg/l range. Effects 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 μg/ml. Future research will quantify the uptake and mineralization potential for these plants and pesticides. Control of Canary Grass and Nutsedge Weeds with Microbially Derived Herbicides S. Gurusiddaiah and M. Ahmedullah; Bioanalytical Center and Dept. of Horticulture and Landscape Architecture, Washington State Univ., Pullman, WA 99164-6414 For the control of Reeds Canary grass (Phalaris arundinacea) and yellow nusedge (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 nusedge. In greenhouse studies using "conetainers," 2 mg of extract per g of soil applied as pre-emergence completely inhibited seed germination and aerial growth of Canary grass, but had no effect on nusedge. 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 nusedge. However, 4-fold increase in concentration of P. S. 3366 extract completely inhibited the sprouting of yellow nusedge 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 nusedge. Suppression of Liverwort Growth in Containers by Cinnamic Aldehyde Sven E. Svoren; Dept. of Horticulture, North Willamette Research and Extension Center, Oregon State Univ., 12510 NE Miley Road, Aurora, OR 97002-9543 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 uninested 4-inch diameter containers, and to containers infested with Marchantia polymorpha. Application to uninested 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. Studies on the Allelopathic Effect of Corn Spurry (Spergula arvensis L.) on Cole Crops and English Pea H.F. Harrison*, J. K. Peterson, and M. Snook; USDA, ARS, Charleston, SC 29414; USDA, ARS, Athens, Ga. 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, brocoli (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 extraction completely inhibited the sprouting of yellow nutsedge in greenhouse studies using "conetainers," 2 mg of extract per g of soil applied as pre-emergence. 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 octanoic or dodecanic acid along with butanolic and pentanoic 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. Tomato Production using Spring-sown Cover Crops’ Mulch for Weed Control Akemo Mary Christine, Mark Bennett, and Emily Regnier, Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210 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 (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 1995 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. Management Alternatives for Purple and Yellow Nutsedge (Cyperus rotundus and C. esculentus) Milton Ed McGiffen, Jr., David W. Cudney, Edmond J. Oguchiekwe, Aziz Baameur, and Robert L. Kallenbach; Univ. of California Cooperative Extension, Riverside, CA 92521-0124; Univ. of California Cooperative Extension, Moreno Valley, Calif.; Univ. of California Cooperative Extension, Blythe, Calif. Yellow and purple nutsedge are problem perennial s 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

Bielinski M. Santos*, Joan A. Dusky, William M. Stall, Donn G. Shilling, and Thomas A. Bewick; Univ. of Florida, Gainesville, FL 32611

The effects of different populations 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

Bielinski M. Santos*, Joan A. Dusky, William M. Stall, Donn G. Shilling, and Thomas A. Bewick; Univ. of Florida, Gainesville, FL 32611

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 banded. 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)


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 of 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 entire 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 reductions were 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)

J.P. Morales-Payan* and W.M. Stall; Horticultural Sciences Dept., Univ. of Florida, Gainesville, FL 32611

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 losses 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 Ombligua' 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 on 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.
026 Developing a Cyberserve Course

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Through a CyberServe Grant, a WWW Home Page and student/community listserve 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, Hercule Poirot.
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 horti-
cultural 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 fol-
lowing 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 gibberelllic
acid (GA3) and solidified as 45° slants with 1.25 g/liter Phytagel and 3.0 g/liter
1962) supplemented with 30 g/liter sucrose, 80 mg/liter adenine sulfate, 1.0 mg/

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 (TIA, 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 TIA 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. ‘Río Red’
grapefruit were harvested four times in 1995 and nine times in 1996 and
challenge-inoculated with 10 L of a 1 x 10^6 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 treat-
ment 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

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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 'Chocow' 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 ~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 \( \alpha \)-pinene, eugenol, limonene, p-cymene, \( \alpha \)-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

Paul Wiley, Carlos H. Crisosto, R. Scott Johnson*, and Harry Andris; Dept. of Pomology, Univ. of California, Davis, CA 95616

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 beet shell, 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 (M) 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, mealdness, 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 importance 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 packhouse 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 packhouses 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, \( \beta \)-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, \( \beta \)-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 5-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) are grown in fields historically planted to peanuts (Arachis hypogaea). Nine nematode treatments were evaluated over 3 years in field experiments on paprika pepper. Materials tested included the chitin nematicide ClandoSan and six chemicals: fosetyl aluminum, carbaryl, aldicarb, oxamyl, fenamiphos, and dichlofipromethane. Plants were harvested at 2 and 3 years. Other shoot/leaf effects (plant dry mass and yield) were minimal for all nine nematode treatments. No one nematode 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 at 2 or 3 years. Nematode 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, Spissistilus 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. Florunner. 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; plants subjected to high rates of herbivory contained 30% less foliar protein that 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 Agri 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 5 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 detering 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 a new alternative to whitefly control. Thus, this study was conducted to determine the effect of Imidacloprid under different application 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, 29, 39, and 73 days after planting, 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.
Effects of Ovipositional Preference on Distribution of the Xylaphagous 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*.

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**053** Effect of Hydrogen Cyanamide on Bloom Date, Quality, and Yield of ‘Kerman’ Pistachios on Three Different Rootstocks

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Hydrogen cyanamide (H₂CN₂) has been shown to effectively substitute for lack of chill in a number of species. A 2% H₂CN₂ 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 Atlantis rootstocks were unaffected by the H₂CN₂ application. Trees on the other two rootstocks produced significantly higher yields after treatment with H₂CN₂. The primary effect of the H₂CN₂ appears to have been to significantly decrease the percentage of blank (empty) nuts.

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

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The persistence of effects of paclobutrazol or uniconazol 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 uniconazol. 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 uniconazol, 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.

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**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, Cycooil, 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 Cycooil significantly affected growth and development without any effect on head formation and color development. Bonzi caused the greatest growth suppression.
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’.

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.

Effect of Nitrogen, Gibberellic Acid, Triadimefon, and Kinetin on the Seedling Growth of Sapodilla (Achras sapota) and Tamarind (Tamarindus indica)
J.P. Morales-Payart and B.M. Santos; Dominican Hort-Research Group, Santo Domingo, Dominican Republic

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 factorial 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 gibberellic acid and triadimefon could be effectively used as a means to stimulate or retard, respectively, the growth of sapodilla and tamarind.

Influence of Polycysteine and Nitrogen on Lettuce (Lactuca sativa) Yield
J.P. Morales-Payart and B.M. Santos*; Dominican Hort-Research Group, Santo Domingo, Dominican Republic

Greenhouse experiments were conducted in the Dominican Republic to determine the effect of methanol and nitrogen (N) and the biostimulant polycysteine 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 polycysteine. 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. The results show that there were no significant effects of ethanol or methanol on lettuce yield. The highest yields were obtained with combinations of 300–400 ppm of polycysteine and 140–210 kg N.}

Influence of Methanol, Ethanol, and Nitrogen on the Yield of Lettuce (Lactuca sativa)
J.P. Morales-Payart*; Dominican Hort-Research Group, Santo Domingo, Dominican Republic

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.

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 7 ± 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 cause 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.

Abstract Withdrawn

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
Marc van Iersel*; Dept. of Horticulture, Georgia Station, Univ. of Georgia, Griffin, GA 30223-1797

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 (Catharanthus roseus) seeds were germinated in a peat-life 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
Jack A. Hartwigsen* and Michael R. Evans; Dept. of Horticulture, Iowa State Univ., Ames, IA 50011

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, 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 µmol·m⁻²·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
Shravan K. Dasoju* and Brian E. Whicker; Horticulture Hall, Iowa State Univ., Ames, IA 50011

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 ≈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 ≈16% at 2 and 4 mg a.i./pot of paclobutrazol, when compared to the untreated control. Flower diameter decreased by ≈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
Brian E. Whicker and Shravan Dasoju*, Horticulture Hall, Iowa State Univ., Ames, IA 50011

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, Honoeyle, 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 period. Pelargonidin 3-glucoside, the major strawberry anthocyanin, was highest in ‘Honoeyle’, while cyanidin 3-glucoside content was similar among the three cultivars.

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

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. xananaasa*. Although Asian wild diploid strawberries such as *F. nilgerrensis* or *F. tinmnae* 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. tinmnae* to *F. xananaasa* cv. ‘Toyonoka’ were all sterile pentaploids. 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 petals 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.

070

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. tinmnae* produces runners that frequently have unequal tap roots. *F. moschata* demonstrated excellent winter hardness in a water-logged field during an unusually long cold winter (1985-96) 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. rubicola* 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 easy to synthetic tetraploids, has a flavor similar to *F. viridis* and *F. rubicola*, but is extremely susceptible to viruses. Aroma is quite variable in *F. vesca* with the most desirable originating from Russian accessions.

071

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 has 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 42º 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 Corysis, 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 fruit *Rubus crataegoides*, many populations of *Vaccinium uliginosum* and *V. idaeus* 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. delicosa* (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 delicosa* was hexaploid. One *chinensis* accession was tetraploid. Two accessions (NGPR 0021.14 and 0021.3), acquired as *chinensis*, were hexaploid and, in fact, be *A. delicosa* 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 alkal from L-tartarate, 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 between isolates. 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.
Holdings surveyed, unequivocally differentiated all but 10 pairs of genotypes in the collection, with the Genetic Resources Unit's core subset collection was screened with five simple

A diverse collection of 133 NY 14456-0462 R. McFerson

Simple Sequence Repeat (SSR) Variation in a Collection of Malus sieversii

The purpose of this study was to adapt an ELISA test for diagnosing of "Apple Chlorotic Leaf Spot Virus" (CSLV) 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 021, which intro-

Adaptation of ELISA Test for the Diagnostication of Apple

During 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 represent 10 diverse ecosystems in Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan have been inoculated with conidia of five races and two wild types of V. inaequalis. Suspicions (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 wrinkling (V, type reaction); B = stellate necrotic lesions (V, 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. 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.

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

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.

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

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 techni-

Cryopreservation of Embryonic 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 on silica gel before freezing in liquid nitrogen had 80% 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.

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

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 9.0–9.5. 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.

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

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4 months after planting the seed, 42% of the hybrids were obtained and transplanted to 4-gallon pots in a screenhouse. At 33 F1 hybrids as pollen and seed parents. Several F1 hybrids were confirmed to be quantities of viable pollen. Numerous crosses were completed using some of these M. warburgiana of 94

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 F1 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 94 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 F1 hybrids as pollen and seed parents. Several F1 hybrids were confirmed to be highly fertile by recovery of healthy F2, 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 Fenny Danes and Hongwen Huang; Dept. of Horticulture, Auburn Univ., Auburn, AL 36849; Wuhan Inst. of Botany, Chinese Academy of Sciences, Wuhan, Hubei, P.R. China.

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 R. Tao1; T. Ohkuma2; M. Tamura2; and A. Sugiyama1; 1Faculty of Agriculture, Kyoto Univ., Kyoto 606-01, Japan; 2Faculty of Biology Oriented Science and Technology, Kinki Univ., Wakayama 649-64, Japan.

Distribution of pollen diameter of Japanese persimmon cv. Zanjurnar (2n = 6x; μ = 15) was determined using pollen grains hydrated with CPW solution supplemented with 0.9 M mannitol. Mean diameter of giant pollen grains (65 μm) was 1.3 times longer than that of normal pollen grains (50 μm). 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 μm). 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 Luz Marina Reyes; Orlando Martinez; and Margarita Beltran; 1Agronomy Faculty, National Univ. of Colombia, A.A.14490; 2CORPOICA/U. de los Andes, A.A. 240142, Bogota, Colombia, S.A.

Fifteen clones of banana and plantain of different ploidy levels, belonging to the Colombian Collection of Musaceas (CCM), maintained 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), phosphoglucomisomerase (PGI), phosphoglucomutase (PGM), ribulose bisphosphate carboxilase (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 acai. The total number of 24 loci was identified that encoded at least 50 alleles. The enzymes with greater genetic variability were DIA and EST, 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, PGI, PGM, and SKDH.

084 Nature of Resistance of Pecan Cultivars to Black Pecan Aphids Bruce W. Wood* and Charles C. Reilly; USDA-ARS Southeastern Fruit and Tree Nut Research Laboratory, 111 New Dunbar Road, Byron, GA 31008.

Foliar feeding by the black pecan aphid [Melanocallis carayaefolias (Davis)] can cause tremendous economic losses. Evaluations of black aphids on pecan genotypes indicates that both antixenosis and antibiosis-like resistance mechanisms exist. 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% fast as ‘Chocaw’ and ‘Alley’ as on ‘Desirable’ and ‘Success’. No cultivar was observed to essentially prevent aphid reproduction.


085 Influence of Ontological Age on Adventitious Bud and Shoot Formation of Pawpaw [Asimina triloba (L.) Dunal] Nodal Explants C.L.H. Finesseth1; Desmond R. Layne2; and R.L. Greene2; 1Dept. of Horticulture and Landscape Architecture, Univ. of Kentucky, Lexington, KY 40546-0031; 2Land-Grant Program, 129 Atwood Research Facility, Kentucky State Univ., Frankfort, KY 40601-2355

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. Disinfection protocols were developed for each explant source. Nodal explants were cultured on MS medium supplemented with 10 μM BA and 0.1 μM 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, axillary shoots had elongated and were suitable for subculture. By 8 weeks, multiple adventitious buds and shoots had formed on all nodal 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 −7 months, axillary bud elongation 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 kaki cv. Jiro (2n = 6x = 90) and 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 KM3p 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 calli isolated from green shoots was discused.

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

Qingzhong Liu, Sarbagh Salih, and Freddi Hammerschlag; Fruit Laboratory, Agricultural Research Service, United States Dept. of Agriculture, Beltsville, MD 20705-2350

Factors influencing regeneration and β-glucuronidase expression from apple (Malus 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 (pSGUS_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 regenerant 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 mg L⁻¹), BAP (5.0 mg L⁻¹), MS vitamins, myo-inositol (100 mg L⁻¹), sucrose (30 g L⁻¹), and agar (6.0 g 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 ± 2°C and 2000 lux. NAA-treated explants performed better than picloram on callus growth. Cellus 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.

Unique Plant Material for Studying Woody-plant Nitrogen Metabolism

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Temperate woody perennial plants 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 A-BSP and WT, respectively). Partitioning in 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, 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

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 flower loads. Average fruit fresh and dry weights increased and the fruit development period decreased with increasing 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 Agrarias, Universidad Nacional del Comahue, c.c. 85, 8303 R. N., Argentina. The growth of fruits was described by a mathematical model that considers the effect of temperature and photon flux density on the growth rate. The model was developed using the SYSTAT software. The results showed that the model was able to predict the growth rate of fruits with an accuracy of 95%. The model was able to predict the growth rate of fruits with an accuracy of 95%. The model was able to predict the growth rate of fruits with an accuracy of 95%.

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 development, 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 (DA). 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 (2–21–23 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 to two 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.

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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 colored by mycorrhizal fungi, leaf P concentration, and plant growth were determined. Root length colored 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 Isoate 51C had higher leaf P concentration than non-mycorrhizal plants. Plants colonized by Glomus AZ2112 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 Isoate 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.

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. Cladastis kentukea (Dum.-Cours.) Rudd (American yellowwood) did not form nodules during inoculation studies in 1939 and 1992. That tree was 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. Transected trees of each species were under more water stress (indicated by more negative pre-dawn water potential) than non-transected trees. However, pre-dawn water potential of transected A. platanioides recovered to near non-transected levels, while transected T. cordata did not. Dawn-to-dusk studies in 1995 and 1996 showed that stomatal conductance was lower throughout the day in transected trees. Once again, transected A. platanioides recovered to near non-transected levels, while transected T. cordata did not. A similar trend for mid-day photosynthesis was found for both species in 1995 and 1996. Transected trees of each species had less stem area increase, shoot elongation, and total leaf area than non-transected trees for each year. These data indicate that transplant A. platanioides can recover to near non-transplant pre-dawn water potential and gas exchange levels earlier, and therefore establish faster, than transplant T. cordata. However, after 2 years, neither transplant tree species were able to fully recover to non-transplant growth rates.

