

Abstracts

Contributed Papers (Poster and Oral)

ACB Orals

ACB Posters

Workshops

Colloquia

96th Annual International Conference of the American Society for Horticultural Science

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

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

42 POSTER SESSION 1 (Abstr. 001–004)
Crop Protection

Thursday, 29 July, 1:00–2:00 p.m.

001

Establishment of Methods in Evaluating the Susceptibility of Chinese Cabbage (*Brassica campestris* spp.) to Soft Rot Disease by *Erwinia*

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Three inoculation methods, including cutting of a leaf, drenching, and point inoculation, were compared in an effort to screen the susceptibility of Chinese cabbage to soft rot disease caused by *Erwinia carotovora* subsp. *carotovora*. Three- to 4-week-old seedlings from 10 lines of cabbage with 16-h-old bacterial culture were routinely used. Inoculated seedlings were kept at 25.0 ± 10.0 °C for 48 h with saturated water vapor using a plastic tunnel in a greenhouse. Sixty-day-old mature plants were produced and inoculated in a greenhouse. Severity of symptoms, which were observed from percentage of plant infected was scored as from 1 to 9, representing resistant to susceptible, respectively. The correlation between seedlings and mature plants from ten lines was evaluated among the three different inoculation methods. Point inoculation gave the most significant corre-

lation ($r = 0.843$, $P < 0.05$) between seedlings and mature plants. A good correlation was also observed between point inoculation of seedlings and drenching of mature plants ($r = 0.609$, $P < 0.05$). Cutting of a leaf of seedlings was also correlated with point inoculation of mature plants ($r = 0.609$, $P < 0.05$). This method provides the advantage of being able to keep the experimental plant alive, as only one leaf is detached. The point inoculation method is simple and relatively sensitive, so it could be used for large-scale screening for this bacterial soft rot disease. From three different evaluation assays, it was concluded that the breeding lines, C3-28, C3-29 from Cornell Univ. (Geneva, N.Y.) and the cultivar Kweonsim319 were relatively resistant to bacterial soft rot, while the Cornell breeding line CC-25 and the 'Rang-no' cultivar were relatively susceptible.

002

Effects of Hungavit® Liquid Bio-fertilizer on Leaf Chlorophyll Content, Disease Incidence, and Yield of Tomato, Pepper, and Potato

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Hungavit® products contain extracts of earthworm castings and are marketed by BioLife Ltd. as liquid Bio-leaf fertilizer and plant conditioner. Three experimental plots were set up on the AAFC-SCPFRC research farm to evaluate Hungavit®UR, Hungavit®P, and a preparation containing the equivalent amount of N, P, K fertilizer. In Spring 1998, four replicate plots/treatment of tomato, pepper, and potato were set up in a randomized block design. Each plot received the following treatments: untreated control, Hungavit®UR for tomato and pepper or Hungavit®P for potato, and the fertilizer equivalent of Hungavit®UR or P without the organic components. Tomato and pepper plants were treated three times by foliar application at the rate of 5 L/ha using 300 L of water/ha carrier. Leaf chlorophyll contents were measured at 2, 4, and 6 weeks after initial treatment application. Early and total yield were determined. Tomato fruit were evaluated for symptoms of bacterial spot, early blight, anthracnose, and blossom end rot; pepper fruit for bacterial spot; and potato tubers for potato scab. Both Hungavit® and its equivalent fertilizer application increased the chlorophyll readings significantly in at least one measurement for tomato, pepper, and potato plants. Although there were 40% to 55% fewer diseased tomato and pepper fruit in fertilizer and Hungavit®UR treatments, this was not statistically significant from the control treatments. Fertilizer treatment also reduced scab incidence in tubers by 50%, but the overall scab level was very low even in untreated plots. Hungavit® and its fertilizer equivalent had no significant effect on the early or total yield of tomato, pepper, or potato plants.

003

Epidemiology and Control of Pepper Stip

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Pepper stip is a physiological disorder manifested as gray-brown to greenish spots occurring on the fruit of bell, pimento, Anaheim, and other types of peppers, most noticeably on red fruit that mature under fall conditions. Most hybrid bell cultivars are resistant to the malady; the problem is most severe for pepper growers reliant on less-expensive, open-pollinated cultivars. In 1995, we initiated studies to evaluate the possible link between mineral nutrition and this disorder. Two susceptible open-pollinated cultivars and two resistant hybrid cultivars were grown in randomized plots at seven sites. Significant correlations were seen between the levels of potassium ($r = 0.59$) and calcium ($r = -0.37$) in whole leaves and the incidence of stip ($P = 0.05$). The stip-resistant cultivars also maintained less total nitrogen in the whole leaves than susceptible cultivars ($P = 0.05$). In 1996 and 1997, we undertook field studies to evaluate the effects of varying calcium and nitrogen application rates. Inconsistent results were observed with calcium applications. Moderate reductions in stip incidence was observed at some sites and no reduction at others following foliar calcium applications. Nitrogen nutrition had no effect on stip severity. In 1998, evaluation of a large number of open-pollinated cultivars was undertaken; 'Gusto' showed excellent tolerance to pepper stip, followed by 'Taurus' and 'Cal Wonder 300'. We conclude that growers that are reliant on open-pollinated cultivars can utilize these cultivars to minimize the incidence of pepper stip.

004

Root Application of Potassium Silicate Reduce Feeding Damage to Sargent Crabapple Leaf Tissues by Adult Japanese Beetles

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Research on silicon nutrition has shown an increase in plant disease resistance to powdery mildew and pythium in some species, such as roses and cucumbers. However, the role of silicon for protecting plants from other stresses e.g., heat, drought, insects, etc., are not known. Two-year-old Sargent Crabapple *Malus sargentii* seedlings were subjected to 4 continuous days of 100 ml root application of potassium silicate at the rate of 0, 100, 200, and 400 ppm in Aug. 1998. After 3 days post-treatment, three detached leaves were placed in each of three petri dishes along with one adult female Japanese beetle ($n = 3/\text{concentrations}$) for 7 days. Potassium silicate at 100 ppm concentration significantly reduced percent leaf tissue eaten by adult Japanese beetles. There was not any statistical difference between control, 200, and 400 ppm application. The ion leakage of stem tissues of 100 and 200 ppm-treated plants were significantly lower than the control and 400 ppm. These lower ion leakage effects were also observed with red-osier dogwood stem tissues at 100 ppm. In a companion study fall webworm larvae were also exposed to the same above concentrations and treatments. There was not a significant effect of potassium silicate on percent leaf tissue eaten by fall webworm larvae, suggesting that there may be differences between major groups of leaf-feeding insects. Leaf and root tissue analysis for Ca, K, Mg, Na, and Si will be reported.