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 more 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.
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 µg g⁻¹ and 115 µg g⁻¹ Fe, and 217 µg g⁻¹ and 176 µg 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

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 mg/ml) in a nutrient solution were applied to grafted seedlings (scion: ‘Momotaru’, resistant rootstock; ‘Hawaii 7998’ grown in a phytother. One week after the Ca treatment, seedlings were inoculated with a 10⁶ cfu/ml suspension of Raistonia 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 re inoculated 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 (>10⁶ 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 latent 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 preplant 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 kg ha⁻¹ P₂O₅; K rates were 0, 168 and 336 kg ha⁻¹ of K₂O. 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 kg 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 soil test 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 (Pomabio type) was planted in the fall of 1995 on a Kendall sandy loam (5% organic matter) and a Spartan loamy sand (15% 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, this sandy loam soil had 2 to 6 times higher biomass C than the loamy sand soil and reflected the higher organic matter content of the sandy loam.
Organic matter (OM) was increased in the profile in treatment T1 with respect to much more than in the bottom layers. Ions were decreased in all soil profile. (BA), the largest decrease was found in T3. pH decreased in the top soil layer the treatments, EC was decreased with respect to T0 and soil before application industry waste application in both saline and non-saline soils was similar. In all our research are significant. They point to the need for new assessments of curvature irrigation uniformity, total yields, or quality, the findings of this initial stage of spacings evaluated in this initial experiment did not result in major differences irrigation uniformities were similar among the treatments. Although the three lateral distribution uniformities (DU) were found to be 80.6%, 78.1%, and 86% for the crop water use, plant growth, and nitrate leaching were made. Mean sprinkler in a 60-acre commercial carrot field in Western Kern County in California's San distribution and improves water and N fertilizer use efficiencies. Three different 35 feet in solid-set sprinkler systems increases the uniformity of irrigation water 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.

Use of Citric Industry Waste on Saline Soil

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 citrus 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, (TO), using just irrigation water (EC = 2.5 dS·m⁻¹). The same treatments were added to non-saline soil. Effect of citrus 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.

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.

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.

Effects of Flood Irrigation Frequencies on Yield and Quality of ‘Lisbon’ Lemons in Southwestern Arizona
Mark Wilcox*; UA Cooperative Extension, 198 S. Main St., 3rd Floor, Yuma, AZ 85364

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 (23% 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.

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).

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

115 The Effect of Substrate pH on the Rooting of Rhododendron with Subirrigation
Thomas Holt, Brian K. Maynard, and William A. Johnson; Dept. of Plant Sciences, Univ. of Rhode Island, Kingston, RI 02881
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 dilution), and rooted in subirrigated perlite substituted 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 rooting 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.

116 Understanding the Role of Cytokinins in Tissue Proliferation of Rhododendron 'Montego'
Eric W. Mercure*, Carol A. Auer, and Mark H. Brand; Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269
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 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 trifluoromethyladenine (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.

117 Effects of Vesicular–Arbuscular Mycorrhizal Fungi on Rooting and Growth of Two Woody Ornamentals
Martin Trappier* and Jacques-André Rous; Horticultural Research Center, Environotron Building, Laval Univ., Québec, Qué., Canada, G1K 7P4
A commercial inoculum of Glomus intraradices Schenck 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 of Glomus intraradices. The cuttings' 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 mycorrhizalized 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 mycorrhizized 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%.

118 IBA and Environment Affect Rooting of Cotoneaster Cuttings
Houchang Khattamian*, and G.A. van der Heevel; Dept. of Horticulture, Forestry and Recreation Resources, Kansas State Univ., Manhattan, KS 66506-4002
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.

119 Rooting of Maple Cuttings as Influenced by IBA Treatment
Houchang Khattamian* and John C. Par; Dept. of Horticulture, Forestry and Recreation Resources, Kansas State Univ., Manhattan, KS 66506-4002
Softwood cuttings of Acer saccharum 'Commemoration', a slow 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.

120 Cold Stratification Improves Germination of Katsura Tree
Michael Sean Dosmann* and Jeffery K. Iles; Dept. of Horticulture, Iowa State Univ., Ames, IA 50011-1100
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 germina-

121 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 µM m–2s–1 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

122 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 Botorion, students studied the formation of ice in various parts of fruit-bearing cranberry (Vaccinium macrocarpon Al.) uprights. The fruits were at the blush to red stages of ripening. Samples were cooled to –1°C in –1 h. 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 blushed 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 blushed 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.

123 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 Cyaneococcus). 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 LT5,0 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.

124 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.

125 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, F1, and F2 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 Tm, the temperature causing the maximum rate of injury. Tm for the parent plants (R. catawbiense & R. fortunei) and the F1, cultivar Ceylon, were estimated to be –51.6°C, –30.1°C, and –40.4°C, respectively. CH estimates among F2 progeny (Ceylon selfed) were normally distributed from –14.8°C to –41.5°C, with mean of –27.6°C. Most F2 progeny were less cold-hardy than the tender parent, R. fortunei. The apparent reduction in F2 CH may be caused by the differences in age between the parents (20-year-old mature plants) and F2 progeny (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.

126
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 Borh.) 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

127 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 regenerate from cultured grafted 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 amycinol, as many as 100 plantlets were regenerated from a single graft union. However, no chimeric regenerants were recovered, indicating that asymmetric responses to grafting may be a limiting factor to in vitro chimera formation.

128 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 (PI), and with lesser intensity in a number of breeding lines. Transfer of high levels of resistance from these breeding lines or PI'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 PI 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 PI. 272636, 2) an unadapted small-fruited resistant line developed from PI. 272636, and 3) the large-fruited breeding line 88B147, also with resistance derived from PI. 272636. Small additive effects identified in large-fruited material, in comparison to the resistant PI, 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 PI. 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.

129 Inheritance of Resistance to Fusarium oxysporum f. sp. radicis-lycopersici, Causal Organism of Fusarium Crown and Root Rot in Tomato from Lycopersicon penellii LA 1277
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Lycopersicon penellii accession LA 1277 was crossed to tomato (L. esculentum) and the F1 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 F2 seed were obtained. The three homozygous FCCR-resistant lines were also crossed to Ohio 89-1, which has a dominant gene for FCRR resistance presently being used in breeding programs. F2 seed were obtained from these crosses. These generations were inoculated with the FCCR pathogen. The resistant parents, F1s, and backcross to the resistant parents were all healthy. The backcross to the susceptible parent and the F2 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 F2 generation derived from the two resistant sources.

130 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. penellii (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 F2 segregating population using an inoculation procedure devised to clearly differentiate susceptible and resistant genotypes.
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 Tm2a [Young et al., Genetics 120:579-585 (1988)] and yielded polymorphic codominant bands. This STS was also tested on the F1 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 from LA1277 were bulked and compared to the recurrent susceptible parent.

### 131 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 F1 hybrid families (‘Addis’ × M 20, ‘Addis’ × ‘Wis SMR 18’, ‘Clinton’ × M 12, M 20 × ‘Tiny Dill’). Within each family, F1, BC A and BC B generations were also formed. Thirty plants of each genotype 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’ × ‘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’ × ‘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.

### 132 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, ‘Poindsett 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), 37 as moderately resistant (3.3 to 5.0), 31 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.

### 133 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 ‘Solera’ 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 Cucurbitas 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 of a total of about 800 were selfed for further evaluation.

### 134 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 F1 derived from a diallel cross (Griffing’s model I, 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 ≤ 0.05) year by location interaction effect was found for ear feeding damage and silk channel length. Genotype ear feeding damage and silk channel length differences were significant (P ≤ 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 classified 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 ≤ 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.

### 135 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 Phytophthora blight. In the evaluation of resistance to bacterial wilt, 12 seedlings per accession 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. 'G93/287' 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.

136 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 primer 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.

137 Screening, Identification, Improvement, and Genetics of Resistance to Bacteria Soft Rot (Erwinia caratovora) 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 prickling petals 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.

138 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 anthr-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 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.

139 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), and the fungal pathogens 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 BeNeb 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 HB83. 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 US8SNP 5-1 and DB2cv74f. However, linked markers were not identified. The V gene controlling flower and stem color was tightly linked with the Operon marker O10.620.

140 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 ash 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.

141 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 Dl1 (MesoAmerican=MA) and Dl2 (Andean=A) (Shii et al., 1980, J. Hered. 71:218–222). The different degrees of leaflet crippling (C) in segregating populations of crosses was due to the interaction between the Dl1, or Dl2 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 (Dl ) using the bulked segregation analysis procedure for F2 of MA x A crosses. Crosses were made between C lines, FB10413-24-2, WA 7807-305, and TY 5578-220 and normal (N)
parents and tester stocks for D1, and D1s genes. The F2, FB 10413-24-2 x Carioca segregated 13 N:3C. F2 families segregated 3N:1C. RAPD marker OPB-10 was linked to Lcr at 32.6 cM. F2 families segregated 1N:3C. RAPD marker OPC16 was linked to D1 at 27.0 cM. The F2 WA-7807-305 x Ro Tibagi segregated 3N:1C. RAPD marker OPQ-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

S.O. Park 1, A. Dursun, and D.P. Coyne 2

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 F2 population from a tepary bean cross Nebr#4B (resistant) x Nebr#467 (susceptible) 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 BK-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

D.P. Coyne 1, J.R. Steadman 1, D.T. Lindgren 2, David Nuland 3, J.R. Stavely 4, J. Rensen 3, and L. Sutton 2

The 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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Development of Pinkeye-type Southernpeas with Green Cotyledons

R.L. Fery 1, D.A. Stock, and A.J. McGlone 2

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 gc gene are easily identified, and this ability to select in the seed stage greatly facilitated breeding efforts. A total of 25 advanced breeding lines (F2 and F1) 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 southernpeas in the U.S.

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Affinity Grouping of Lentil Accessions through Comparative Electrophoresis of Seed Proteins

S. Echeverrigaray 1, A.C. Oliveira 2, M.T.V. Carvalho 3, and E. Derbyshire 4

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

S. Echeverrigaray 1, D.P. Cansian 2, R.M. Hannan 3, and A. Gray) is of interest to bean breeders because of resistance to CBB and purple flower color. Seven RAPD 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.

M.M. Jenderek 1, K.A. Schierenbeck 2, and R.M. Hannan 3

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. Similarities 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

M.M. Jenderek 1, K.A. Schierenbeck 2, and R.M. Hannan 3

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
Jennifer K. Hart* and David J. Hannapel; Dept. of Horticulture, Iowa State Univ., Ames, IA 50010-1100

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 tunica and corpus layers of the apical dome of the shoot apex and the stolon apex. In situ studies indicate accumulation of 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.

An Ethylene-inducible Lipoxygenase Gene from Potato Leaves
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Due to apparent participation of plant lipoxygenases (LOXs) in the biosynthetic pathways for jasmatic acid, methyl jasmonate, tramanitin, 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 accord with the heterogeneity of LOX isozyme forms. It is possible that different LOX isofoms 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 provides evidence that POTLX-3 is a lipoxgenase. 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.

Lipoxygenase POTLX-1 and POTLX-2 Genes are Expressed during Potato Tuber Initiation and Development
Mikhailo V. Kolomiets*, David J. Hannapel, and Richard J. Gladon; Dept. of Horticulture, Iowa State Univ., Ames, IA 50011-1100

Plant lipoxygenases (LOXs) (linoleate:oxxygen oxidoeductase, 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 traumanitin, 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 tuberic acid and tuberic acid glycoside have been shown to be tuber-inducing substances. In order to study possible lipoxygenase 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, 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 (NA), and cytokinin (BA) did not trigger transcriptional activation of either of these genes.

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 'Buearegad' collected from different sources all have the same RAPD profiles. Moreover, with 150 markers, the transgenic 'Coojoku' 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.

Transformation of Carrot (Daucus carota L.) with Genes Involved in Carbohydrate Metabolism and Partitioning via Hypocotyl Tissue Cultures
Mingbo Qn*, Chiwon W. Lee, Alex Y. Borovkov, and Murray E. Duyser; Dept. of Plant Sciences, North Dakota State Univ., Fargo, ND 58105

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 (UDPf) genes were isolated from potato (Solanum tuberosum L.) and cloned in an anti-sense orientation into Agrobacterium tumefaciens Bin19, which has a CmV 35S promoter. Seedling hypocotyl sections of selected carrot lines were pre-incubated on BS medium for 2 days, co-cultivated with A. tumefaciens Bin19 for additional 3 days, and then transferred to ammodified BS 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 breed- ing line (W204-C) were found to be transformed, respectively, with SS, SPS, and UDPf 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.
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 F₁ generation segregated widely with many recombinant types that neither parent showed (e.g., extreme thorniness of leaves and petals). 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'.

**154** 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 (Rand 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 F₁ 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 Rand Y of 8.95 ± 0.49 cM. The linkage distance between Rand BL was calculated at 13.49 ± 1.18 cM, and the overall linkage between Y and BL was determined to be 28.8 ± 4.2 cM. Our data suggest the RBL1 genomic region plays a critical role in the genetic control of betalain biosynthesis.

**155** 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 15 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 (Ho) 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.

**156** Evaluation of Popular Mountain Vegetables in Korea using Molecular Markers

_Hak-Tae Lim*; Division of Applied Plant Sciences, Kangwon National Univ., Chunchon, 200-701 South Korea

Five edible mountain vegetables (Saussurea sp., Aster tataricus, A. scaber, Synurus defolioides, 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 taxon 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 defolioides, 34.7%, 17 bands; Ligularia fischeri, 39.9%; 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.

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

_Hak-Tae Lim*; Division of Applied Plant Science, Kangwon National Univ., Chunchon, 200-701 South Korea

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, cauleine 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.

**158** 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 pSS QUS Intron was inoculated on the wound site. Three days later the seedlings were transferred onto MS media with antibiotics (Cefotaxime, Cefalixin, 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 AIA 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)
Cultural & Management—Woody Ornamentals/Landscape/Turf

159 Recycled Paper as a Growth Substrate in Container Production of Spiraea
Paula Craig* and Janet C. Cole, Dept. of Horticulture and Landscape Architecture, 360 Agriculture Hall, Oklahoma State Univ., Stillwater, OK 74078

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. 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 the chemical and physical properties that characterize WE as a growth substrate.

160 Tree Growth in Potting Media Made with De-inked Paper Sludge
Robert R. Trippe* and Mary W. George, Plant Science Division, Univ. of Idaho, Moscow, ID 83844-2339

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 ‘Royal’ crabapple (Malus L.) were planted in 15-L plastic pots that contained potting media amended with 0%, 20%, 40%, 60%, 80%, and 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 crabapple trees grown 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.

161 Effect of Nursery Stock Type and Size on Growth of Three Deciduous Shrub Species in Containers
Jeffery K. Iles* and Paul C. Seaberg, Dept. of Horticulture, Iowa State Univ., Ames, IA 50011-1100

Newhales, 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 (Spirea x bumalda Bv.), and ‘James MacFarlane’ lilac (Syringa xepresatnae 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.

162 Comparison of Pour-through and Ceramic Cup Methods of Extracting Nutrients from a Pine Bark Substrate
Ronald F. Walden* and Alex X. Niemiera, Dept. of Horticulture, Virginia Tech, Blacksburg, VA 24061-0327

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.

163 Water and Nitrogen Management to Reduce Nitrate-Nitrogen Leaching from Container Crops
David J. Colangelo* and Mark H. Brand, Dept. of Plant Science, Storrs, CT 06269

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 ‘Catawbiense Azure’ 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 control corresponding to each irrigation treatment (three replications each). All fertilizer 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
Brian K. Maynard and William A. Johnson; Dept. of Plant Sciences, Univ. of Rhode Island, Kingston, RI 02881

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; rewrapping 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 rewrapping 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), rewrapped 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-ball ing and root removal prior to shipping and planting B&B nursery stock.

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

165 Technology Transfer through the Use of Growers Clubs in Northwest Mexico
Raul Leonel Grijalva-Contreras, Francisco Lopez-Vilches, and Victor Salvador-Rivas; INIFAP-SOCOAADA and IFIRA, Apdo. Postal No. 125. H. Caborca, Sonora, Mexico

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”-SOCOAADA 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.

166 Vegetable Crops Research and Information Center World Wide Web Site
Wayne L. Schrader, Ronald E. Voss, Kent J. Bradford, and Carol O’Neil; Univ. of California Cooperative Extension, and Dept. of Vegetable Crops, 5555 Overland Ave., Bldg. 4, San Diego, CA 92123-1219

The Univ. of California’s Vegetable Crops Research and Information Center (VRC) has developed a new World Wide Web site that allows the rapid development and peer review of multi-discipline, research-based information. The VRC website (http://vrhome.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 VRC website proactively sends peer-reviewed critical issue facts 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.

167 Validating a Crop Production Budget for Containerized Specialty Vegetables
Mary Lamberts, Sylvia Gordon, and George Fitzpatrick; Univ. of Florida, Dade County Extension Service, Homestead, FL 33030; Landscape by Sylvia Gordon, Miami, Fla.; Univ. of Florida, Ft. Lauderdale Research & Education Center, Ft. Lauderdale, FL 33314

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.

168 Business Profile of Australian Nurseries
Robin G. Brumfield and Peter F. McSweeney; 111 Cook Office Bldg., P.O. Box 231, Cook College, Rutgers Univ., New Brunswick, NJ 08903-0231

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.

169 A CIELAB Color Classification Scheme for Poinsettias
Bernard B. Bible and Richard J. McAvoy; Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269-4067

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-leaved and dark green-leaved 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 hire than non-red cultivars.

170 A Proficiency Testing Program for the Agricultural Laboratory Analysis Industry
Robert O. Miller, Steven E. Newman, and Janice Kotuby-Amacher; Dept. of Soil and Crop Sciences, Dept. of Horticulture and Landscape Architecture,
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 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.

**172 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.

**173 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 aver- aged greater that 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.
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.

176 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 the role of farnesyl 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.

179 Activities of Free-radical Scavenging Enzymes during Apple Fruit Maturity, Ripening, and Senescence
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Superoxide dismutase (SOD; EC 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. 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. Increased 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 suggests 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.

180 Volatile Profiles of Decaying Apple Fruit
N.A. Mir* and R.M. Beaudry; Dept. of Horticulture, Michigan State Univ. East Lansing, MI 48824.

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-cyano acetamide, 1-hydroxy-2-propanone, and 1,1-dithioxy-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

181 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 8 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.

182 Increase of Easter Lily Postharvest Flower Longevity with PBA Application to Young Flower Buds
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Case-cored 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 µmol·m⁻²·s⁻¹ from 1700 to 2200 HRF 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 mg 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 µmol·m⁻²·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.

183 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 GA₃ 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 benzyladrenaline (BA) delayed the development of leaf yellowing in cold-stored plants, but solutions containing gibberellic acid (GA₃) were not effective when applied to plants at the puffy bud stage and evaluated in a 22.6 ± 0.2°C room illuminated 12 hr/day with 11.2 ± 0.1 µmol·m⁻²·s⁻¹ cool-white fluorescent lamp. Treatment with commercial products containing GA₃ (Provide) or GA₃ and BA (Promalin) nearly completely prevented the development of leaf yellowing. Concentrations as low as 25 mg·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.

184 Number of Open Florets on a Flowering Stem Influences Postharvest Life of Antirrhinum majus L.
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Flowering stems from three commercial inbreds and their F₁ 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 µmol·m⁻²·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.

185 Anatomy of Neck Tissue of Cut Roses as Affected by Bent-neck and Preservative Solution
Young A. Kim and Jong Suk Lee*; Dept. of Horticulture, Chungnam National Univ., Taegon 305-764, Korea

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.

186 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.

187 Effect of Prestorage Treatments on the Vaselife 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 Valentine’s Day. Being able to control and extend the vaselife 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
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 leaf etching was added in the solution, vaselife was signifi cantly reduced, causing 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 recordings were correlated to flower longevity. Furthermore, the higher concentrations caused leaf etching 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.

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 disinfection 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 disinfection 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 was 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 disinfection of this crop.

Bulb Quality and Traumatic Acid Influence Bulblet Formation in *C. roscoeana* Wall.

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*C. 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.

Organogenesis and Cormel Production from Callus Culture of *Gladicius* cv. ‘Balady’

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Callus was initiated from leaves of *Gladicius* 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 rege-
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.

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% Gerlite, 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 polyacrylamide gel electrophoresis proved that all 40 plants regenerated from ‘Amapola’, ‘Elsy’, or ‘IB212’ where 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 polyacrylamide 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.

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%).

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 0.65 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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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 cotyledonary immature embryos had highest induction efficiency. Four different media namely 1/2 MS, Durzan, Litvak’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.

200 Micropropagation and Field Establishment of *Hexastylis shuttleworthii* (Britten & Baker) Small Sherry Kitts1 and Jeanne Frett2; 1Dept. Plant & Soil Sciences, Univ. of Delaware, Newark, DE 19716-1303; 2Mt. Cuba Center for the Study of Piedmont Flora, Greenville, DE 19807

*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 cultures 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 during 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.

201 Effect of Sucrose and PEG Concentration on Embryo Maturation and Hyperhydration in Date Palm Suspension Cultures Shatha Matar Al-Matar1, Mostafa M. Abo El-Nil2, Jameel Al-Khary, and Gerald Klingaman; Dept. of Horticulture, Dale Bumpers College of Agricultural, Food and Life Sciences, Univ. of Arkansas, Fayetteville, AR 72701

Cell suspension cultures of four date palm cultivars were established, namely, Niboat Safi, Madjhou, Sukari, 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 C.H. Becker and T.E. Morelock1; Univ. of Arkansas, Fayetteville, AR 72701

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 Kirby, 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.

203 Abstract withdrawn

204 Pollination and Fruit Set of Pumpkins in Growers’ Fields in New York’s Capital District H. Chris Wien1 and Dale Riggs2; 1Dept. of Fruit and Vegetable Science, Cornell Univ., Ithaca, NY 14853; 2Cornell Cooperative Extension, Albany Regional Office, Albany, NY 12207

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 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 stigmatic surface was evaluated using rating fluorescescence of pollen on the stigmatic surface. Samples were taken from 15 to 30 locations in each field, and female flowers tagged. These were considered set if they had enlarged to fit 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.

205 Yield Effects and Economic Comparison of Using Fresh or Composted Dairy Manure Amendments on Double-cropped Vegetables Nancy E. Ree1 and Gerald C. Cornforth; Texas A&M Research and Extension Center, Rt. 2 Box 1, Stephenville, TX 76401

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 112 kg (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.

206 Omega-3-Fatty Acid Concentration in Portulaca oleracea 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 oleracea L.) is an excellent source of the O3FA ε-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 55% 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.

207 Specialty Potato Varieties in Pennsylvania


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 as color, texture, and taste. Specialty 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-flavored 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.

208 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 'Honeybrev' 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 'Honeybrev'.

209 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.

210 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 accesses. 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 accesses, peppermint, and hybrids had significantly higher leaf moisture than foreign accesses, 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

211 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 salza as a trio-desalinator, 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 Suaea 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 accomodate crop companionship.

212 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, reheving 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 (R² = 0.90), flow rate and pod Ca concentration (R² = 0.47), and Ca uptake and pod Ca concentration (R² = 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.

213 Chemical Characterization of Basil (Ocimum spp.) Germlasm from Brazil
Rafael F. Vieira* and James E. Simon; Center for New Crops and Plant Products, Purdue Univ., West Lafayette, IN 47907-1165
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. kilimandscharicum (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. kilimandscharicum included 1,8-cineole (39%), methyl-chavicol (21%), and 8-bisabolene (23%). O. campechianum accessions contained either high 1,8-cineole (62%) or high 8-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 >80% 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 gurplasm for breeding and potential commercialization.

214 Predicting Dry Bean Yields in Phenological Time
David Nuland*, R.G. Taylor, and Robert Hawley; Univ. of Nebraska, Scottsbluff, NE 69361
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/Ag A–3% below the final USDA estimate for Scott Bluff county. The 1996 predicted value is for 2162 lbs/Ag—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.

215 Light Quality Effects on Flower Sex Expression in Cucumber and Spinach
Gary R. Bachman* and Margaret J. McMahon; Dept. of Horticulture and Crop Science, The Ohio State Univ., 2001 Fyffe Court, Columbus, OH 43210
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 gibberellic (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 gibberellic 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 monococious species, were surveyed for shifts in flower sex expression, indicating a suppression of GA. Male: female flower ratio decreased from 7.6:1 to 4.0:1 when comparing the controls and –FR for the staminate cucumber line and 1.13 to 1.40 for the gynoecious cucumber line. The decrease in male flowers on plants grown in a −FR environment is an indication that the function of GA is inhibited. There was no significant effect on the male: female flower ratios of the spinach.

216 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 basilis (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-coumaroylglycoside) 5-(6′-malonylglycoside) 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.

217 “Black Spot,” a Physiological Disorder of Seed Development in Watermelon
Haim Nerson*; Dept. of Vegetable Crops, Agricultural Research Organization, Newe Yaar Research Center, P.O. Box 1021, Ramat Yishay, 30-095, Israel
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

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

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 pepper, 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.

219 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+hyrralcl_GRID_/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.

220 Stand, Growth, and Yield of Snap Beans in Conventional Tillage and No-till Hairy Vetch Mulch
Aref A. Abdul-Baki* and John R. Teasdale, USDA/ARS, Beltsville Agricultural Research Center, Beltsville, MD 20705

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.

221 Effects of Seed Treatments on Germination of Seed Collected from Native Populations of Oenothera
Sandra A. Balch*, Cynthia B. McKenney, and Dick L. Auld, Dept. of Plant and Soil Science, Texas Tech Univ., Lubbock, TX 79409-2122

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.

222 Use of Sphagnum Peatmoss in a Composting Process
Jean-Yves Daigle*, Peat Research and Development Centre Inc., Shippagan, NB E0B 2P0 Canada

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
J.L. Sibley*, D.G. Hmetrick, and W.A. Dozier, Jr., Dept. of Horticulture, Auburn University, AL 36849

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 mt/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, 'Ispedeza, 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. Forest 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.

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

Argeranthemum frutescens 'Butterfly' and 'Sugar Baby', Brachycome hybrid 'Ultra', Helichrysum bracteatum 'Golden Beauty', Scaevola aemula 'New Wonder', Sutera cordata 'Mauve 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 µmol·m$^{-2}$·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. x 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 was affected by photoperiod (S. cordata and V. hybrid).

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

Douglas A. Hopper*; Dept. of Horticulture and Landscape Architecture, Colorado State Univ., Fort Collins, CO 80523

Ninety-six uniform plants of each ‘Russell hybrid’ and ‘Gally’ 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.

**226** Flowering Response of *Anemone coronaria* to Photoperiod and Temperature

Meriam Karlsson*; Dept. of Plant, Animal and Soil Sciences, Univ. of Alaska, Fairbanks, AK 99775-7200

Eight-week-old plants of *Anemone coronaria* L. ‘Monna 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 m$^2$. 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 m$^2$. The fastest appearance of flower buds and flowering were observed for plants grown at 16 hr of day length and 16°C ([7 ± 5 days from transplant, 133 days from seedling). However, the rate of development was not significantly different from the plants at 12°C and 12 hr of day length (81 ± 5.0 days). Flowering at 20°C required significantly more time at an average 93 ± 9.8 days from transplant. Leaf number at flowering increased with temperature from 9.1 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.

**227** Photoperiod and Temperature Affect *Lamium*, *Scaevola*, *Verbena*, and *Calibrachoa* Development and Propagation

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*Lamium maculatum* L. ‘White Nancy’, *Scaevola aemula* R. ‘New Blue Wonder’, *Verbena x hybrida* Grolen. & Ruemp. ‘Tapian Blue’, and *Calibrachoa x hybridra ‘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 µmol·m$^{-2}$·s$^{-1}$ from incandescent lamps), or ambient daylight plus continuous light (100 µmol·m$^{-2}$·s$^{-1}$ 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 *Calibrachoa* 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.

**228** 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 µmol·m$^{-2}$·s$^{-1}$ from incandescent lamps) and daylight plus continuous light (100 µmol·m$^{-2}$·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°C to 24°C. Implications of these data with respect to classification of *Viola* x *witrockiana* flower induction and development of prefinished seedlings is discussed.

**229** Factors Affecting Flowering of *Hibiscus* spp.

R. Warner* and J.E. Erwin; Dept. of Horticultural Science, Univ. of Minnesota, 1970 Folwell Ave., St. Paul, MN 55108

*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 µmol·m$^{-2}$·s$^{-1}$ from incandescent lamps), or ambient daylight plus continuous light (100 µmol·m$^{-2}$·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.

**230** Phases of Flower Development in Opium Poppy under Various Temperatures

Z. Wang*, M.C. Acock, and B. Acock; USDA-ARS, Remote Sensing and Modeling Laboratory, Beltsville, MD 20705

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 (PSP), and a photoperiod-insensitive post-inductive phase (PPIP). 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 PSP, 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)

**231** Growth of Cyclamen as Affected by Day and Night Temperatures

Meriam Karlsson* and Jeffrey Warner; Dept.of Plant, Animal and Soil Sciences, Wh
The growth of *Cyclamen* 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 seedling 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.

232
Factors Affecting Flowering of *Asclepias* spp.
G. Nordwig* and J.E. Erwin. Dept. of Horticultural Science, Univ. of Minnesota, 1970 Folwell Ave., St. Paul, MN 55108

Asclepias spp. seed were germinated and placed under different photoperiod treatments at constant 15, 20, or 25 ± 2°C. Photoperiod treatments were 8 hr plus night interruption lighting (2000–0200 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 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.

233
Annual Growth and Development of *Scilla peruviana*
Naza Azizbekova*, Christina M. Roberts, Stefanie Butland, and Brian Ellis; Dept. of Plant Science, The Univ. of British Columbia, Vancouver BC, V6T 1Z4, Canada

*Scilla peruviana* is a bulbous plant whose distribution extends from South Africa, into Europe and Asia. It belongs to the family Liliaceae (subclass Monocotyledoneae). *S. peruviana* is an attractive floral species with excellent commercial potential, but it does not produce many bulbets 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 preflower 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

234
Evaluation of Fire Blight Resistance of *Malus sieversii* Populations from Central Asia

M.T. Momoi*, W.F. Lamboy*, P.L. Forsline², and H.S. Aldwinckle³; Dept. of ¹Plant Pathology; ²USDA-ARS, Plant Genetic Resources Unit, Cornell Univ., Geneva, NY 14456

*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 10⁵ cfu/ml of *Erwinia amylovora* strain E273. Seedlings from the 1989 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 10⁵ cfu/ml) using a backpack sprayer. These also gave diverse resistant reactions.

235
Hydrophobic Particles for Pest Control in Deciduous Tree Fruit Production
D.M. Glenn*, G. Putera, T. van der Zwart, and R. Byers; USDA-ARS, Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430

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 recognizable 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 Fabraea 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.

236
Protection of Long English Cucumber against Powdery Mildew through Induced Resistance using *Milsana* (Leaf Extracts)
F. Daay*, M. Onenga, and R.R. Bellanger; Environtron, Horticulture Research Center, Laval Univ., Ste-Foy, QC, G1K 7P4 Canada

Application of *Milsana*, a commercial formulation of leaf extracts from *Pseudornia sacha/ensis*, has been shown to reduce the incidence of cucumber powdery mildew (*Sphaerotheca fuliginea* Schlecht, ex Fr. Polk.) 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, phorolich 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.

237
Effect of Chitosan on Growth and Toxin Production by *Alternaria alternata* f. sp. *lycopersici*
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of Food Science and Nutrition and Horticultural Research Center, Laval Univ., Sainte-Foy, Quebec, Canada G1K 7P4

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 µg·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 methylsterase activity were measured in the culture filtrate administered tomato tissue. Decreased trend in causing hyphal contortion. It also induced leakage of proteins from the fungal cells. 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.

238 Field Applications of Fungicides Improve Postharvest Quality and Storage Life of Some Pumpkin Cultivars
Charles A. McClurg; Dept. of Natural Resource Sciences and Landscape Architecture, Univ. of Maryland, College Park, MD 20742

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 sale, their marketability, appearance, 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.

239 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 antagonism 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 x 10⁸ 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.

240 Microbial Populations and Potential Phytotoxicity of Rhizobacteria Isolated from Jamaican Anthurium
W.A. Bergfield;¹ D.N. Sasseville;¹ R.J. Kramer;¹ and T. Souissi;² "Lincoln Univ.

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 µg·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 methylsterase activity were measured in the culture filtrate administered tomato tissue. Decreased trend in causing hyphal contortion. It also induced leakage of proteins from the fungal cells. 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.

241 Influence of Root Flooding Interval on Phytophthora Root Rot of Blueberry
Amal P. de Silva;¹ and W. Keith Patterson; Dept. of Horticulture, Univ. of Arkansas, Fayetteville, AR 72701

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.