90 POSTER SESSION 9 (Abstr. 005–015) Crop Protection

Friday, 30 July, 1:00–2:00 p.m.

005

Investigations Into the Cause of Gold Flecking on the Surface of Ripe Tomato Fruit

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In recent years there has been an increase in the incidence of "gold flecking," which develops on the surface of ripe tomato fruit. Gold flecking looks like a light sprinkling of gold on the skin of the fruit. There are no lesions and the interior of the fruit is not affected. Usually, gold flecking is barely noticeable. In 1998, however, gold flecking was severe enough in some cases to cause economic losses. It has been suggested that gold flecking is due to use of the insecticide Asana or it may be a genetic disorder. The objective here was to determine if gold flecking is caused by Asana and/or is cultivar-dependent. Treatments consisted of three cultivars (Mountain Fresh, Celebrity, and Mountain Pride) and four insecticides (Asana XL, Karate 1 EC, Thiodan 50 WP, and a water control). There were two plantings. Only red fruit was harvested. For both plantings, there was more gold flecking in the control than any of the insecticide treatments. There were no differences among the insecticides. For the early planting, 'Mountain Fresh' had more gold fleck than the other cultivars. In the late planting, there were no differences between cultivars. This study demonstrates that Asana was not responsible for gold flecking and actually reduced it compared to the control. These results also suggest that insects may play a role in gold flecking.

006

Effects of Chitosan on Growth and Rot of Soybean Sprouts

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The practicality of utilizing chitosan (MW = 5000–10,000) as a natural antimicrobial compound to reduce soybean sprout rot was tested. Soybean seeds were soaked for 6 h in solutions containing different levels of chitosan and acetic acid (glacial), and cultivated at 25 °C for 5 days. Soaking seeds with 1000 ppm

chitosan increased germination percentage, hypocotyl thickness, total length, and fresh weight of sprouts by 4%, 5%, 2%, and 1%, respectively. The total sprout yield was increased by chitosan in a concentration-dependent manner in that 1000 ppm chitosan resulted in 8% increment of total yield (7.47 kg sprouts/kg seed). Compared to control (13.8%), chitosan significantly reduced sprout rot percentage to 7.0%, and consequently enhanced the marketable sprout yield by 39%. Although 100 ppm acetic acid also decreased sprout rot percentage to 11.8%, its yield-increasing effects were not as prominent as chitosan.

007

Yellow Nutsedge is Poor Competitor with Summer Squash

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Yellow nutsedge (YNS) can be a serious problem where vegetables are grown on polyethylene mulch. YNS will rapidly cover the row and become a nuisance. This study was conducted to determine the effect of various population densities of YNS on the yield response of yellow squash grown on black polyethylene. Presprouted YNS tubers were planted at densities of 0, 10, 20, 40, and 50/m² the day after 'Superpik' yellow squash was planted. In 1996 the YNS did not produce tubers. Top growth increased up to 40/m², but root growth increased to 50/m². In 1997 top and root growth increased up to 20/m². Tuber production increased up to 40/m². In 1998 top, root, and tubers dry weight increased as the YNS density increased to 50 tubers/m². There were no differences in weight of the squash plants or fruit yields any year. In experiments over three growing seasons, YNS at the densities tested did not interfere with the yield of yellow summer squash grown on black polyethylene mulch. The rapid growth of the squash and its dense canopy provide too much shade for the YNS to grow competitively. The yield of the YNS was greater in wet years than in dry years. The increased supply of YNS tubers could cause squash yield reductions in future plantings because of potential densities greater than those used in this study. YNS competition could also be a problem in rotational crops that are less competitive.

008

Evaluation of Weed Control in a No-tillage Vegetable Production System

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In the tropics, weed control is a year-round concern. The use of cover crops in a conservation tillage system allows for the production of a crop biomass that can be killed and mowed, and later used as mulching material to help reduce weed growth. This study compared yields of three vegetable species grown in two conventional tillage systems, one weeded and one unweeded control, and in two no-tillage treatments using two different cover crop species, oats (*Avena sativa* L. 'Cauyse') and rye grain (*Secale cereale* L.). The cover crops were seeded (112 kg/ha) in Spring 1998 in 4 x 23-m plots in a RCB design with six replications per treatment, and mowed down at the flowering stage before transplanting the seedlings. Data collection throughout the experimental period included quadrant weed counts, biomass levels, and crop marketable yields. Weed suppression was compared with the yields of the vegetable crops. The greatest vegetable yields were in the conventionally hand-weeded control and the worst in the un-weeded controls. Weed species composition varied depending on the cover crop species treatment. The rye better suppressed weed growth than the oats, with greater control of grass species. Rye, however, suppressed romaine and bell pepper yields more than the oat treatments. Similarly greater eggplant yields and more fruit per plant were found in the oat treatment than in the rye. Both cover crops suppressed weed growth for the first month; however, by the second month most plots had extensive weed growth. This study showed that at the given cover crop seeding rate, the mulch produced was not enough to reduce weed growth and provide acceptable yields of various vegetable crops.

009

Annual Weed Chemical Control in Asparagus

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Approximately 50% of the asparagus plantations (3000 ha) in the Caborca, Sonora, area is furrow-irrigated. Under these conditions it is common to observe growing weeds in the furrow section, which impede water flow and compete for

resources with the asparagus plant, finally reducing spear production and quality. Hence, the objective of this study was to validate herbicides to achieve an efficient annual weed control in the asparagus plantations. The validation plot was established in May 1998 on a commercial asparagus plantation that was highly infested mostly with annual grasses (*Echinochloa colonum* and *E. crusgalli*), and *Amaranthus* spp. and *Portulaca oleracea* as a secondary weeds. The herbicides and rates tested were: Prometryne (2 L • ha⁻¹), Norflurazon (4 kg), Metribuzin (0.5 kg), Linuron (2 kg), and the control plot (no herbicide application). All the tested products showed significant weed control percentages compared with the control plot. Norflurazon, however, was clearly superior to the other herbicides, exhibiting a 100% control for a period of almost 18 weeks. Metribuzin had a 85% control for 12 weeks. Linuron and Prometryne exhibited a 68% and 47% control, respectively, for up to 12 weeks. Plant toxicity symptoms on the asparagus plant were not observed with any of the tested herbicides.