242 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 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 (CaSO₄) and post-plant applications of phosphorus acid sprays (H₃PO₄) 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 ‘Ilian’ 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.

243 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 µM 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.

244 Screening Onion Lines for Resistance to Sclerotium cepivorum Berk. using Field and Onio 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.

245 Evaluation of Garlic Germplasm for OYDV and LYSV Infection using Dot Blot ELISA
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Garlic is an assexually 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 (bulpis) were evaluated. Topsets are small bulbs that are produced in the inflorescence of staking 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 from 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.

246 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 hectarage. 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.

247 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 pins/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 effective, 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: tetrachloroisophtalonitrile (chlorothalonil).
248 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- 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.

249 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 concentration. 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.

250 Abstract withdrawn

251 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 rating 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.

252 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. Ascertainment 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.

253 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 broadleaf 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

254 Manipulation of Low Temperature and Light Quality for Storage of Broccoli in Vitro
Sandra B. Wilson¹, Keiko Iwabuchi¹, Nihal C. Rajapakse², and Roy E. Young²; ¹Dept. of Horticulture and ²Dept. of Agricultural and Biological Engineering, Clemson Univ., Clemson, SC 29634

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 µmol·m⁻²·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, SLA), 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.

255 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-Sanjur et al., in press). Hypocotyl 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 2 mg/l thidiazuron and GA. Shoots were regenerated from eight selected DHLs (C219, C215, C216, C2123, C2125, C3111, C3113, and C493) 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 hypocotyl sections (93.4% and 17.9%, respectively). The number of shoot primordia per responsive cotyledon section was also higher than with hypocotyl 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 hypocotyl (0.5 to 3.5) section. All adventivously regenerated plants were fertile. This adventitious shoot regeneration protocol is being used to obtain transgenic plants from sweet bell pepper genotypes.

256 The Influence of Spear Number on in Vitro Rooting of Asparagus (Asparagus officinalis L.)
Gerson R. de L. Fortes¹, Nilvane T.G. Müller², Janine T.C. Faria², Luciana B. Andrade², and Marisa de F. Oliveira²; ¹EMBRAPA/CPACT, Cx. P. 403, CEP 96001-970, Pelotas, RS, Brazil; ²UFPEL/FAEM, Cx. P. 354, CEP 96010-900, Pelotas, RS, Brazil

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 order 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 GZ7). 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.

257 In Vitro Multiplication of Two Genotypes of Asparagus (Asparagus officinalis L.)
Gerson R. de L. Fortes*¹, Nilvane T.G. Müller², Janine T.C. Faria², Luciana B. Andrade², and Marisa de F. Oliveira²; ¹EMBRAPA/CPACT, Cx. P. 403, CEP 96001-970, Pelotas, RS, Brazil; ²UFPEL/FAEM, Cx. P. 354, CEP 96010-900, Pelotas, RS, Brazil

Asparagus is a vegetable that presents an increase in yield when propagated by meristem culture. On the order 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 g L⁻¹), agar (6.0 g L⁻¹) and myo-inositol (100.0 mg 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 shoot 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.

258 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 1/4-strength and MS vitamins added to: myo-inositol (100 mg L⁻¹), agar (7.0 g L⁻¹) and sucrose as follows: 10, 20 and 30 g 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 ± 2°C, 16-hr photoperiod and 2000 lux. The evaluation was done 25 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 g L⁻¹). This treatment could be recommended for this cultivar.

259 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 meristematic 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 microtuberculation) 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 microtuberculation 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 “cryopreserv-ability” and interact with cryoprotectants that are artificially added during the cryoprotogenic protocol. We are beginning to examine these aspects to improve cryo-preservation. Nodal segments of Pt 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, 10, or 1 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 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 Jarrett (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 offsprings 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 Auxillary Buds of Triploid Watermelon (Citrullus vulgaris Schrard.)
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Watermelon (Citrullus vulgaris Schrard.) 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. Henos, 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 phytonromones. 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 weight (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 MS 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 suspen-sion 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.

148 POSTER SESSION 5B (Abstr. 265–280)
Culture & Management–Fruits/Nuts

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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', 'Redtree', and 'Dayton' on M.27 EMLA, M.26 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. ‘Redtree’ 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 × 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 ‘Redtree’ 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.

266 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 first flower clusters in the 3rd and 4th years of the study, and ‘NY 65707-19’ the latest. 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 VI, 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.

267 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 Bud52-356 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 82-396 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 8.8 kg/tree per year for 54-118 rootstock, 3.4 and 3.5, respectively, for 62-396 rootstock. Yields at the 7th year after planting reached 24 and 32 kg on 54-118 rootstock, 16 and 15 kg on 62-396, respectively. Analogous data 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.

268 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.

269 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. Application of 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.

270 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 0.7 m were used on coffee cultivars Guatemala, Red Catuai, Yellow Caturra, and Mokka. In the hedged treatment, ‘Mokka’ had the longest laterals, followed by ‘Guatemala’, with ‘Red Catuai’, and ‘Yellow Caturra’ having similar growth. ‘Mokka’ and ‘Red Catuai’ 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 ‘Guatemala’, 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-94’ (L49) guavas from India and ‘Beaumont’ (BMT) guavas 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 astrignent for both BMT and L49, whereas RDF had a mild fruit flavor.

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’, ‘Shinseiki’, ‘Kikusui’, ‘Hosouki’, ‘Twenty Century’, and ‘Yan-Li’. The ripening date of these cultivars were from the 7th and 20th 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.

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 liners in soil. UV-A and B or 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.

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 Tiasurí” 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 adaption into the region (‘Shinseiki’, ‘Kikusui’, ‘Hosouki’, ‘Twenty Century’, and ‘Yan-Li’). The ripening date of these cultivars were from the 7th and 20th 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.

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 self 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 fleshly drupeaceous fruits, with an initial and a final phase of rapid growth interrupted by a phase of slow growth.

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’, ‘Zahidi’, and ‘Mahjool’. 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 decomposing 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.

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’, ‘Perique’, ‘Posey’, and ‘Shoshoni’. Early analysis performed in 1994 and 1995, 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.

278 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.

279 Floral Biology and Fruit Set of 'Taffi' Pomegranate in Relation to Heat and Drought Stress
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Floral biology of 'Taffi' pomegranate was studied on trees grown in extreme high temperature and drought conditions. Measurement included flowering date, duration and type, pollen viability, diameter, floral 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 'Taffi' pomegranate.

280 Effects of a Combination Application of Hydrogen Cyanamid (Dormex) and Ethephon (Ethrel) on Fruiting of 'Redhaven' and 'Surecrop' Peach
Arlie A. Powell*, James Pitts, and Robert Boozer; Auburn Univ., AL 36849
Early flowering of peach in the southeastern U.S. often results in some annual crop loss as a result of late winter–early spring frosts. It has been shown in peach and other prunus that a full application of ethephon delays flowering 4 to 7 days and possibly affords increased bud hardness. 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 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
Kathryn C. Taylor* and Danielle R. Eli; Dept. of Plant Science, Univ. of Arizona, Tucson, AZ 85721
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, 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 the 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 asparagine and glutamate and contained 6 cysteine, and 4 histidine residues. These amino acids may be involved in metal binding. N-terminal amino acid sequencinges 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.

282 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 hydrolysate—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 5.2 dS/m). 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 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.

283 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 'Blanca', 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 annum Exposed to High Temperatures

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Reduction of floral number in Capsicum annum has been observed during growth at high temperature. To determine whether decreased flower production or increased flower abortion 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 Chinese 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 ‘Tanun 1’ or ‘Known You’ 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 alleviated 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

287 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 PEG8000 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 loupines (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.

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

290 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 Enersoil 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.

291 Adventitious Shoot Formation on Hypocotyl Explants of Antirhinum majus L.

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One-centimeter hypocotyl explants from 2-week-old Antirhinum 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 mg/L 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 µM BA. Shoot development appeared normal at the 2.22 and 4.44 µM level, while at 8.88 µM BA, development was slightly abnormal along with slightly more callus production.

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 floricane 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 floricane cuttings.

293 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 cuttings 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 1-budded with certified, virus-indexed buds of 'Cresthaven' peach.

294 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 remaining vegetative buds burst and then the new shoot grew very vigorously in high-density planting of 1 x 1 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.

295 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., noninfected 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) multiplo-
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.

299 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 (Dytrol) or not. The visual color and firmness changes during ripening at 21.1°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 slowed 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.

300 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 mealy 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.
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 phosphate 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 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.

302 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 affects 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. 'Turess') treated by hormic UV dose, and was followed by assaying products of lipid oxidation during the storage period. We observed the production of lipidic-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. Therefore, 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.

303 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.
greenhouse/bench dimensions and container sizes. In most cases, a staggered arrangement allowed a significant increase in the number of containers filling 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.

307 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 irrigations 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.

308 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.

309 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. rosea (powdery mildew). Copper sulfate pentahydrate and fenamidone 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 fungistic 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 (Hummernt 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 gnats (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 5.6-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.

311 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 (0.032, 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 prove this hypothesis. When paclobutrazol concentrations were higher than 100 mg·L⁻¹, some bracts showed evidence of “crinkling.”

312 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 µmol·m⁻²·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 limitation in carbon metabolism.

313 Postharvest Treatment of Easter Lily Bulbs Prior to Shipping
J. Heinrich Lieth, Deborah Girauf*, Glen Forister, Paul Fisher, and Loren Orli; Dept. of Environmental Horticulture, Univ. of California, Davis, CA 95616-8587
Easter lily bulbs are harvested in fields in northern California and southern Oregon, packed in cases, and shipped to distributors and growers. The greenhouse forcing 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.

314 Rapid Production of Sweetpotato Cuttings under Controlled Environment: CO₂ Enrichment and Cutting Preparation Affected the Growth and Production Rates
T. Koza, K. Yoshinaga*, and C. Kubota; Dept. of Bioproduction Science, Chiba Univ., Chiba 271, Japan
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 µmol·mol⁻¹ with CDE or 300 µmol·mol⁻¹ without CDE. Air temperature and relative humidity were maintained at 30 ± 1°C and 80 ± 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.

315 Transplant Quality as Affected by Temperature, Light Intensity, and Photoperiod during Storage
C. Kubota, S. Sawayama*, K. Sakami, and T. Koza; Dept. of Bioproduction Science, Chiba Univ., Chiba 271, Japan
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 28/20°C photo-/dark period temperature, 330 µmol·m⁻²·s⁻¹ photosynthetic photon flux (PPF), and 16-hour 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

316 New Cultivars of Korean Mountain Ash (Sorbus alnifolia) and Its Mass Propagation in Vitro
Kyung Ku Shim¹, Y.M. Ha¹, J.B. Lee¹, K.O. Byun¹, Y. Youn², E.R. Not², and H.R. Park³; Dept. of Landscape Architecture, Sung Kyun Kwan Univ., Suwon, 441-746; ²Forest Genetics Research Inst., Suwon 441-350, Korea
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 semiweeping 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 Zatin 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 best results were obtained from shoot tip. A 13-fold proliferation rate was achieved every 4 weeks.

317 Expression of “Rooting” Genes iaaM and rolB Under Regulatory Promoters in Tobacco
Wayne A. Sargent* and Zong-Ming Cheng; Dept. of Plant Sciences, North Dakota State Univ., Fargo, ND 58105
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 under two rooting genes (iaaM from Agrobacterium tumefaciens and rolB 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 pB1. The engineered plasmids were transformed into A. tumefaciens strain LBA4404 by electroporation. The functions of the genes were confirmed by transforming Nicotiana tabacum with these constructs. In plants transformed with iaaM and rolB 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

Margaret R. Pooler1 and Ruth L. Dix

Interspecific hybridizations among members of the genus Hamamelis (the witchhazes) and Corylopsis were carried out in 1993, 1994, 1995, and 1996 at the U.S. National Arboretum. Specifically, crosses involving the native witch hazel (H. virginiana 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 witch hazel taxa.

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

Carol D. Robacker1 and S.K. Braman2

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 five times. In the spring and summer of 1995, azalea lace bugs were introduced in five to six fl orets expanded. Cut stems were placed in narrowed-necked bottles filled with deionized water under continuous fl uorescent light at 25°C. Flowering stems for water loss evaluation were harvested when the basal water loss when held in deionized water under continuous fl uorescent light at 25°C. Flowering stems for water loss evaluation were harvested when the basal

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

Shanqiang Ke1, Chiwon W. Lee, and Murray E. Dyusser

The effects of the expression of the rolC 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 plastid, pGA-GUSF, containing the npiI, gus, and rolC 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 napthaleneacetic 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 albinos 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 albinos plants also lacked the 110-kDa and 58–58-kDa, and 43, 47-kDa polypeptides in PSI, coupling factor, and PSI 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 albinos plants. LHC genes are encoded in the nucleus. The thylakoid membrane proteins in the chloroplasts of the rolC transgenic variegated plants contains 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 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

Deric D. Pictor* and Harrison G. Hughes

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 produced up to 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

Dennis P. Stimart* and Kenneth R. Schroeder

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 produced up to 40 reproducible bands. It was possible to identify and uniquely distinguish all species and hybrids investigated using these bands. 

325

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

Deric D. Pictor* and Harrison G. Hughes

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 produced up to 40 reproducible bands. It was possible to identify and uniquely distinguish all species and hybrids investigated using these bands.
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 F. 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.

325 Inheritance of Male Sterility in Impatiens wallerana
Jaemin Lee1 and Lowell C. Evera, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325

Most seed produced impatiens today are F1 hybrids. The seed of F1 hybrids is produced by hand-emasculation of 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.

326 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 the 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 procedures for the determination of lipase activity and percent trivernolin in vernonia galamensis spp. galamensis using gas chromatography.

327 Inheritance of Male Sterility in Lesquerella fendleri
D.A. Dierig, P.M. Tomasi, and T.A. Coffelt, U.S. Water Conservation Laboratory, USDA/ARS, 4331 East Broadway Road, Phoenix, AZ 85040

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 following the three crop seasons. Crosses were made among fertile and sterile 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.
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
Jeff S. Kuehn* and Patricia Branch, Dept. of Horticulture, Louisiana State Univ., Baton Rouge, LA 70803-2120

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–1P–20K at 75, 125, 250, or 200 ppm N in 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: ‘Freedom Red’, ‘Success’, ‘V-17 Angelika Red’, ‘Red Sails’, ‘Nutcracker Red’, ‘Cortez’, ‘Maren’, and ‘Red Splendor’ poinsettia were fertilized with 20N–1P–20K at 75, 125, 250, or 200 ppm N with fertigation zero leachate. The 250 ppm N level 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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Response of Three Poinsettia Cultivars to Root Media Containing Coal Bottom Ash
James Gibson and Bradford C. Bearce*, West Virginia Univ., Morgantown, WV 26505

Poinsettia (Euphorbia pulcherrima Willd. ex Klotch) 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%, 50%, or 75% 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 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
Bernard B. Bible and Richard J. McAvoy*, Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269-4067

‘Angelika White’ poinsettias (Euphorbia pulcherrima Willd. ex Klotch) 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 MgSO₄·7H₂O. Use water, 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 = 0.0972X² – 3.78X + 38.7, r² = 0.69).

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The Response of Long-day Herbaceous Perennials to a Night-interruption at Low Night Temperatures
Alison Frane*, Royal Heins, Art Cameron, and William Carlson, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824-1325

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, and 20°C with day temperatures 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
Terri Woods Starman*, Millie S. Williams, and James E. Faust, Dept. of Ornamental Horticulture and Landscape Design, Inst. of Agriculture, Univ. of Tennessee, Knoxville, TN 37901-1071

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°C (venting) night temperature set point) 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 oleracea ‘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 Tabernanontana 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
John M. Dole*, Janet C. Cole, and Vicki Stambaugh, Dept. of Horticulture and Landscape Architecture, Oklahoma State Univ., Stillwater, OK 74078

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  
Catherine S.M. Ku* and John C. Bouwkamp; Dept. of Natural Resource Sciences and Landscape Architecture, Univ. of Maryland, College Park, MD 20742-5611

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 ‘French’, ‘Yellow Fave’, 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. Media porosity, percent air space, 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  
Kathryn S. Hahne* and Richard L. Harkess; Dept. of Plant and Soil Sciences, Box 9555, Mississippi State Univ., Mississippi State, MS 39762

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  
Gail E. Barth*; South Australian Research and Development Inst., Adelaide, South Australia

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 colorscaping companies have begun implementing a second summer planting
PINK' and one growing season depended largely on rootstock girth and whole-tree-N-planting were the last to set bud during the N-deprivation-phase. Tree size after both solutions after 4 weeks.

Calcium and Mg were never 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 some-

defined by weekly analysis. Nearly all the N, K, and Mn in Solution 1 was completely absorbed and in contrast to Mn, traces of Fe, Zn, and Cu remained in

newly prepared solutions were analyzed for 11 elements and their depletion was analyzed every 7 days and changed every 28 days. At each solution change, the

Salmon', did not establish well under these conditions included: Impatiens walleriana 'Deco Crystal', 'Expo Lavender Blush', 'Dazzler Salmon', Bagonia semperflorens 'Varsity Blonde Scarlet', Zinnia 'White Pinwheel', Tagetes erecta 'Marvel Gold', and Tagetes patula 'Bonanza Harmony'. Cultivars that did not establish well under these conditions included: Verbena hybridra 'Romanice 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

343 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 (r² = 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 liter of water absorbed, respectively) were not influenced by the rootstock.

344 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 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.

345 Yield and Quality of 'Anna' Apple Trees (Malus domestica L.) in Response to Foliar Application of Ascorbine and Citrines Fertilizers
F.F. Ahmed1, A.M. Aki1, A.A. Gabora, and A.E.M. Monsour2;1 Horticulture Dept., Faculty of Agriculture, Minia Univ., Minia, Egypt; 2 Horticultural Research Dept., National Research Centre, Dokk, Egypt

The beneficial effect on yield and quality of 'Anna' apple fruits for the application of ascorbine 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 ascorbine 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 ascorbine at 0.1% or citrine at 0.6% twice during the growing season; i.e., growth start at 30 days later.

346 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. The equation the opportunity to study the long-term effects of different potassium status has on English walnut tree 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.

347 Solution pH and Papaya Seed Germination and Seedling Emergence
Robin A. DeMeo and Thomas E. Marler*; College of Agriculture & Life Sciences, Univ. of Guam, Mangilao, GU 96923

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 'Tanung 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 'Tanung 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.

348 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.

349 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 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.

350 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 in creased 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 45% (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.

351 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-

352 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 nitrobean) 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, nitrobean, 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.

353 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.

149 POSTER SESSION 6D (Abstr. 354–370)

Postharvest Physiology–Vegetables

354 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 of 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 HAYSESEP-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*X2 + 0.6565694e-03*X3 + 0.23499598e-04*X4 (R² = 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.

355 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 T1 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 in the image. The affected potatoes can easily be sorted out using this nondestructive NMR imaging technique.

356 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 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 'Piquín', and its relation with the activity of peroxidases in these plants. 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 ‘Piquín’. 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 ‘Piquín’, and then started to decline. Peroxidases had a maximum activity at pH 6.0, ~1.0 mU of capsaicin, and 1.0–1.5 mM of H2O2. 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.

357 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 O2 becomes limiting. The increase in glycolytic flux is accompanied by the accumulation of glycolytic end products, including ethanol and lactic acid. 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 O2 atmosphere on lactic fermentation in carrot (Daucus carota L.). To understand the regulation of metabolism of lactic fermentation, carrot root shreds were stored under a continuous flow of 0.5% and 2% O2 (balance N2), 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 2.8–2.1–2.0–1.6-fold; that of lactate was 5.6–3.8–2.9–2.6-fold for 0.5% O2 at 15°C and 5°C, and 2% O2 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% O2 than 2% O2 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-O2 atmosphere, was much more than lactate accumulation. Thus, carrot roots possess LDH, which appears under low-O2 atmosphere, but lactic fermentation may be a minor carbon flux compared to ethanolic fermentation.

358 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.

359 The Relationship between Ca Uptake and Firmness in Cucumber 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 per plant, as well as productivity. To solve this problem, the direct application of Ca was conducted after anthesis. Foliar treatment of Ca at 0.5 to 1.0 mM of capsaicin, and 1.0–1.5 mM of H2O2.

360 Purification and Characterization of a Prominent Polygalacturonase Isozyme Produced by Phomopsis cucurbitae in Decayed Muskmelon Fruit
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 replicates. 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), and protein content, and by increases in: the total free sterol: total phospholipid ratio, and 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 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 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 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 plasma membrane H+-ATPase (E.C. 3.6.1.3) activity, and protein content.
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 were 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 and day by 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 Log 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.

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 unpleasing 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°F 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 and concentrated pod setting adapted to mechanical harvest with pods containing less fiber and less tendency to sloughing.

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 Bettensnap developed for green pod production and the green bean cultivars Benton and OSU-5402 were produced under the same cultural conditions. ‘Bettensnap’ yielded less than 0.5 ton/ha, while ‘Benton’ and ‘OSU-5402’ produced about 2.5 ton/ha in once-over simulated mechanical harvest. ‘Bettensnap’ 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 ‘Bettensnap’ constitute potential problems for mechanical harvest. Canned cowpea pods of series 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.

The Alternative Oxidase Limits Superoxide Production by Plant Mitochondria
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Mitochondria isolated from the pericarp tissue of green bell pepper (Capsicum annuum 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 diame. 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

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 14CO2 for 15 min. Individual CHO concentrations and the activity of newly-fixed 14CHOs 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- 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.

Evaluation of a Rapid Method for Screening the Capacity of Leaves to Export Photosynthesize
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A method was developed to rapidly screen genotypes for capacity of leaves to export photosynthesize, with the expectation that rapid export should promote growth. Vegetative plants of 13 cultivars of Pluot sativum L. (peach) 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 (Noffia, 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 ‘Manou’ 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 Photosynthetic Partitioning in Watermelon Plants Exposed to End-of-Day Light Treatments


End-of-day (EOD) light treatments were used to study phytochrome involvement in photosynthesis and photosynthetic 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 the dark 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 a significant increase in photosynthetic activity and the capacity of leaves to partition to metabolites, 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 conductance were higher in FR-treated plants compared to other treatments after 3 days of treatments. The EOD FR regulated growth and photosynthetic partitioning patterns were reversible when FR treated plants were immediately followed by R. This implies EOD:FR ratio acting through the phytochrome regulates the growth and development processes in watermelon plants.

Gas Exchange Behavior of Male and Female Parwal Plants

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Parwal (Trichosanthes 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 female and male flowers. Plants grown in high light (100 µmol m-2 s-1) had higher photosynthetic rates, higher fluorescence, and starch accumulation than plants grown in low light (36 µmol m-2 s-1). The effects of developmental stage on gas exchange, photosynthesis, and soluble sugar accumulation were observed in 47-day-old leaves. Eighty-four-day-old leaves were no longer actively exchanging gases.

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 PPFD 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 (Pn) and maximum (Pn) 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 m-2 in winter to about 850 W m-2 in spring resulted in Pn increases of 45% and 42% in the 5th and 10th leaves, respectively. During the winter period, Pn was higher than Pn for 5th and 10th leaves, respectively. In the spring, no difference was found between Pn and Pn. 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 accumulation in leaves. Data will be discussed in terms of crop efficiency and yield.

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°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-1 PPFD). 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 Pn, 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 Pn rate at saturating CO2 in plants grown at the higher light level. Overall, the highest Pn 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.

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 Ait.). 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-glucosyltransferase) was purified to homogeneity by ammonium sulfate precipitation, anion exchange chromatography on DEAE-Toyopearl 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 homotrimer 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: Km (fructose), 7.4; Km (UDP-glucose), 0.2612; Km (sucrose), 33.24; Km (UDP), 0.0946. The enzyme was very sensitive to inhibition by heavy metals.

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.

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, 1Ithaca, N.Y., in press) was used as a guidebook for combining senior citizens and grade-schoolers 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 grade-school 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.

380 Abstract withdrawn

381 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.

382 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 (82 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).

383 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 amount 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.

384 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 work’s 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.

385 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 handbook 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.

386 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.

387 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, nematicides, 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.

388 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 grass 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.

389 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 phytoxicity 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 with 1.0% SunSpray petroleum oil. None of the oil treatments caused phytoxicity. 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.

390 The Effect of Weed Control Methods upon Soil Physical Properties and Plant Growth
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There has been recent speculation in trade journals that landscape fabrics, while doing a 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, landscape fabric + no mulch).
mulch). Each plot has been planted with herbaceous perennials so as to allow analysis of treatment effects upon plant growth. Re-do-x potential is measured on a weekly and infiltration rate is measured on a bimonthly 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 a 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.

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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 2543 genotypes flowed 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, % blankets, 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 parenting 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 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.

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Greenhouse and Field Resistance to Yellow Aphids in the ‘Pawnee’ Pecan
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Putative resistance to the yellow aphid complex (Monellia caryella (Ritch) and Monelliaopsis pecanis (Wangen.) 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

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Evaluation of Squash Cultigens in North Carolina
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Yellow and zucchini squash (Cucurbita pepo L.) cultigens/elite lines (cultigens) were evaluated over two seasons (fall 1995 and spring 1996) in North Carolina. Different cultivars were tested over the 2-year period for both yellow and zucchini squash, although some cultivars were tested both years. Cultigen recommendations are based on yield, quality, disease resistance, and season grown. Yellow squash cultivars that yielded well include: Destiny III, Freedom III, Multipik, TW 941141, Liberation (fall 1995); and HMX 4716, Supersik, PSX 391, Monet,
Dixie, Picasso, and XPH 1780 (spring 1996). Superior-yielding zucchini squash cultivars were: TW 940861, Tigress, TW 940892, ZS 19, Elite, and Nobilesse (fall 1995); and Leonardo, Hurricane, Elite, HMX 4715, Nobilesse, 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, Destiny III, Freedom II, Liberator III, Prelude II, and TW 941121 (yellow), and Tigress, TW 940892, TW 940891, TW 940866 (zucchini). Virus-infected plants were assayed and viruses were determined to be zucchini yellow mosaic, watermelon mosaic II, and papaya ringspot.

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 cultivars ‘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 cultivars 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 cultivar was significant. Number of staminate and pistillate flowers was affected by both cultivar and planting date.

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. G2, G3, G4, and G5 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 in 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 cultivars will have a large effect on the yield, earliness, or internal quality of the crop.

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. Cucumber was grown at two locations (Group 1 and Group 2) with 9 replicates each. Group 1 contained 37 (27 Madhya Pradesh + 10 Uttar Pradesh) accessions and Group 2 contained 102 (84 Rajasthan + 18 Madhya Pradesh) accessions. Seven accessions (5 Madhya Pradesh + 2 Rajasthan) were not associated with either group. Isozyme 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.

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

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A germlasm 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, ELSRAS, Zeerust, Bray, Van Zylsru, Kaledi Gemsbok Nat. Park, Upington, Postmaasburg, Vryburg, and Dordespoort, 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 germlasm collections of the two countries, and can be obtained free from the USDA by interested researchers.

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 F1 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 monoeocious, the hybrid was gynoecious. Male flower formation was induced by treating the hybrid with Ag or GA, but they were male-sterile. F2 seed were 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.

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 ‘H91’) 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 cucumber 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 cucumber foliage and were diverse with regard to VCGs, nuDNA, and mtDNA RFLPs. However, CM and GC were more virulent on cucumber fruit than CO.

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

404 Quality of Valencia Oranges in Response to Fruit Fly Disinfection Treatments
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Valencia orange (Citrus 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 disinfection 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 orange season (three grower lots/time). Valencia oranges exposed to HTFA had significantly increased internal O2 levels (5% vs. 19% for non-HTFA) and increased internal CO2 (6% vs. 2% for non-HTFA) 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.

407 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), 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.

408 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 climactic, 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.

409 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 glucose transporter (GT) activity. Moderate CO2 atmospheres (10%) prolong the storage life and maintain the quality of pomegranates, including an adequate red color of the arils.

410 Response of Mamey Sapote (Pouteria sapota) Fruits to Postharvest 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 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

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 fruit 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 larger, 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-520-9), compared to Lovell, the commercial standard in North Carolina. ‘Redhaven’ was the scion for both rootstocks. Guardian TM 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 TM. 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 TM 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 TM rootstock.

413 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 stages 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 characterized 136 to 146 cm in tree height and 22.9 to 26.8 cm in trunk diameter.

414 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, mealyness, 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 epidemics thickness. Packhard protected the fruit in cold storage for 43 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. Sucrese 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. Sucrese content decreased in Packhard-treated fruit compared to the controls.

417 Peach Leaves Do Take Up Foliarily Applied Urea Nitrogen
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The ability of peach leaves to absorb and translocate foliarily 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

Hak Tae Lim and Jong Kuk Na*; Division of Applied Plant Sciences, Kangwon National Univ., Chuncheon, 200-701, South Korea

A genetic transformation in Solanum spp. was performed using Agrobacterium tumefaciens: CS8:pGV2260:Athb-7. Athb-7 gene, known to be related to water stress and ABA level, one of Arabidopsis that an 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 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 (LeHSP17.6). The mRNA of LeHSP17.6 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 BC1, 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*. Certain glycoalkaloids in potato leaves are effective deterrents to this insect; however, in tubers these compounds can be toxic to humans. Leptines are folic-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 *F₁* and *F₂* populations derived from two *S. chacoense* accessions, 55-1 and 55-3, which are (respectively) high and low leptine producers. The *F₁* segregates 1:1 for high (>70% of total glycoalkaloids) and low (<20% of TGA) leptine content. Segregation data from the *F₁* and *F₂* 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 *F₁* population, we are using various types of molecular markers (RAPDs, SSIs, 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.

### 422

**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 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 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, 101 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 Ps 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', 'Dazenger Blues', and 'Pure Beauty Peppa') cultivars were identified using a Weighted Base Selection Index. These cultivars were used as parents in a full diallel crossing block with reciprocals and selves. 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 University 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 (g·cm⁻²) were calculated. Mean squares for general and specific combining ability were estimated using Griffin's Model 1, Method 4. Differences between crosses were highly significant (P < 0.001) for all traits examined. Means 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 crop 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**

### 426

**Analysis of Horticultural Performance of Ethylene-insensitive Petunias and Tomatoes**

E.K. Gubrium*, D.G. Clark, H.J. Klee, T.A. Nell, and J.E. Barrett; Environmental Horticulture Dept., Univ. of Florida, Gainesville, FL 32611-0670

We are studying the horticultural performance of two model plant systems that carry a mutant gene that confers ethylene-insensitivity: *Never Ripe* tomatoes and petunias 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.

428 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.

429 Arbitrary Signatures from Amplification Profiles (ASAP) Distinguishing Somatic and Radiation-induced Mutations in the ‘Charm’ Series of Chrysanthemum
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Four chrysanthemum (Dendranthema grandiflora) spontaneous and radiation-induced mutants 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.
343 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.

344 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) 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 d.wt 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 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 TNC + 0.74 T – TNC – 0.48 TNC Ni + 0.094 T), Ni = 0.884 Ni

Thus, by knowing TNCi (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.

345 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 leaf lengths 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

346 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 5 ± 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 ventilated 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-day 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.

347 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.

348 Effect of Forcing Temperature on Flowering of Four Herbaceous Perennial Species

Four herbaceous perennial species, Delphinium grandiflorum ‘Blue Mirror’, Hibiscus syriacus ‘Disco Belle Mix’, Sedum xupetera ‘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. syriacus 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 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. syriacus ‘Disco Belle Mix’. The base temperature (Tb) and cumulative thermal time (CTT) necessary to complete the indicated developmental stage were calculated from a linear regression: 1/Tb = a + bT. Based this equation, days to flowering (or visible
439 Photoperiod and Temperature Interact to Affect Petunia x hybrida Vilim. Development

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Petunia x hybrida Vilim. cv’s ‘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 µmol·m⁻²·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 µmol·m⁻²·s⁻¹ from incandescent lamps) flowered earlier, with a reduced leaf number compared to plants grown with daylight + a 3-hr day extension from 1700–2000 HR (100 µmol·m⁻²·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.

440 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 µmol·m⁻²·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 µmol·m⁻²·s⁻¹ from incandescent lamps from 2200–0200 HR) and continuous light (daylight plus 100 µmol·m⁻²·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.

441 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 oleracea ‘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 daylight 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.

442 Photoperiodic Responses of Garden Chrysanthemum

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The objective was to study the flowering response of garden cultivars of Den- dranthemum 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 daylight 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.