010

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

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While the majority of terrestrial plants are colonized in soils by vesicular-arbuscular fungi (AM), that does not mean that these species can form a symbiosis with AM fungi in an artificial substrate under commercial production conditions. The purpose of this study was to identify those plants having a colonization potential. In Mar. 1998, 51 species and cultivars of ornamental plants were inoculated with two vesicular-arbuscular fungi (*Glomus intraradices* Schenk & Smith, and *Glomus etunicatum* Becker & Gerdemann; Premier Tech, Rivière-du-Loup, Québec). Periodic evaluations of colonization were done 5, 7, 9, 12, and 16 weeks after seeding. More than 59% of these plants tested were shown to have a good colonization potential with *G. intraradices*. Species belonging to the Compositae and Labiatae families all colonized. Species in the Solanaceae family showed slight to excellent colonization. Several species studied belonging to the Amaranthaceae, Capparidaceae, Caryophyllaceae, Chenopodiaceae, Cruciferae, Gentianaceae, Myrtaceae et Portulacaceae families were not colonized. Root colonization with *G. etunicatum* was not detected on these species and cultivars during this short experimental period.

011

Reflective Mulches and Yellow Sticky Tape Control Whiteflies in Greenhouse Poinsettia (*Euphorbia pulcherrima*)

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Greenhouse Whitefly (*Trialeurodes vaporariorum*) and Silverleaf Whitefly (*Bemisia argentifolii*) are the most serious insect pests of poinsettia. Most growers rely on the use of foliar insecticide applications before bract coloring and an application of a single soil application of imidicloprid (Marathon) subsequently. This research was undertaken to investigate the use of reflective mulches or bench covers, which have been shown to be effective in outdoor applications for control of whitefly in the greenhouse. In an early trial, silver painted pot spacers and silver polyethylene mulch were placed between pots and both nymphs on leaves and adults caught on yellow sticky cards were monitored. Nymph populations were reduced by ≈35% and adults caught on sticky cards increased by ≈40% when compared with the control. In a subsequent trial, reflective bench covers were combined with the use of yellow sticky tape placed above the canopy of the crop and compared with sticky tape alone, reflective mulch alone, and no treatment. The combination of sticky tape and reflective mulch significantly reduced whitefly populations after 6 weeks and performed better than either of the other treatments alone.

012

Inhibition of *Phytophthora megasperma* in Coconut Coir-based Root Substrates

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Glycine max (soybean) seed were sown in root substrates composed of 80:0:20 or 0:80:20 coconut coir dust (coir):Sphagnum peat (peat):perlite (v/v) amended with dolomitic limestone to a pH of 5.5. Substrates were inoculated with

Phytophthora megasperma races 5 and 25 isolated from soybean and grown in dilute liquid V-8 cultures. Uninoculated controls were included. Containers were watered daily to maintain moisture levels at or near container capacity. The experiment was repeated twice. Plants grown in peat-based root substrates inoculated with *P. megasperma* suffered 50% to 100% mortality. No plants in coir-based root substrates displayed visually apparent infection symptoms. Soybean seed were also sown in root substrates that contained 0:80:20, 20:60:20, 40:40:20, 60:20:20 or 80:0:20 coir:peat:perlite (v/v). Inoculum of *P. megasperma* races 1, 5, and 25 was grown on water agar and diluted in deionized water. Solution containing 20,000 colony-forming units (oospores) was mixed into the root substrate of each container. Uninoculated controls were included. As the proportion of coir in the substrate increased, the mortality, the number of plants displaying disease symptoms and the severity of disease symptoms decreased. Plants grown in substrates containing at least 60% coir displayed no visually evident disease symptoms.

013

Euphorbia pulcherrima* Cultivars Differ in Susceptibility to Varying Inoculum Levels of *Pythium ultimum

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Rooted cuttings of 22 different *Euphorbia pulcherrima* Willd. ex Klotzsch cultivars were grown in root substrate inoculated with 0, 5000, 15,000, and 30,000 oospores of *Pythium ultimum* Trow per 10-cm containers. The root substrate was a mixture of 50% peat, 30% perlite, and 20% soil, adjusted to a pH 5.5. Plants were grown in a greenhouse with a temperature range of 15–32 °C, and were fertilized daily with 200 ppm N (Excel 15–5–15, Scotts Co. Marietta, Ga). After 8 weeks, roots were rated for disease incidence and root fresh and dry weights were determined. The data were analyzed using ANOVA with six blocks in a 22 x 4 factorial design, linear regression, and cluster analysis. Significant differences among the responses of the cultivars were found. The slopes of the regression equations, using the log¹⁰ of the inoculum level for the X axis, were more positive for disease incidence and more negative for fresh and dry root weights in the more susceptible cultivars. The cultivars were separated, by the cluster analysis, into three groups, less susceptible, moderately susceptible, and highly susceptible. Cultivars Marblestar and Galaxy Red were representative of less susceptible, 'Pepride' and 'Jolly Red' were representative of moderately susceptible, and 'Snowcap' and 'Success' were representative of highly susceptible cultivars.

014

Weed Control and Productivity of Field-grown Cut Flowers

E. Jay Holcomb*, Tracey L. Harpster, Robert D. Berghage, and Larry J. Kuhns; Department of Horticulture, The Pennsylvania State University, University Park, PA 16802

A set of studies was established in Summer 1998 to determine the tolerance of field-grown cut flower species to specific preemergence herbicides, the effectiveness of weed control by those materials, and to determine if productivity of cut flowers is affected either by the herbicides or by colored mulches. Pendimethalin provided excellent early season weed control, but poor late-season control. It consistently caused injury at 4 lb a.i./A and sometimes at the 2 lb a.i./A rate. Oryzalin provided good to excellent weed control, but slightly injured celosia and zinnia when applied at 4 lb a.i./A. Napropamide provided excellent early season weed control, but marginally acceptable weed control later in the season. Though napropamide caused some injury to celosia early in the season when applied at the high rate, no injury to any of the plants was observed later in the season. Proflam and trifluralin were the overall safest of the herbicides, but they provided the weakest weed control. OH-2 was very effective when placed on the soil surface, but was less effective when placed on an organic mulch. The organic mulch was designed to keep the OH-2 particles from splashing on to the crop plant and injuring the plants. OH-2 tended to be safer placed on a mulch than on the soil surface, but stative was slightly injured even when a mulch was used.

015

Evaluation of Fungicides for Use with TOM-CAST on Fresh-market Tomatoes in Northern New Jersey

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A research trial evaluation of fungicides and fungicide combinations in conjunction with weekly or TOM-CAST (an early blight forecast system) spray schedules was conducted in 1998. Fungicide regimens were: Quadris (alternating with Bravo Weatherstik); Bravo Weatherstik; Manzate followed by Bravo Weatherstik; Champ; Champ and Bravo; Nu-Cop; NuCop and Bravo. The weekly schedule resulted in 15 fungicide applications; the TOM-CAST schedule required five applications. Foliar disease was rated weekly. Mature fruit were harvested weekly to obtain total and marketable yields. All fungicide treatments reduced foliar disease compared to the untreated control. Quadris alternating with Bravo Weatherstik on a weekly or TOM-CAST schedule provided better disease control than any other material on either schedule. There were no significant differences in disease control among the other materials applied weekly. Disease control achieved with the TOM-CAST schedule was somewhat less than with the weekly schedule for all materials. Quadris/Bravo or Bravo provided the best control and Champ or Nu-Cop alone provided the least control on the TOM-CAST schedule. Total yield was not affected by fungicide or schedule. Marketable yield was reduced by weekly applications of copper fungicides compared to most other treatments. Chemical names used: tetrachloroisophthalonitrile (chlorothalonil); [methyl (E)-2-{2-[6-(2-cyanophenoxy) pyrimidin-4-yloxy]phenyl}-3-methoxyacrylate (asoxystrobin); copper hydroxide; manganese ethylene bisdithiocarbamate and zinc.

142 POSTER SESSION 15 (Abstr. 016–024) Crop Protection

Saturday, 31 July, 1:00–2:00 p.m.

016

Characteristic Dimension: A Novel Adjunct to Analyzing Species Composition in Digitized Photos of Turfgrass Plots

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Digitized photographic images of turf plots composed of bermudagrass, buffalo grass, tall fescue, and zoysiagrass were taken at a height of about 150 cm with a 28-mm lens. Fast Fourier transforms of these images were performed, and a radial plot of the power spectrum was obtained from each image. Hurst plots (log frequency vs. log intensity) were used to subtract "background" from the power spectra, so peaks would be more evident. The peak of the power spectrum occurs at the average spacing between leaves (more precisely, between areas of the canopy that reflects a significant amount of light) and defines the characteristic dimension. Zoysiagrass had the lowest characteristic dimension, while tall fescue had the highest. The width of the power spectrum is indicative of the variability of the characteristic dimension within the canopy. The minimum characteristic dimension (occurring at the highest frequency) was less than 1.7 cm, whereas all the other species had about the same minimum characteristic dimension of ≈1.9 cm. The maximum characteristic dimension was greatest for fescue (6.9 cm), followed by buffalo grass (3.8 cm), bermudagrass (3.3 cm), and zoysiagrass (2.8 cm). These results indicate that the characteristic dimension can be a useful tool for discriminating between turfgrass species in digitized images.

017

Influence of Surfactants on Manage Herbicide Control of Nutsedge and Nursery Crop Tolerance

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Research was conducted to compare non-ionic, paraffin-based crop oil, soybean oil, sunflower oil, and organosilicone surfactants combined with Manage (MON 12051, holosulfuron) applied at a reduced rate for yellow nutsedge (*Cyperus*

esculentus) control efficiency and evaluation of phytotoxicity to five container-grown ornamental species. Manage at 0.018 kg a.i./ha was combined with 0.25% or 0.5% (v/v) of the following surfactants: X-77, Scoil, Action "99", Sun It II, or Agri-Dex. Yellow nutsedge tubers (10 per 3.8-L container) were planted into containers along with the following nursery crops: 'Lynnwood Gold' forsythia, 'Big Blue' liriope, 'Pink Lady' weigela, 'Blue Girl' Chinese holly, and 'Bennett's Compacta' Japanese holly. Treatments were applied 5 weeks after potting on 13 June 1998 and phytotoxicity ratings taken 4 and 8 weeks later and growth measured after 8 weeks. Sun It II provided the most-effective nutsedge control without reducing growth and causing minimal phytotoxicity to the ornamental plants tested. X-77 (the recommended surfactant for Manage) provided only moderate nutsedge control. Efficient nutsedge control can be accomplished with Manage at one-half the recommended rate when combined with the correct surfactant. Some temporary phytotoxicity symptoms can be expected and a slight overall growth reduction is possible, depending on the surfactant selected.

018

Preemergent Weed Control in Container-grown Herbaceous Perennials

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During the 1998 season, preemergent herbicides were applied to container-grown herbaceous perennials and evaluated on the basis of weed control, phytotoxicity, and effect on plant growth. The herbicides and rates were: Napropamide (Devrinol 10G), 0.72 and 1.44 kg a.i./ha; Oryzalin (Surflan 40AS), 0.36 and 0.72 kg a.i./ha; Oxadiazon (Ronstar 2G), 0.72 and 1.44 kg a.i./ha; Oxyfluorfen + Oryzalin (Rout 3G), 0.54 and 2.16 kg a.i./ha; Oxyfluorfen + Pendimethalin (Scott's OH II), 0.54 and 1.09 kg a.i./ha; and Trifluralin (Treflan 5G), 0.72 and 1.44 kg a.i./ha. Herbicides were applied to *Phalaris arundinacea* 'Picta', *Scabiosa caucasica*, *Sedum* x 'Autumn Joy', *Pennisetum setaceum* 'Rubrum', *Salvia argentea*, *Penstemon* x *mexicali* 'Red Rocks', *Osteospermum barberiae* v. *compactum* 'Purple Mountain', and *Gazania linearis* 'Colorado Gold'. Phytotoxicity symptoms (visual defects) were apparent with Napropamide on *Phalaris* (at both rates) but recovered by the end of season. All herbicides provided good weed control.