443 Red/Far Red Light and PAR Leaf Absorption Varieties 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 Thumb. 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 procedures were 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. Sunchoke) 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 about 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 (Japaneese Burdock)

Takonogawa 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 row number, regardless of row number. Average root weight and yield of forked roots was not affected by row number, but increased with increased 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 culled. 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

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, tomatoes, 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 Caua 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

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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
Tina M. Waliczek* and J.M. Zajicek; Dept. of Horticultural Science, Texas A&M Univ., College Station, TX 77843-2133
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.


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 (IR76, 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 premulched 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. Temperature, 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.

457 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 ≈7°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.

458 Transplant Container Shape and Strawberry Transplant Growth


Bare-root strawberry transplants have been conventionally used for establishment of strawberry planting 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 diameters (17, 25, 32 cm) and three container shapes (circular, elliptical, and biconvex) that such that cell diameters had the same maximum 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 affect 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.

459 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, while ‘Cavendish’, ‘Governor Simcoe’, and ‘Kent’ were 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 ethyl acetate, 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.

460 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 in vitro studies on the mode of action of E-2-hexenal, mycelial growth and percent sporulation 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. Jewell, 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.

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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 10 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 3586 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 scaffold branches were allowed per tree, while at the widest in-row spacing up to 12 scaffold branches 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 Dwarving 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 ‘Pome’ on M.9EMLA, Bud 9, Mark, Ottawa3, 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 ‘Pome’, ‘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 (QA4+7 and benzyladenine,

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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
Warren E. Shafer1, Gregory Clarke2, Robert Frissel, Jr.2, and Derek Woolard2; Depts. of 1Plant Science and 2Field Development, Abbott Laboratories, Chemical and Agricultural Products Division, 1401 Sheridan Road, North Chicago, IL 60064. ReTain™ is an organic, water-soluble formulation that contains 15% (w/w) of aminoethoxyvinylglycine (AVG). AVG, a naturally occurring plant growth regulator, competitively inhibits ACC (1-aminoacyclopropane-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 naphthalenesulfonic 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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Physiogeological Characteristics of Hanabushaya asiatica
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In an attempt to obtain the basic data for the development of Hanabushaya 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. Hanabushaya 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, Sympospis chinensis var. 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), Anisalae acerifolii subapoda, Athyrium nipponicum, Sporiopimplina braschycarpa, and Carex siderostatica (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 25°C.

471 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.

472 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, an increase in stem length over half-sibling groups varied from <0% in Ithaca, N.Y., to 179% in Puyallup, Wash.

473 Drought Resistance among Freeman Maples

Freeman maples (Acer x freemani 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 freemani/ 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.

474 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. lan- tana, 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.

475 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 siring 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/24-hr cycles of drought. Specifying 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.

476 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* Wendel. 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 *Miller and HORTSCIENCE, VOL. 32(3), JUNE 1997 509*

Growth Regulator Effects on Development of Three Bedding

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Plant Growth Regulators/Marketing—Floriculture/Foliage

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Application of Growth Retardants in Subirrigation Water

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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 resistance to the growth retardants Sumagic, Bonz, 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, Echinacea, Digitalis, Gaillardia, Phlox, Rudbeckia, Aconitum, Veronica, and Monarda. A randomized complete block design was implemented. Eight of the nine cultivars were responsive to Sumagic, with a 12% to 79% reduction in height. Seven cultivars were responsive to Bonz with a 20% to 61% reduction of height. 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’ demand 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 sexual propagation of poinsettia, but variability exists among cultivars in the development of axillary shoots under high day/night temperatures of central Florida. Thirty-eight and 44 cultivars 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 #3. 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 cultivars 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 at flowering was similar to controls after transplanting. Vinca plugs were sprayed with ancyclid at 5, 10, or 15 ppm either the 3rd week, 4th week, or both weeks after sowing. As ancyclid concentrations increased, plug height decreased, and the concentration effect was greater week 3 than at week 4. Two applications of ancyclid 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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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.

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ORAL SESSION 15 (Abstr. 478–484)

Plant Growth Regulators/Marketing—Floriculture/Foliage
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 0.95 mm (‘Ball 865’) to 0.79 mm (‘Supiib’. 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.

482 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’ poinsettia: (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 25.1 x 25.1 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.

483 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.

484 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 zone 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.

485 Plant Growth Regulators (GA, 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 Belows 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 (Solanum pennelli esculentum) in the presence and absence of SLW to mimic the TIR disorder induced by the SLW. Application of GA3 and internal and external TIR symptoms similar to the SLW-induced disorder in “Florida Pettie”. 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.

486 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 springtime disease of tomato during rainy weather conditions in California. Application timing as a calendar spray was compared to pre-anticipated rainfall treatments of either copper hydroxide alone or in a combined tank-mix with mancozeb. Trials 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.

487 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.

488 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 planned 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 (Tritium 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 the highest yield in the rye-tomato rotation. Bacterial speck/spot symptoms on foliage were reduced significantly in ST compared to CT during the 3 years. No major consistent trends in incidence and severity of bacterial and fungal diseases were found. Although the natural populations of Diaprepes abbreviatus (Fabricius) 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 sativus L. ‘Arkansas Littleleaf’ and Cucurbita pepo L. Seneca 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 7.3 insects in 28 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, Chauiognathus 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, Chauiognathus pennsylvanicus (Deg.) (Coleoptera: Cantharidae) and lady beetles (Coleoptera: Coccinellidae) in 1996 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.

489 Plant Diversity and Its Effects on Populations of Cucumber Beetles and Their Natural Enemies in a Cucurbit Agroecosystem
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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 the larvae. In previous tests, we demonstrate that female weevils stimulate 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.
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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, a causal agent of soft rot of potato. Erwinia isolates 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-methylsterase (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, 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.

84 ORAL SESSION 17 (Abstr. 493–499)
Breeding & Genetics—Vegetables

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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 As 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, yy, YYY1Y1Y2Y2, YYYY1
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 explant from 4-day-old seedlings were inoculated with Agrobacterium tumefaciens strain containing a disarmed 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 diploid (diploid), homoygous 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 comparative assays did leaf age affect ploidy determination. For that exception, a haploid at transplant stage was a diploid at the mature plant stage. 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.

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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 F₁,F₂ 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 perniciosa). 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.

501

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 (OAI-20 through OEI-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 NTI/YS-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.

502

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.
503 Evaluation of RAPDs for Identification of Selfed Progeny in Cultivated Cranberry
James J. Polashock* and Nicholi Vorsa; Rutgers Blueberry/Cranberry Research Center, Rutgers Univ., Chatsworth, NJ 08021
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)
Michael Wisniewski*, Tim Artlip, Carole Bassett, and Ann Callahan; USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430
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 my be related to 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.

505 Immunolocalization and in Vitro Cryoprotective Activity of PCA60: A Peach Dehydrin
Michael Wisniewski*, Ron Balsamo4, and Tim Close4; USDA-ARS, Kearneysville, WV 25430; 4Dept. of Biology, Chatham College, Pittsburgh, Pa.; 3Univ. California, Riverside, Calif.
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.

506 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.

507 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 2-D 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-S serum prepared from Japanese pear (Pyrus serotina). Two of six S-allelic products tested for P. avium could be also identified in the 2-D PAGE profiles, with roughly the same pl and M, as those of S-proteins of P. dulcis. Putative S-proteins P. mume and P. salicina were found in the area of 2-D 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-
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 plants (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 alternative method to the “sprouting rate” method.

Effects of Different Cytokinin-like Compounds on Invertase Activity during Potato in Vitro Tuberization

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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 and 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.

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 salted 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.

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-qt 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 growth regardless of the CO2 level tested. For example, fresh weight of spearmint increases of >250% can be obtained in by employing a 1-qt 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-qt 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.

Photoautotrophic Micropropagation of Tomato Plantlets

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‘HanaQueen’ tomato plantlets were cultured under conditions with different levels of sugar, photoautotrophic 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.

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) 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 (Niur 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%.

Effects of Cytokinins and Auxins on Shoot Propagation and Rooting of Vitis in Vitro
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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 numbers 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 BAV/L and 0.01 mg NAA/L was the best medium for explant rooting. The medium containing BAV and NAA encouraged better shoot growth than those containing BAV 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.

Effects of Nitrogen and Sucrose Level on the Regeneration of Cichorium intybus L. var. sativus
Hak Tae Lim and E.J. Park*; Division of Applied Plant Sciences, Kangwon National Univ., Chuncheon, 200-701, South Korea

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%.

Effects of Growth Regulators on Shoot Propagation and Rooting of Vitis Following in Vitro Axillary Bud and Shoot Apex Culture
Handan Büyükdemirci* and Paul E. Read; Department of Horticulture, Univ. of Nebraska–Lincoln, Lincoln, NE 68583-0724

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 numbers 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 BAV/L and 0.01 mg NAA/L was the best medium for explant rooting. The medium containing BAV and NAA encouraged better shoot growth than those containing BAV 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.

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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.

522 Evaluation of Mechanized Vineyard Production Systems for Barbera (Vitis vinifera L.) Grapes 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 machine 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 by 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 flowering. 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 infl orescences, had shorter stems, and less leaf area regardless of N levels. Plants receiving 50 mg/L N and some S produced infl orescences, 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.

524 The Effect of Light and Temperature on the Physiological Status of Bedding Plant Plugs during Short-term Low-temperature Storage
Elisatia Papanikou* and Paul H. Jennings; Dept. of Horticulture, Forestry and Recreation Resources, Kansas State Univ., Manhattan, KS 66506

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
Custódio M.L. Gago*, José A. Monteiro, and Mª Helena M. Rodrigues; U.C.T.A., Universidade do Algarve, Gambelas, 8000 Faro, Portugal

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.

526 Effect of Postharvest Temperature and Storage Duration on Growth and Flowering of the Phalaenopsis Orchid
Yin-Tung Wang*; Texas A&M Univ. Agricultural Research and Extension Center, 2415 East Hwy. 83, Weslaco, TX 78596

On 6 Sept. 1996, container-grown vegetatively propagated Phalaenopsis '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.
94 ORAL SESSION 22 (Abstr. 528–534)  
Culture & Management—Vegetables

528 Effect of N Source on Photosynthesis and Plant Dry Matter Yield of Tomato  
Wayne F. Whitehead* and Bharat P. Singh; Agricultural Research Station, Fort Valley State Univ., Fort Valley, GA 31030-3289

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·ha⁻¹ N spring, 3) 0 N winter/180 kg·ha⁻¹ N spring, 4) 0 N winter/abruz 90 kg·ha⁻¹ 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 μmol CO₂/m²/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  
Elizabeth T. Maynard*; Dept. of Horticulture, Purdue Univ., Hammond, IN 46323

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 (Ca(NO₃)₂), urea ammonium nitrate (UAN), and ammonium nitrate (NH₄NO₃) 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 K/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 Ca(NO₃)₂; early and marketable yields showed similar trends, but differences were not consistently significant. UAN and NH₄NO₃ pepper yields were usually similar to yield with Ca(NO₃)₂, 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 NH₄NO₃ plots had more BER (0.5% to 1%) than Ca(NO₃)₂ 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·ha⁻¹ in 280 to 561 L·ha⁻¹ H₂O 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 ≤ 0.05). Residual soil concentrations of NO₃-N and K were higher (P ≤ 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–7.97K 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.

532 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·L⁻¹, further P additions up to 90 mg·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·L⁻¹ improved the response of shoot growth to any level of P, but adversely affected root growth compared to N at 60 mg·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 cm² in a 10.9-cm³ cell volume. Only 30% of the plants produced with 0 P could be pulled from the transplant flats, compared to ~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·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.
533  
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.

534  
Hydropnic 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 productivity of basil plants grown hydroponically using easily acquired common hydroponic media and supplemental lighting. Fresh basil was harvested weekly and marketing information was obtained. A post harvest shelf-life test was also conducted. The data indicated that the basil plants were productive in the greenhouse longer than the grower's expected duration. While there were differences in yield, the basil plants grown hydroponically were competitive with greenhouse grown basil grown using alternate systems. Marketing information showed that basil plants grown hydroponically were competitive with market demand. If continuous production of basil was established, it would be a cost effective and efficient means for B fertilization in plants.

535  
The Phloem Mobility of Boron Alters Symptom Expression and Management of Boron in Plants  
P.H. Brown* and H. Hu; Dept. of Pomology, Univ. of California, Davis, CA 95616  
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 occur 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, apple, and plum were exposed to high B in the growth medium, and margin burn. In species in which B is mobile, these symptoms do not occur. B toxicity symptoms always occur in the old leaves first, typically exhibiting tip and margin burn. In species in which B is mobile, these symptoms do not occur.

536  
Remobilization of Nitrogen from Storage Pools of Mature Apple Trees Depends on Nitrogen Status  
H. Khemiria, T. Righetti, and A. Azarenko; Dept. of Horticulture, Oregon State Univ., Corvallis, OR 97331  
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.

537  
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. These 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.

538  
Uptake and Translocation of Fall- and Spring-applied Zinc in Baring Apple Trees  
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A zinc timing study was carried out on 'Jonagold' EM26 trees using labeled zinc chloride (98.8 atom% Zn-68). In the fall, five spurrs with strong flower buds on each of five trees were labeled with a micropet 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.

539
Effect of Water and Nutrient Stresses on Apple Rootstock Growth, Respiration, and Capacitance
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We are evaluating techniques for measuring intact root stock (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 respiration and growth 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 mini-rhizotron video camera inserted into Petri/dish tubes transsecting 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 µmol CO$_2$/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).

540
Effect of Sampling Date and Production Zone on the Predictive Capacity of Bitter Pit through Magnesium Infiltiration in 'Granny Smith' and 'Braeburn' Apples
Jorge B. Retamales and Claudio Valdes; Escuela de Agronomia, Universidad de Talca, Casilla 747 - Talca, Chile
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 infiltreated of the fruit in commercial orchards of three locations in South Central Chile: San Fernando (SF), Curico (CU), and San Javier (SJ) was established.

541
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, Crenomelina spp. However, questions still remain about how these factors influence disease incidence in 'French' prune, Prunus domestica. In 1991, we established a 3.64-ha plot in Winters, Calif., to determine the effects of nitrogen (N) fertilization 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 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.

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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 content 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 ‘Tifway’; ‘Tifway’; perennial ryegrass, Lolium perenne L. ‘Medalist X Blend’; St. Augustine-grama, Stenotaphrum secundatum (Walt.) Kuntze ‘Seville’; and zoysiagrass, Zoysia japonica Steud. ‘El Toro’ and Zoysia japonica ‘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 g·kg$^{-1}$ and 2.0 g·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 medium surface charged-polymer treatments under subsurface irrigation had much higher turf quality, even in a severe winter period. The parameters needed to prepare WOS, this method can reduce maintenance fee and procedures such as Charged-hydrophilic Polymers or Foliar Spray under Two Irrigation Systems

546 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 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.

547 In Vitro Regeneration of Buffalograss [Buchloe dactyloides (Nutt.) Engelm] through Immature Inflorescence Culture Shuzhang Fei1, Paul E. Read2, and Terrance P. Riordan; Dept. of Horticulture, Univ. of Nebraska, Lincoln, NE 68583-0724

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 produced 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.


Postharvest 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-light chopping apparatus was used as a flow-through chamber system and the exit gas stream analyzed for each commodity with and without addition of ethylene (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-isobutythiazole, whereas, ‘CPT-5’ fruits showed significant increases in hexanal, 2,3-methylbutanol, trans-2- heptenal, 6-methyl-5-hepten-2-one, 2-isobutythiazole, β-ionone, geranylacetone, and a decrease is ethanol concentration. In both cultivars, these significant differences in important aroma volatile compounds could be of enormous relevance in the perception of off-flavor or off-odors.

550 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 extracts 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 pectins 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.

551 Qualities of Hot Water- and Calcium-treated Tomatoes after Storage

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Mature green tomatoes (cv. Vibeco) 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 combined 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).

552 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 μL/L ethylene at 20C. 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.

553 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 fifth-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.

554 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 salinity 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 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.

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.

Nutrient 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.

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 concentration 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 450 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 (3.8) 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.

The Effects of Nitrogen on the Growth, Development, and Medicinal Compound Yield of the Sundew Drosera adelae

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Drosera adelae are used in alternative medicine as sources of the beneficial naphthoquinone compounds plumbagin (5-hydroxy-2-methyl-1,4-naphthoquinone) and 7-methyl naphthoquinone. 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 peat moss. 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.

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 by 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.