019

Hybrid Poplar Establishment in Tilled Ground or Grass Sod Using Polyethylene Films for Weed Control

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Hybrid poplar is traditionally established using dormant stem cuttings in tilled soils followed by chemical or mechanical weed control. In 1996, we initiated a study to evaluate the effects of site preparation and four weed control treatments on growth and morphology of three hybrid poplar clones established on a 0.2-ha tall fescue field in southern Illinois. Site preparation included application of 2000 kg/ha of 12N-12P-12K. The experiment was arranged as a split-split plot. Main plots were closely mowed tall fescue or tilled to remove the grass sod. Within each main plot, weed control treatments were applied to 1-m wide strips in rows 2.4 m apart. Weed control treatments included porous black film, solid black film, and solid white film, and a control treatment of 3.7 L/ha of glyphosate applied each spring. On 15 Apr. 1996, three 25-cm-long dormant stem cuttings from each of three clones were randomly planted 15 cm deep every 1.8 m within each row. Clonal differences existed after the first year for survival, number of stems, stem height, stem basal diameter, and stem volume, but not for number and total length of lateral branches. Nearly all tree growth measurements analyzed during the first 3 years had a highly significant interaction between type of site preparation and method of weed control. With polyethylene films, tree survival exceeded 90% on both the tilled ground and grass sod sites after 3 years; however, with the herbicide treatment survival averaged only 18% in the grass sod and 51% in tilled soil. Excluding the herbicide treatment, tree growth was better in the grass sod than in the tilled soil. Tree growth using porous black polyethylene film was usually less than that with either of the two solid polyethylene films. The best tree growth was found with a grass sod and solid white polyethylene film for weed control.

020

Phytotoxic Properties of Soybean Oil and Emulsifiers on Miniature Roses

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Previous research indicated that soybean oil effectively controlled insects and mites on ornamentals. In some conditions, emulsified oil sprays have also been shown to cause phytotoxicity. The objective of this research was to determine which soybean oil emulsions and/or emulsifiers produced the least amount of phytotoxicity on miniature roses. Greenhouse-grown 'Fashion' (pink), 'Fiesta' (fuchsia), 'Tender' (white), 'Orange' (red), and 'Bronze' (yellow) miniature roses in trade-gallon containers were sprayed once in late fall 1998. Treatments included: 1) water (control); 1% concentrations of commercial soybean oil formulations of 2) Soygold 1000 and 3) Soygold 2000 (Ag Environmental Products), 4) Emulsion A and 5) Emulsion B (Michigan Molecular Institute); 1% soybean oil emulsified with 6) 0.1% Ballistol (F.W. Klever, Germany), 7) 0.1% ERUCICHEM (International Lubricants), 8) 0.1% ERUCICHEM mixed with 0.01% lecithin (Chem Service), 9) 0.1% soy methylester (Michigan Molecular Institute), 10) 0.06% Atlox and 0.04% Tween (ICI Americas), 11) 0.1% E-Z-Mulse (Florida Chemical Company), or 12) 0.1% Latron B-1956 (Rohm & Haas). The emulsifiers were also tested alone for phytotoxicity to rose foliage. None of the emulsifiers caused significant damage. Soybean oil emulsified with E-Z-Mulse did not cause significant phytotoxicity as indicated by chlorosis of foliage. The commercially prepared Emulsion A, Soygold 1000 and Soygold 2000 caused slight phytotoxicity. Emulsion B and soybean oil plus Latron B-1956 caused moderate phytotoxicity. The soybean oil-Ballistol emulsion was the most phytotoxic. Cultivars varied in sensitivity ($P < 0.01$) to soybean oil emulsions (listed in the order of increasing sensitivity): 'Orange', 'Fashion', 'Bronze', 'Fiesta', and 'Tender'.

021

Assessment of Insecticide Efficacy For Root Weevil Control

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The efficacy of new formulations and application techniques were compared to existing standard pesticides for adult root weevil control. A known number of adult black vine weevils (*Otiorhynchus sulcatus*) were added to *Rhododendron* 'Cunningham's Blush' growing in 1-gal containers. Spray or hand-applied treatments were assigned to three plants each within the six blocks of a randomized complete-block design. Treatments were evaluated for percentage adult mortality at 7 and 14 days after treatment (DAT). Orthene (16 oz/100 gal), Pinpoint (2.0 g and 3.0 g prod/pot), Talstar (20 oz/A; both day- and night-applied), and CGA 293 343 (8.5 oz thiamethoxam/100 gal) provided greater than 90% control of root weevil adults 2 weeks after treatment. Although providing less than 50% control at 7 DAT, the low rate of Pinpoint (0.5 g prod/pot), Cryolite bait (30 lb/A), and Kryocide (50 lb/A) treated blocks showed greater than 60% mortality by 2 weeks after treatment. Bifenthrin-treated weed barriers (1.5% ai) placed on the surface of the growing medium provided more than 50% control 14 days after treatment. Differences in speed of control may reflect differing modes of action or application methods. One possible benefit in use of the slower-acting stomach poisons and systemic insecticides is reduced risk to nontarget organisms such as predator mites.

022

Delivery of Gases to the Soil Matrix via Buried Drip Irrigation Tubing

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The impending worldwide restrictions on the use of methyl bromide (MeBr) as a soil fumigant have prompted an intensive search for more-effective methods for delivering MeBr or replacement compounds. Although the majority of agrochemicals are applied in the solid phase or the liquid phase at ambient pressure and temperature, some chemicals, including certain soil fumigants such as MeBr, are gases under normal field conditions. Experiments were conducted to evaluate use of two types of commercial drip irrigation tubing to deliver gases to nontarped planting beds. Air moved through each tubing type immediately after burial;

water was not necessary for inflation. Air was also able to move through 40 m of buried rigid drip tubing and through 90 m of buried flat tape that had been used for subsurface drip irrigation for more than 1 year. Mixtures of known ratios of propane and air were introduced into the buried tubing over several time intervals to evaluate gas movement from buried drip tubing into the surrounding soil matrix. Samples were collected from sets of three soil gas sampling tubes placed 15, 30, and 45 cm to the side of the buried tubing and at regular intervals along the length of the tubing, and propane concentrations were quantified by gas chromatography. Tubing lengths and run times affected the magnitudes and uniformity of propane concentrations. Results suggest gas-phase chemicals can be delivered via buried drip-irrigation tubing, but effective distances from the point of introduction will be limited by the low densities and viscosities of gases, and corresponding high rates of escape through tubing emitters.

023 Examination of Carriers in Application of Pre-Emergence Herbicides in Container-grown Nursery Stock

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Weed growth in container-grown nursery stock is a particularly serious problem. Inexpensive and easily accessible carriers for safe application of concentrated preemergent herbicides have been investigated. Monaco and Hodges (1974) evaluated standard pine bark used in potting media. Coating broadcast fertilizers with preemergents has also been recently examined in agronomic crops (Koscelny and Peeper, 1996; Rabaey and Harvey, 1994). The four objectives of this experiment were: 1) determine the efficacy and duration of weed control of a range of preemergent herbicide-impregnated carriers, applied as a top-dressing. The preemergents to be tested are: Goal, Surflan, Rout, Gallery, Gallery/Surflan, Ronstar and Regal 0; 2) determine the efficacy and duration of weed control of a range of preemergent herbicide-impregnated slow and controlled release fertilizers, applied preplant incorporated in the potting mix; 3) assess the phytotoxicity of the chemical-treated carriers on the ornamental plants evaluated; and 4) determine which weeds were controlled. Of the carriers investigated, bark was the best treatment regardless of pre-emergent used. However, Surflan and Gallery were slightly better than Goal. The effectiveness of the bark in controlling weeds is worth investigating in further studies. A significant species effect with the efficacy data was observed. *Euonymus* 'Emerald Gaiety' was significantly better at competing with the weeds present than the other species evaluated. Top dressing gave significantly fewer weeds, with rated data, vs. incorporation. The effect was most pronounced for Kansel or Fert. plus Ronstar. Osmocote micro-fert. gave less weeds, top-dressed, when weed weights were analyzed. However, using the weed weight data, there were no significant differences whether the carriers were applied top dress or incorporated. Phytotoxicity was not significantly different with incorporation vs. top dressing.

024 IPM Practices Reduce Pesticide Levels in Runoff Water at a Container Nursery

Jeanne Briggs*, Ted Whitwell, Melissa B. Riley, and Tom Fernandez, Clemson University, Clemson, SC 29634

This study investigated effects of two pesticide applications regimes, Integrated Pest Management (IPM), in which pesticides were only applied to affected plants when damage was noticed, and Traditional, in which pesticide applications were made on a scheduled and preventative basis, on growth and health of container grown plants. Field research was conducted at a large wholesale nursery in the piedmont region of South Carolina. An isolated portion of the nursery contained eight beds that housed 25 species of woody and herbaceous ornamentals. IPM beds were subjected to weekly in-depth scouting of indicator species, and all other plant materials in both treatments were visually checked for problems on a weekly basis. The study began in June 1998 with weekly scouting ending in late October. Monthly scouting continued through the winter of 1999. Runoff water was collected from the treatments after all pesticide applications and analyzed to determine concentrations of chemicals. Plant health was rated at study's end to allow comparison between treatments. Amounts of isoxaben detected in runoff water were 7.9 g for the traditional treatment and 0.9 g for the IPM treatment. Amounts of thiophanate-methyl and chlorothalinalol were similarly lower for the IPM treatment. Preliminary results indicate that plant growth was similar for both treatments.

43 POSTER SESSION 2 (Abstr. 025–049) Genetics/Breeding/Biotechnology

Thursday, 29 July, 1:00–2:00 p.m.

025 WITHDRAWN

026 Genetic Analysis and Breeding for Resistance to Bacterial Wilt in Capsicum Pepper

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Bacterial wilt caused by *Ralstonia solanacearum* is sporadically causing damage to pepper in Korea. We put efforts in analyzing the genetics of resistance to bacterial wilt and in subsequent breeding for resistance by selection. Two Korean cultivars, Subi and Chilsung, were crossed with a resistant source, MC-4, which was kindly provided by Lopes in Brazil. In addition, four breeding lines bred for resistance to Phytophthora blight were crossed with another resistance source, PBC631, which we received from AVRDC. F₂ and backcross populations of the crosses were developed and tested by inoculation by dipping the roots of the seedlings before transplanting 25 days after seeding. Segregation in the F₂ and backcross populations did not fit any mode of simple Mendelian inheritance, but appeared inheriting in a quantitative mode with relatively low heritability. Selection was practiced in the subsequent F₃, BC₁F₂, F₄, and BC₁F₃ generations and a few resistant selections were obtained.

027 Genetic Analysis of Resistance to the Peanut Root-knot Nematode Exhibited by the *Capsicum chinense* Germplasm Line PA-353

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The peanut root-knot nematode (*Meloidogyne arenaria* race 1) is potentially a major pest of pepper cultivars belonging to the species *Capsicum chinense*. Greenhouse tests were conducted to: 1) compare the level of resistance to the peanut root-knot nematode exhibited by the recently released *C. chinense* germplasm line PA-353 to that exhibited by the *C. annum* cv. Carolina Cayenne; 2) to determine the inheritance of the resistance in the *C. chinense* germplasm line PA-353; and 3) to determine the genetic relationship between the resistance exhibited by the *C. chinense* germplasm line PA-353 and that exhibited by the *C. annum* cv. Carolina Cayenne. The level of resistance exhibited by the *C. chinense* germplasm line PA-353 was equal to the high level of resistance of the *C. annum* cv. Carolina Cayenne. Evaluation of parental, F₁, F₂, and backcross populations of the cross between the resistant *C. chinense* germplasm line PA-353 and the susceptible *C. chinense* accession PA-350 indicated that the resistance in *C. chinense* is conditioned by a single dominant gene. The F₂ population of the interspecific cross between the resistant *C. chinense* germplasm line PA-353 and the resistant *C. annum* cv. Carolina Cayenne did not segregate for resistance, indicating that the dominant resistance gene in *C. chinense* is likely allelic to or closely linked to a gene conditioning resistance in *C. annum*. The availability of a simply inherited source of outstanding resistance makes breeding for peanut root-knot nematode resistance a viable objective in *C. chinense* breeding programs.

028 Selecting Sweetpotato Genotypes Tolerant to Chilling Stress

Ehiorobo Izeakor*, J.O. Garner, and F.B. Matta, Plant and Soil Sciences Department, Mississippi State University, Mississippi State, MS 39762

A procedure to determined selection of sweetpotato (*Ipomoea batatas* L. Lam.) genotypes tolerant to chilling injury was initiated by crossing two resistance lines and two susceptible lines. Experimental design on the F₁ progeny was a completely randomized design (CRD) with two groups, tolerant and sensitive genotypes, and 90 lines in each group. Four plants per lines were selected and each

plant represented a replication. The rating of plants according to the degree of chilling injury was recorded at 36 h after chilling temperature of 5 °C with 85% relative humidity. Significance of the analysis was based on the number of plants tolerant to chilling injury from both the resistant and the sensitive groups. Results from the statistical analysis based on visual rating of the F₁ progeny plants for 36 h, indicated that higher populations of resistant plants could be produced when two resistant lines were crossed in a control pollination process. Evaluations to be continued are chlorophyll fluorescence, leakage of cell content, structural changes of the cell, and peroxidase content, before and after chilling stress. These assays will be used to further determine the similarities among the chilling-tolerant genotypes. Findings will aid in elucidating mechanism of chilling injury in fruit and vegetables.