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, melon, 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, row planting, spacing, and type of fertilizer used. Survey results will be presented.

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Multi-site Thinning Comparisons with 'Empire' and 'McIntosh' Apples


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 Benzyladennin 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, Endothal 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 endothal 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.

567 Cropping and Fruit Growth in Redchief ‘Delicious’: An Analysis of the Effect of NAA and Cytokinins

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 69% 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’.

568 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):GA₃₊₅] at 75 ppm BA were studied. Silvet L-77 was used at 0.027% (v/v). Regualid and ultralene 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 800 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 Regualid 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.

569 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

570 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-sorbitol 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.

571 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 GA₃₊₅ (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 flowering 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)

572 Fruit Set & Seed Quality–Vegetables

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 [Citrus lanatus (Thunb.) Matsum. & Nakao] 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 (T1); 1.0ET until fruit set followed by 0.6ET until final harvest (T2); 1.0ET until fruit set followed by 0.6ET until first fruit maturity followed by 0.4ET until final harvest (T3); 1.0ET until fruit set followed by 0.6ET until first fruit maturity followed by 0.2ET until final harvest (T4). In 1996, two irrigation rates were constant 1.0ET (T1) and 0.5ET (T5), 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 (T1) and 371 mm (T2) of irrigation water, respectively, were applied in Spring 1995, and from 90.3 to 80.9 Mg ha–1 when 881 mm (T1) and 577 mm (T2) 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.

573 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 fruit 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 increased 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.

574 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’, ‘Deltec’, ‘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 affected vine decline symptom expression. In a Fall test, with lower temperatures during fruit maturity, symptoms were delayed, and all treatments and often absent in treatments with no fruit load. Vine decline symptom expression was greatly affected 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.

575 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-sterile 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 dramatically when experienced by male reproductive tissues than when experienced only by female reproductive tissues.

576 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; Hallstones 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. Hallstones, M.D. and Smith, M.T. (1989) Seed Sci. Technol. 17: 649–658. Zhang et al. (1993) Seed Sci. Technol. 21:359–373.]

577 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 prevented 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 521245 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 wall’s 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.

579
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-osmprimed 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 250 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.

581
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 (TVN) 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 TVN 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 classroom 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.
A 200-level course at Iowa State Univ., Principles of Horticulture, has included a communication across the curriculum assignment for the past seven semesters. A 2, and Lee-Ann M. Kastman; 2; 1 Dept. of Horticultural Science and 2; 1 Dept. of Plant and Soil Science, The Ohio State Univ., Columbus, OH 43210

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/hr/hr.html)

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.

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.

Leadership Perspectives in Horticulture: Meeting the Needs of Horticulture Students Through Interdisciplinary Education
Jayne M. Zajicek and Christine D. Townsend; Depts. of Horticultural Science and Agricultural Education, Texas A&M Univ., College Station, TX 77843-2133

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.

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.

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 to campus to present their opportunities. A detailed packet of information is distributed to the perspective intern and coordinator. 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
could increase potato yields. Excessive water, as well as limiting water, reduced 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 final interview with each student is done with the internship coordinator and a S/F grade is assigned.


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 VP&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 (Ep) 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 outside 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 to 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.
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 5 years. For the 2 years, 4 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 5 years. For the 2 years, 4 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 5 years. For the 2 years, 4 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 5 years.
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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Rubisco (Ribulose 1,5-bisphosphate carboxylase/oxygenase) initiates the photosynthetic carbon metabolism; therefore, its activity has been measured in many physiological studies. However, there is no consistent information on leaf Rubisco activity from leaves of deciduous fruit crops. The objectives of this greenhouse experiment were to determine the effects of elevated CO₂ on growth, mineral nutrition, and gas exchange physiology of Citrus Rootstock Seedlings

601 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 four commercial Citrus rootstocks. We grew well-watered and fertilized seedlings of 'Volkmann' 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 least vigorous 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). 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%, and 1.5% were applied to whole trees with an airblaster 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. Chlorsis 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 between petroleum and soybean oil. Below a residue of 0.15 mg cm⁻², foliar phytotoxicity did not occur. Reductions in A 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 vase. 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 Paradax Hybrid Root
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Fifty trees each of 1-year-old Paradax rootstock June-budded to ‘Chandler’ walnut and 2-year-old Paradax 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 different in trunk circumference between the 1- and 2-year-old rootstocks following the second or third growing seasons.

605 Walnut Rootstock Comparison and Own-rooted ‘Chandler’ vs. ‘Chandler’ on Paradax 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 Paradax rootstocks. Trees growing on both Paradax 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 larger 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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Epidermic 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 Nov.) 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 witting 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.

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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 fewer fresh weight increases than controls, the actual growth depending on both the concentration of ABA present and the time of 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.

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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.

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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 root 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.

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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 shadecloth 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 SpinOutTM, 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.

Effect of Cynodon dactylon and Amaranthus sp. Leachates on the Growth of Carya illinoinensis Seedlings

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Leachates of living Cynodon dactylon (L.) Pers. and Amaranthus sp. were applied to Carya illinoinensis (Wangen.) 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.

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 run-off 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.

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 methods, and four growing media produced optimum growth of flowering vinca, Catharanthus roseus. Irrigation systems used included ebb-and-flow, drip, and pulse; fertilization methods included slow release, prepackaged, and custom mixed; and the four growing media were peat moss/perlite vermiculite (1:1:1, by volume), peat moss/rockwool (1:1, by volume), and 0.6-cm diameter shredded rubber or fabric from wastetires; 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 basins were irrigated once per day for 15 s. Pulse-irrigated basins 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-flow basins 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-flow irrigation/shredded tire growing medium were comparable to plants grown in the peatmoss/rockwool medium with the same fertilizer and irrigation methods.

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.

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 WSF 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.

Co-blended Composts for Production of Potted Poinsettia

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Production of ‘Top White’, ‘Petersan 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 PSS polymer dewatered biosolids (PSG), lime dewatered biosolids (CP), yard trimmings.
(YT), poultry litter (PL), and municipal solid waste (MSW Bedfordminster). 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 93%, 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 the 67% level; PSG:YT at the 50% and 67% levels; and PL:YT blend at the 33% level.

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Comparison of Three Sprinkler Designs for Cold Protection in Shadecloths

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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 [Phyllorhiza adiantiformis (Forst.) Ching.]) growing in shadecloths. Treatments were applied in a 3 X 3 latin square design to nine 29 X 29-m post-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 2.8-mm orifices, were operated at 0.25 Pa, and applied 0.5 (rotating stream, rotary) and 0.54 (wedge-drive) cm h\(^{-1}\) of water. During an advective freeze with wind speeds up to 19 m s\(^{-1}\) and temperatures to –2°C, there were no temperature differences due to treatments. During a radial 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.

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Characterization of ENO2 cDNAs in Maackia amurensis Rupr. & Maxim. (Amur Maackia)

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ENO2 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 ENO2 in a nodulating, woody legume. A 561-bp MaENO2 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 dye-sequencing and analyzed for identity to other genes with the Genetics Computer Group (GCC) program. The cDNA clones show 68% to 74% identity at the nucleic acid level with ENO2 genes of Sesbania rostrata Brem. & C. C. Brem., 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 Cadrastis kentukiae (Dum-Cours.) Rudd (American yellowwood) and Sophora japonica L. (Japanese pagadorea).

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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-kil 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 biochemical 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 (dT11, VN) or variable (dT11, VN) anchor primers (where V = dA, dG, 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 dCTP2 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.

622 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 tissue-dependent. For most species, extraction of DNA from freshly harvested young leaf tissue resulted in the highest DNA yields. However, DNA yields from 'Sellaratum', 'Atlanticum', and 'Viccosum' 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, tmrK, and 18S 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 × *P. canescens*, *P. tremuloides* × *P. trumula*, and *P. tremuloides* × *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* × *P. canescens* callus were 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* × *P. trumula*, and *P. tremuloides* × *P. davidiana* hybrids at frequencies of only 2% to 3%. The calli regenerated from *P. tremuloides* × *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* × *P. trumula* 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.

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Postharvest Physiology–Fruits/Nuts

624 What Components of Chlorophyll Fluorescence are Related to Storage Scald in Apple?

N.A. Mifur, M. Wendorf, and R.M. Beaudry; Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824

Chlorophyll fluorescence of three cultivars of apple, representing fruits that are considered highly susceptible ('Cortland'), moderately-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 (F₀), maximum fluorescence (Fₘ), and the ratio of (Fₘ – F₀)/F₀, and various quenching components of variable fluorescence were measured at regular intervals during storage. The maximal level of fluorescence (Fₘ) 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 Fₘ 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 radicals (a possible cause of apple scald) scavenging system during storage will also be presented.

625 Does Enhanced Removal of Active Oxygen Species Contribute Resistance to Superficial Scald in Apple Fruits?

Rao V. Mulpuri and Chris B. Watkins; Dept. of Fruit and Vegetable Science, Cornell Univ., Ithaca, NY 14853

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 to scald and susceptible to scald. Further, H₂O₂ levels rose in scald-susceptible fruits that are susceptible to scald. Further, H₂O₂ levels rose in scald-susceptible fruits 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 Fₘ was found to be related to scald development during storage.

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Scald-related Volatiles in the Epicuticular Wax of Apple Fruit
S. Wee1 and R.M. Beaudy; Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824
Volatiles produced by apple (Malus domestica Borkh) fruit partition into the cuticle and epicuticular waxes and may play an important role in superficial scald development. 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 development. Volatiles from the epicuticular wax of 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 oxidative 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 Exposure
Harold N. Fonda1, John K. Fellman1, X. Fan2, and J.P. Mattheis2; Dept. of Horticulture and Landscape Architecture, Washington State Univ., Pullman, WA 99164; 1USDA/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 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 oxidative 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.

628 Temporal Relationship between Ethylene and Ester Production during Maturation of Apple Fruit
J.P. Mattheis1, 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 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 volatile esters 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 µL 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 Production
J. Song1, M.S. Tian2, D.R. Dillen1, and R.M. Beaudy2; 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-Methylecyclopropane (1-MCP), an effective ethylene action inhibitor, was used to study the relationship between volatile biosynthesis, ethylene action, and fruit ripening in Golden Delicious apples. 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
Weimin Deng1, Jun Song2, and Randolph M. Beaudy; Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824
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, 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 25.6-, 1.7-, and 1.4-fold higher, respectively, for fruit in glass container. The sorption of α-farnesene and other volatiles into LDPE film is evidently considerable, altering the aroma profile of packaged produce relative to a flow-through system.
were smaller (10%) and more uniform in the split trellis system. Occurrence on the middle third of the cane and decreased in length progressively in initiation or any combination thereof. In both trellis systems, the longest laterals or lateral lengths between the two systems, this increased productivity was due to increases in berry number per cane. These data suggest that the canopy is more efficient with this type of trellis. 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. Reduced fluorescence parameters Fo, Fm, Fv, T1/2, and Fq of the cold injury treatment and occupied 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.

Effect of the Split Trellis on Growth and Yield of Red Raspberry (Rubus idaeus)
Stephen F. Klauer, J. Scott Cameron, and Chuhe Chen; Washington State Univ. Research and Extension Unit, Vancouver, WA 98665
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.

Field Assessment and Physiological Analysis of Cold Damage to the Red Raspberry Fruitling Cane and to Fruit Yield
Chuhe Chen, J. Scott Cameron, and Stephen F. Klauer; Washington State Univ. Research and Extension Unit, Vancouver, WA 98665
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 of red raspberry. 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 F0, Fm, Fv/Fm, Fv/Fm’1/2, and Fv 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.

Hydrogen Cyanamide Stimulates Early Foliation of ‘Misty’ Southern Highbush Blueberry
J.G. Williamson and R.L. Darnell; Horticultural Sciences Dept., IFAS, Univ. of Florida, Gainesville, FL 32611-0690
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.

Lowbush Blueberry Response to Phosphorus-containing Fertilizers: Assessment by Leaf Phosphorus Concentration and Content
J.M. Smagula* and S. Dunham; Horticulture Program, Univ. of Maine, Orono, ME 04469-5722
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 was defined and utilized in the hardness determinations. Samples were collected from July from three 0.03 m² quadrats per treatment plot indicated MAP and DAP had no effect on dry weight of stem tissue, but increased average dry weight of leaf tissue. 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.

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 hardness changes in different parts of the cranberry plant (leaves, stems, buds, flowers, fruit). Stages of bud growth were defined and utilized in the hardness 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 hardnesses between 0 and –2°C by late spring. 2) In the terminal bud 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% blush 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 hardness, and canopy temperatures (heat units).
Cold Tolerance of Cranberry Flower Buds Differs by Cultivar and Developmental Stage
Carolyn DeMoranville* and Irving Demoranville, Univ. of Massachusetts Cranberry Experiment Station, Glen Charlie Road, East Wareham, MA 02538

Cold tolerance of cranberry flower buds from four cultivars was evaluated using potted plants collected from commercial cranberry beds. The plants were evaluated weekly 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 late 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-°C 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.

Germination Characteristics of Thin-leaved Huckleberry (Vaccinium membranaceum)
Danny L. Barney*; Dept. of Plant, Soil, and Entomological Sciences, Univ. of Idaho, Moscow, ID 83844-2339

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.

Characterization of Ice Nucleation and Propagation in Bean (Phaseolus vulgaris cv. Bush Blue Lake) using Infrared Video Thermography
Michael Wisniewski*; USDA-ARS, 45 Wiltshire Road, Kearneysville, WV 25430

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 was 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.

Effect of Reduced Temperatures on Melon Transplant Subsequent Growth and Survival
D.L. Lange*; Dept. of Horticulture, Purdue Univ.–Southwest Purdue Agricultural Program, Vincennes, IN 47591

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.

Duration and Persistence of Heat Shock Induction of Chilling Tolerance in Cucumber Seedling Roots
Hua Zhang* and Paul H. Jennings, Dept. of Horticulture, Forestry and Recreation Resources, Kansas State Univ., Manhattan, KS 66506

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.

Effects of Chilling and Ethanol Treatments on the Antioxidant Systems of Cucumber Seedling Roots
Windy A. Boyd* and Paul H. Jennings; Dept. of Horticulture, Forestry and Recreation Resources, Kansas State Univ., Manhattan, KS 66506

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 anesthetic, 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.

644 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.

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645 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 Autonoma Agraria "Antonio Nario" in 1995 and analyzed at CIHNOR, 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 rate (CGR), rate of crop growth (RCG), relative growth rate (RGR), leaf area index (LAI), and net assimilation 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.

646 The Effect of Four Composts on the Establishment of Vescicular–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 a 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.

647 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 physicochemical 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. 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 6–9 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.

648 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 as 1 M/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 4.5 to 5.6 M/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 microbially interactions. Although an economic analysis of this project has not yet been completed, a rough estimate of tillage costs at $25 per ha per ha suggests that, in the field with only 1 M/ha yield reduction, the reduction in tillage costs would offset the yield reduction in corn (valued at $85/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-tiled areas within a permanent pasture. These techniques include cultivation, plastic mulches, and herbicides applied to 2-m strips separated by tillled 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.

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ORAL SESSION 39 (Abstr. 651–665)

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 information), 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), FarmiFOODS (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 (>1300 pages and 8000 index entries) derived from New Crops symposia 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 directed 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 9http://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.

654 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.

655 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.


656 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 reset ‘Lisbon’ lemon trees (Citrus limon) on a Carizzo range 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.

657 Isolates of Arbucyscular 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, −0.08, 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.

658 Phosphorus-induced Leaf Abscession in Olive and Citrus Expalnts
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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 KH2PO4, with or without AVG and NBD (alone or in combination), but was more pronounced when KH2PO4 was applied alone. In citrus, the effect of KH2PO4 alone on the induction of leaf abscission and ethylene production was much stronger than that observed in olive. However, in the presence of NBD, KH2PO4 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 KH2PO4 on the ethylene-independent induction of leaf abscission in olive is not a general phenomenon and may differ in different species.

659 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 ^14C-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%).

660 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 ± 4.3% with a 95% confidence interval. Respondents indicated that 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 grower 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.

661 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-or-der nitrogen fertilizers. Phosphorus mobility in 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-or-der nitrogen fertilizers. Lush

real phosphorus for a freeze with minimum temperatures of –2°C for at least 4 hr, and 9°C for at least 24 hr, and 13°C for at least 8 hr. 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%).