029

Performance of Short-vined Tropical Pumpkins Derived from Temperate x Tropical Crosses

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A joint breeding effort of the Universities of Puerto Rico and Florida involves the development of short-vined tropical pumpkin (*Cucurbita moschata*) genotypes that are able to reach maturity earlier than traditional long-vined types. Sixteen promising hybrids and inbreds were planted in Lajas, Puerto Rico, in June 1998. Pedigrees of this material included traditional tropical genotypes crossed with bush or compact temperate genotypes. Anthesis in both pistillate and staminate flowers occurred on average 49 days after planting. However, the variability of flowering dates among genotypes was far greater for pistillate (40 to 60 days) than staminate (46 to 54 days) flowers. Hybrids flowered earlier than inbred lines. Female flowers opened before male flowers in many genotypes. It seems likely that an inadequate source of pollen contributed to the low yields of some of the earliest genotypes. The five highest-yielding genotypes had pistillate flowers that opened after their male counterparts. All plots were once-over harvested 86 days after planting. Average yield per plant varied from 1.4 to 6.0 kg. Average fruit weight varied from 0.8 to 3.1 kg. High-yielding genotypes tended to have the highest fruit weight, a factor that should be considered when breeding for the next generation of short-vined genotypes. Yields were less than what could be expected from a long-vined tropical pumpkin. However, this yield could be obtained with a once-over harvest at about 90 days, compared to multiple harvests beginning at 120 days, saving costs of additional field practices, and allowing the land to be used for other purposes.

030

Yield Evaluation of the Cucumber Germplasm Collection

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Yield was evaluated in 817 plant introduction accessions of cucumber (*Cucumis sativus* L.) along with 19 check cultivars. The study was conducted in spring and summer seasons of 1997 and 1998 with three replications using recommended horticultural practices and optimized field plot trials. In order to get fruit from each cultigen regardless of sex expression, plants were sprayed with ethrel (2-chloroethyl phosphonic acid) to make them gynoeocious. Plots were harvested once-over when 10% of the fruit in a plot were oversize. Data were collected on fruit weight (total, marketable, early and cull), fruit number (total, marketable, early and cull), fruit type, fruit quality, and days to harvest. Total fruit weight for all cultigens ranged from 4 to 214 Mg/ha, with 1 to 40 fruit per plot. Based on statistical analysis, fruit number was the most useful trait for yield evaluation. Stand corrections for yield were not found to be useful. The cultigens with the highest fruit numbers for pickling type were PI 215589, PI 179678, PI 249561, PI 356809, and PI 370643. Highest fruit number for slicing type were PI 344440, PI 422199, and PI 342951. Highest fruit number for middle-eastern type were PI 525150, PI 525153, PI 181910, and PI 534540. Highest fruit number for Oriental trellis type were PI 432849, PI 432866, PI 508455, PI 372893, and PI 532520. Several cultigens produced more than the check cultivars. High-yielding cultigens could be used in breeding programs to improve the yield of cucumber.

031

Rate of Natural Outcrossing in Cucumber Isolation Blocks

Todd C. Wehner*, Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

Cucumber (*Cucumis sativus* L.) populations often are intercrossed after each selection cycle using bees in isolation blocks. Previous research showed the rate of natural outcrossing in monoecious cucumber inbreds was 36%. The objective of this experiment was to determine whether the rate of natural outcrossing could be increased using hormones, plot size, and node of fruit for seed harvest. The experiment was run with 2 years (1997, 1998), two hormones (treated, none), two plot sizes (hills, small plots), two nodes of harvest (2, 8), and four replications. Each treatment combination consisted of four plots or hills planted in 1.5-m rows in one isolation block. Plots or hills were planted to white-spined 'Sumter', and were surrounded by rows of black-spined 'Wis. SMR 18'. Treatment combinations receiving hormones were sprayed at the cotyledon stage and 1 week later. Plots or hills received ethrel to make them gynoeocious, and surrounding rows received silver nitrate to make them androecious. Unsprayed isolation blocks remained monoecious. At maturity, fruit were harvested from nodes 2 or 8 from the white-spined plants in each isolation block. Node of harvest had no effect on outcrossing rate. However, hormones and plot size had a significant effect. Sprayed plots, sprayed hills, and unsprayed hills had high outcrossing rates relative to unsprayed plots. Therefore, if families are to be intercrossed in isolation blocks, they should be sprayed with hormones for maximum outcrossing among families.

032

Resistance to Papaya Ringspot Virus in Watermelon

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Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] is a major crop in the southern U.S., where the most important virus diseases are papaya ringspot virus (PRSV), watermelon mosaic virus-2, and zucchini yellow mosaic. The most economical control of virus diseases of watermelon is probably through genetic resistance. Watermelon has not been screened extensively for resistance to PRSV. The objective of this research was to develop a suitable method for screening watermelons for resistance to PRSV and then to screen the USDA germplasm collection. To date, we have developed an effective method and have nearly completed the screening. Several of the 1283 accessions have shown resistance to the virus. Methods tests involved 10 isolates of PRSV, several watermelon accessions and multiple inoculation procedures. Seedlings were screened in greenhouse flats with six replications per test. Tests were rated visually on a 0 to 9 scale (0 = no damage, 9 = plant dead), as well as with ELISA to detect the presence of virus. The watermelon germplasm collection was screened in four separate runs of 1283 accessions with 'Charleston Gray' as the susceptible check. This research will be useful for those interested in effective screening methods, and sources of resistance for development of improved watermelon cultivars.

033

Characterization of Downy Mildew Resistance in USDA Broccoli Inbreds

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Downy mildew, caused by *Peronospora parasitica* (Pers. ex Fr.), is one of the most economically important diseases in broccoli (*Brassica oleracea* L. Italica group). Previous studies reported that resistance to downy mildew in broccoli depends on plant age and that seedling resistance appears to be independent of mature-plant resistance. The objectives of our studies were to evaluate resistance and susceptibility of USDA broccoli inbreds to downy mildew and to investigate the interaction between the host and pathogen at two plant stages with single or double inoculation. Multiple screening tests at both cotyledon and three-expanded leaf stages using 38 entries, including USDA inbreds and commercial hybrids, were conducted in randomized complete-block designs. In these tests, every leaf of each plant was thoroughly sprayed with *P. parasitica* isolate PP1 at a concentration of 10,000 sporangia per ml at both stages. Ratings for downy mildew reaction phenotype were made at 9 days postinoculation on a 0-9 scale of increasing disease severity. We found significant phenotypic variation to infection among broccoli entries. We observed three general phenotypes: 1) resistance at both stages; 2) susceptible at cotyledon stage combined with resistance at three-

expanded leaf stage; and 3) susceptibility at both stages. Additionally, inoculation at the cotyledon stage had no effect on inoculation at the three-expanded leaf stage.