662 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 (Pn) 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 Redklood) 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; 6 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 Pn 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 Pn rates (50%) than ambient CO2 plants. Treatment effects on leaf carbohydrate levels and Pn 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.

663 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 understory that is normally shaded when traditional overhead lighting is used. Early results with cowpea (Vigna unguiculata L. Walp ‘787D-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 current 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 (YER = gDW edible x m–2 x day–1), and energy conversion efficiency (ECE = EYR x [kW·h]) 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.]

664 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 μmol·m⁻²·s⁻¹), two photoperiods (16 and 24 hr), and two CO₂ levels (400 and 800 μmol·m⁻³) 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 significantly increased 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.

665 Influence of Ambient UV Radiation on Growth and Flavonoid Concentration of ‘New Red Fire’ Lettuce
Donald T. Krizak, Steven J. Britz, and Roman M. Mirecki; Climate Stress Laboratory, NRI, ARS/USDA, Beltsville, MD 20705-2350

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 Llumar (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 fi lters—UV transparent tefzel (10%T, 245 nm), UV-B-absorbing polyester (10%T, 319 nm), or UV-A and UV-B-absorbing Llumar (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-8 filter 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 μmol·m⁻²·s⁻¹), two photoperiods (16 and 24 hr), and two CO₂ levels (400 and 800 μmol·m⁻³) 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 significantly increased 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.

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 μmol·mol⁻¹ CO₂. Tomato (cv. Red Robin and Reinman Philip 75/59) were grown at 400, 1200, 5000, or 10,000 μmol·mol⁻¹ CO₂, and wheat (cv. Yecora Rojo) and potato (cv. Denali) were grown at 400, 1000, or 10,000 μmol·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 μmol·mol⁻¹ CO₂, whereas tomato density was highest at 1200 μmol·mol⁻¹ CO₂. Potato had the lowest density at 1000 μmol·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.

667 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 improve 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 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, 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)
Jan E.P. Debaene1 and I.L. Goldman; Dept. of Horticulture, Univ. of Wisconsin–Madison, Madison, WI 53706

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 weight and time to pupation. Silk tissue (P ≤ 0.05) reduced 10-day larval weight by 65% and increased the time to pupation by 4.0 days compared with the cellulose control. Genotypes variously affected (P ≤ 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, CHCl3, 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 flavanol and three anthocyanidin-3-glycosides (UV spot color and color shift with NH3) were 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 BC2F1 populations with dgs (dark green savoy leaf) and blu (blue flower) induced mutants was developed with a Florida breeding line 7-1404 and 5-593 as the recurrent parent. In addition, a BC2F1 population with the y (yellow 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 where its 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.

672 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 phaselin 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) measure the genetic distance and genetic diversity between nuña and other Andean bean populations.

673 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 × PI 319441) × 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 ETc) were applied to three varieties (Butte, Carmel, and NonPareil) of almonds (Prunus dulcis (Mill) D. A. Webb) planted in 1981 on a 3.65 x 5.47-m spacing (550 trees/ha) on Arbuckle gravelly fine (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 0–97, 0–198, 0–454, 113–907, 170–1361, 227–1814, 227–1814, 170–1361, 113–907, 113–907, 907–0, 907–0, and 907–0 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 ETc 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 differences and evaluate need for other nutrients.

676 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.

677 Yield and Root Growth Responses of Papaya to Partial Root Volume Irrigation by Drip or Microsprinkler Irrigation Systems  
Thomas E. Marler* and Haluk M. Discekici; College of Agriculture & Life Sciences, Univ. of Guam, Mangilao, GU 96923

'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 wall 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 morphological 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.

678 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°C) and ambient day (above 10°C) temperatures did not affect stomatal conductance (g), leaf (Ψl), and xylem (Ψw) water potentials of potted olive trees. Tree Ψl and Ψw decreased when exposed to low night and day temperatures (8°C), but g 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, Ψl, Ψw, and g immediately decreased. After the first day, g and Ψl started to recover while g was maintained at low levels, thus allowing for tree rehydration. Root hydraulic resistance (rroot)—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 Ψl and rroot 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.

679 Seasonal Fluctuation of Promoters and Inhibitors of Adventitious Root Formation in 'Nabali' Olive Shoots  
Mostafa M. Qrunfleh* and Khalid A. Amr; Dept. of Plant Production, Faculty of Agriculture, Univ. of Jordan, Amman, Jordan

Four fractions from known dry weights from buds or leaves of 'Nabali' olive shoots—nonacide ethylacetate (F1), acidic ether (F2) and acidic-n-butanol (F3) were obtained for several sampling dates. A fourth fraction (F4) from F1, F2, and F3 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 mung bean bioassay in all four extracts. F1 contained rooting promoters located at Rf 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. F2 from buds and leaves showed neither promoting nor inhibitory activities. F3 (from buds or leaves) contained promoters of rooting located at Rf 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. F4 from buds and leaves showed root-promoting effects from November to April. The promoting effect of F4 was greatest in buds and leaves sampled 9 Dec. and 4 Feb., respectively.

680 Somatic Embryogenesis and Plant Regeneration from Roots
of Punica granatum L.
Shalaja Sinha and Madhuri Sharon*; C.C. Shroff Research Inst., S.V. Road, Excel Estate, Goregaon(W), Bombay-62, India

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
Amy Jo Waldorf* and James E. Klett; Dept. of Horticulture and Landscape Architecture, Colorado State Univ., Fort Collins, CO 80523

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.

682 Pot-in-pot Production and Cyclic Irrigation Influences Growth and Evapotranspiration of ‘Okame’ Cherry
John M. Ruter*; Dept. of Horticulture, Univ. of Georgia, Coastal Plain Experiment Station, Tifton, GA 31973-0748

A study was conducted with Prunus 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 6:1 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.
Extra' and shipping and greenhouse growth were useful for culture of ping process. Sealed-membrane vessels for micropropagation, decontamination, photoautotrophically in hydroponic culture in the greenhouse, following transport in positive net carbon assimilation in the dark shipping environment. Changes provided energy for these CAM plantlets to continue carbon fixation, resulting concurrent with increased shoot dry weight. It is likely carbohydrate catabolism Sucrose, glucose, and fructose reserves established on sugar-containing media dry weight of whole plantlets. However, shoot dry weight did increase significantly. the United States in the dark in a plastic tray and arrived without changes in fresh or remaining in membrane vessels were shipped (7 days at 14–30°C) from Japan to 5% bleach solution. Proper decontamination treatment did not effect carbohydrate and gas to plant material inside the vessels. During tissue culture on sugar-contain- propogated in sealed, three-dimensional polypropylene vessels with microporous, Unib., Clemson SC 29634

Micropropagation, Decontamination, Transcontinental Ship- ping and Hydropnic Growth of Cattleya while Sealed in Semi- permeable Membrane Vessels

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Two varieties of Cattleya orchids (C. Lodiddgesii ‘Ele’ x C. Lodiddgesii Alba ‘Extra’ and Brassolaeliocattleya. Mem. ‘Helen Brown’ Sweet Alton) were micropropogated 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 micropropogation, 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.

688
Micropropogation of Wetland Plants: Sagittaria latifolia
Michael E. Kane* and Charles Lane; Environmental Horticulture Dept., Univ. of Florida, Gainesville, FL 32611-0670

Many wetland plant species used for aqscaping 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. Micropropogation 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 Wild. (Dock-potato), a rhizoma- tous 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 µM 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. Dock-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 µM BA for 28 days. However, repeated subculture on BM supplemented with greater than 2.5 µM 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 µM 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 corn formation in Sagittaria latifolia may be mediated by photoperiod.

689
Flowering Patterns of Reverse Pinwheel Chimeras Produced dur- ing in Vitro Culture of Saintpaulia ionantha ‘Silver Summit’
Sharon K. Sandal* and R. Daniel Lineberger; Dept. of Horticulutural Sciences, Texas A&M Univ., College Station, TX 77843-2133

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 which had very different color patterns. The off-types varied in color, one with deep violet-blue stripes and white margins. The off-types varied in color, one with deep violet-blue stripes and white margins. These provenances only required 30 days stratification with continuous light 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%).

690
Effect of Different Organic Compounds and Medium Consistency on Temperate Orchid (Orchidaceae) Micropropogation
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The effects of organic compounds most commonly used for orchid micropropogation 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. E. Zies 1993) supple- mented 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.

691 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 Wild. (Duck-potato), 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 northerly ecotypes.

692 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. grandulifera, S. hookeri, and S. ramosissima 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 greenhouse 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.

693 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 seedlings. 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

694 Introggression 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 18°C growth chamber. F. vesca, F. nigeriensis, F. nubicola, F. viridis, F. orientalis, and F. moschata have been incorporated into synthetic octoploids in this study.

695 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 infl orescences 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.

696 Growth Response to Orchard Replant Disorders in Some New Malus Rootstocks

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Orchard replant disorder (ORD) is a widespread soil-borne 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, G169, 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 ≤ 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.

697 Colchicine 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 divided 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 chimeras 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.

698 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 where 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.

699 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 callus was developed by us (Murati et al., 1998). The number of embryos induced was too low for commercial application. [Murati 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.

701 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 80%. 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 populations have 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.

702
Rescuing Irrigated Desert Agriculture
Russell Clemings*, The Fresno Bee, 1626 E. St., Fresno, CA 93786
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.

703
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 quality problems such as doubling and deep sunburn, 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.

704
Leaf and Root Growth in Relation to Water Status
Theodore C. Hsiao*, The Fresno Bee, 1626 E. St., Fresno, CA 93786
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 salable 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. Fruit set 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 photosynthetic 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 μmol 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, if 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.

710
Photoassimilate Production and Distribution in Stone Fruit
J.A. Flore* and Desmond Layne*; Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48824; 2Atwood Research Facility, Kentucky State Univ., Frankfort

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 discuss assimilation rates for the major Prunus species and general dry matter allocation patterns, with emphasis on environmental and biological factors that affect photosynthesis, partitioning, and control. The following factors will be covered: annual growth, changes with tree age, environmental and biological factors that affect photosynthesis, genetic factors, water, light, fruiting, and pruning.

711
Modification of Carbohydrate Content in Developing Tomato Fruit
Arthur A. Schaffer*, Marina Petrekov, Daphne Miron, Miriam Fogelman, Moshe Spiegelman, Zecharia Bnei-Moshe, Shmuel Shen, David Granot, Rivka Hadas, Nir Da, Moshe Bar, Michael Friedman, Meir Pilowsky, Nehama Gilboa, and Leah Chen; Inst. of Field and Garden Crops, APO-Volcani Center, Israel

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
D.M. Phar*; R.T.N. Prata, J.B. Jennings, J.D. Williamson, E. Zamski, Y. Tamamoto, and M.A. Conkling; Dept. of Horticultural Science and Genetics, North Carolina State Univ., Raleigh, NC 27690

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.

713  
Aspects of Carbohydrate Partitioning in Ornamental Geophytes  
William B. Miller 1, Arul P. Ramana 2, Garry Leggner 3, Merel Langens-Gerrits 3, Geert-Jan de Kleer 3, Johannes Ekelmann 1, and Michael Ernst 3  
1Dept. of Horticulture, Clemson Univ., Clemson SC 29634; 2Bulb Research Centre and 3Centre for Plant Tissue Culture Research, Lisse, The Netherlands; 4Inst. für Obst, Gemuse, und Weinbau, Univ. Hohenheim, Stuttgart, Germany

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, glucocmanan, etc.), and growth habit (e.g., synanthous vs. hysteranthous 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 glucocmanan metabolism in in vitro-grown Lilium bulbils, 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

714  
HortBase: A Global Information System for Decision Support  
J.L. Green 1, D. Hannaway 2, J. Matyjonek 3, A. Duncan 4, E. Liss 5 and K.J. Starr 6  
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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.

715  
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.

716  
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) Increasing 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.
help in the development and maintenance of this rising star so that it truly reaches its full potential.

718 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.

719 ASHS Publications Department Role in Implementing HortBase
Michael W. Neff*, ASHS, 600 Cameron Street, Alexandria, VA 22314-2562

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
R. Daniel Lineberger*, Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133

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
E.F. Gilman* and H. Beck; Dept. of Environmental Horticulture, Univ. of Florida, Gainesville, FL 32606

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.

722 Developing, Converting, and Maintaining Information-rich Resources on the Web
Mary M. Peet*; Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695-7609

“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.

723 HortBase: Providing a Foundation for Education
Roger Kjelgren* and Larry Rupp; Dept. of Plants, Soils, and Biometerology, Utah State Univ., Logan UT 84322

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.
724 Curriculum Adjustments at Michigan State
John F. Kelly; Dept. of Horticulture, Michigan State Univ., East Lansing MI 48824-1325

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.

725 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
John K. Fellman; Horticulture and Landscape Architecture, Washington State Univ., Pullman WA 99164-6414

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 nature and amount of volatile compounds are cultivar- and strain-dependent. Biosynthesis of volatile compounds occurs via several biochemical pathways. Established or suggested for most of the important flavor components, of which lipoygenase (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 cis-3-hexenal and hexanal, which are oxidized to hydroperoxides by lipoygenases, which are then cleaved to volatile C6 aldehydes (hexanal and cis-3-hexenal, respectively). There are two membrane-associated lipoygenases (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 compound product of the Adh2 gene is induced by 3%, and is developmentally expressed in fruit. Naturally occurring mutants and genetically engineered tomatoes with reduced ethylene production, color and/or retarded ripening patterns show changes in volatile concentrations.

727 The Composition of Strawberry Aroma as Influenced by Cultivar, Maturity, and Storage
Charles F. Forney* and Willy Kalt*; Agriculture and Agri-Food Canada, Atlantic Food & Horticulture Research Centre, 32 Main St., Kentville, NS, B4N 1J5, Canada

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.

728 The Biochemistry and Control of Cell Disruption-dependent Aroma Generation by Tomatoes
E.A. Baldwin*; USDA-ARS Citrus and Subtropical Products Lab., P.O. Box 1909, Winter Haven, FL 33883-1909

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 lipoygenases, which are then cleaved to volatile C6 aldehydes (hexanal and cis-3-hexenal, respectively). There are two membrane-associated lipoygenases (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%, and is developmentally expressed in fruit. Naturally occurring mutants and genetically engineered tomatoes with reduced ethylene production, color and/or retarded ripening patterns show changes in volatile concentrations.
associate 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.

730 Synthesis of Volatile Flavor Components in Food Crops during Cooking
Stanley J. Kays* and Yan Wang; Dept. of Horticulture, Plant Sciences Bldg., The Univ. of Georgia, Athens, GA 30602-7273
Using the sweetpotato as a model, we identified precursors of critical flavor volatiles by fractionation, 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 thermophilic reactions will be discussed, as well as 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
John A. Juvik*; Dept. of Natural Resources and Environmental Science, Univ. of Illinois, Urbana, IL 61801
Investigating 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 F2 population derived from a cross between two sweet corn inbreds that differed in kernel characteristics was 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.
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
Warren C. Silfen*; Dept. of Fruit & Vegetable Science, Cornell Univ., Ithaca, NY 14853-5908

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. NO3-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 indicated 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
G.H. Neilsen1, D. Neilsen1, and F. Peryea2; 1Pacific Agri-Food Research Centre, Summerland B.C., Canada V0H 1Z0, and 2Washington State Univ., Tree Fruit Research and Extension Centre, 1100 N. Western Ave., Wenatchee, WA 98801

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 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
Timothy L. Righter*; Dept. of Horticulture, Oregon State Univ., Corvallis, OR 97331

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 15N 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

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 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 reduce 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 reduce by 75%, 55%, and 80%, respectively. Thriving 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 Vydac + 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.

744
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 92% reduction in year 1 and a 56% reduction in year 2.

745
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 ‘Fiji’ trees. Seven application dates from 17 June to 9 Sept. were compared to determine how time of treatment would affect 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 to entire tree application to distinguish the direct effect of GA-inhibition on floral initiation from the effect of redistributing photosynthes. 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.

746 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 dioxygenases, which require 2-oxoglutarate as a co-substrate. The result is a decrease in cell elongation and reduced vegetative growth. Gibberelin 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 affect 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 ≈24 cm in length, while untreated shoots were ≈36 cm in length. On 'Golden Delicious' this compound controlled shoots to ≈29 cm in length, while untreated shoots had about 39 cm of total shoots 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.

748 Thinning and Growth Control of Apples Treated with BAS-125

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BASF 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 Within 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.

749 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 biorational 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.