034

Independence of the Reduced Pigment (*rp*) Gene and the *Y* and *Y*² Loci in Carrot (*Daucus carota* L.)

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Five genes, including alleles at *Y*, *Y*₁ and *Y*₂, and the alleles *I* and *IO*, have been implicated in conditioning carrot root color. Various combinations of these alleles can condition white, yellow, and orange xylem and phloem color in carrot roots. The recently discovered reduced pigment gene, designated *rp*, conditions pale orange xylem and phloem and reduces carotenoid content by 92%. To determine if the *rp* gene is an allele of a previously described locus or a separate locus involved in pigment biosynthesis, we crossed *rprp* plants to plants with yellow phloem and yellow xylem (yellow/yellow) and to plants with purple phloem and yellow xylem (purple/yellow). We generated BC₁ and F₂ progenies for evaluation of segregation data. The expected genotype of plants with yellow xylem was *yyY₂Y₂RPRP* and the expected genotype of plants carrying *rp* was *yyy₂y₂rprp*. More than 1900 individual plants were evaluated for root color in 38 matings. In F₂ progenies resulting from crosses of *rprp* × yellow/yellow, segregation data from 19 out of 20 families fit expected 12:3:1 (yellow: orange: *rprp*) or 15:1 (orange: non-orange) ratios ($P < 0.001$) indicating independence of the *rp* gene. In addition, 12 out of 16 families of F₂ progenies from the cross between purple/yellow plants and *rprp* plants fit expected 12:3:1 (yellow: orange: *rprp*) ratios ($P < 0.001$) for a 2-gene model. These data support the hypothesis that the *rp* gene is independent and not linked to *Y* and *Y*₂ genes.

035

A New Southernpea

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Southernpea (cowpea), *Vigna unguiculata* L. Walp, is an important processing and fresh-market vegetable in the southern United States. While many of the newer varieties are early maturing, there is still a need for late-maturing, high-yielding varieties. Arkansas 92-552 fills this niche. It is a bush plant that produces silver pods in the upper portion of large plants that are free of basal runners. The seed are medium size with a bright pink eye. Maturity is 5 to 7 days later than 'Coronet' under Arkansas conditions. The variety processes well and canned peas have been rated equal to 'Coronet' by consumers panels. The yield potential is high and it has produced higher yield than 'Coronet' in replicated trials in Arkansas. 92-552 is also resistant to rootknot nematode.

036

'Quickpick': A New, Fresh-market Southernpea Suitable for Machine Harvest

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The Louisiana Agricultural Experiment Station has released a new pinkeye purple hull-type southernpea cultivar for the fresh market. The new cultivar, Quickpick, originated from a cross between breeding lines LA 88-74 and LA 88-9. 'Quickpick' has a bush-type plant habit with synchronous pod set and is suitable for either machine- or hand-harvest. Pods of 'Quickpick' are straight, ≈20 cm long, and about 8 mm in diameter. Fresh peas are green with a light-pink eye. Yield of 'Quickpick' equaled or surpassed yield of 'Texas Pinkeye Purple Hull' in machine-harvested replicated tests. In hand-harvested replicated tests, yield of 'Quickpick' was comparable to 'Texas Pinkeye Purple Hull', 'Coronet', 'Pinkeye Purple Hull-BVR', 'Mississippi Pinkeye', and 'Santee Early Pinkeye'. 'Quickpick' is immune to a Georgia isolate of blackeye cowpea mosaic virus, a major virus of southernpea in the United States.

037

Variability for Processing Quality Traits in Two Recombinant Inbred Populations of Kidney Bean

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Two recombinant inbred populations of kidney beans were developed and evaluated for canning quality. One population, composed of 75 recombinant inbred lines (RILs), was from a Montcalm/California Dark Red Kidney 82 cross. The second population, with 73 RILs, was from a Montcalm/California Early Light Red Kidney cross. RILs from both populations were planted in North Dakota in 1996 and Michigan in 1996 and 1997. Beans of each RIL were thermally processed using established procedures. Appearance and degree of splitting of each sample and the check varieties were scored subjectively on a 1–7 scale to represent the minimum and maximum acceptability levels of the traits, respectively. Genotypes and genotype × environment interactions were highly significant based on analyses of variance. In the 75 RIL population, seven lines, based on appearance, consistently appeared in the top 25% in all environments (mean = 4.5; range = 4.0–6.1), and four had consistently high acceptability scores (mean = 4.6; range = 4.0–6.3) for the degree of splitting trait. In the population with 73 RILs, nine lines consistently appeared in the top 25% in all environments based on appearance (mean = 4.6; range = 4.1–5.3). For degree of splitting, nine lines had consistently high acceptability scores (mean = 4.2; range = 3.7–5.1). Appearance and splitting of cooked dry bean are quantitatively inherited traits. The field experiments were useful to obtain RILs for screening to identify molecular markers associated with QTLs. Three primers—OQ11, ON186, and OF5—reported to be useful RAPD markers for processing quality in navy beans are of special interest in the current study.

038

Characterization of an Architectural Mutant of Bean (*Phaseolus vulgaris* L.)

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Genetic and morphological characteristics of an architectural mutant in common beans were studied. The mutant had shiny, dark green leaves, overlapping leaflets, short petioles and a terminal reproductive bud even though the line did not carry the *fin* gene. Branching was nearly absent, resulting in a single stem vine. This is a new form of determinancy in common bean. Inheritance studies demonstrated that the mutant trait was controlled by a single recessive gene. Allelism tests were performed between the mutant and a previously reported similar mutants, which were overlapping leaflets mutant (*ol*), and dark green savory leaf mutant (*dgs*). Results showed that the mutant trait was not allelic to *ol* and *dgs*. As a temporary designation, the name "topiary" describing its compact and neat appearance is being used. Linkage was tested for growth habit (*fin*), shiny leaf, cross-sectional shape of pods, striped pod (*prp*^{sh}) and pod suture strings (*st*) with the topiary mutant. No linkages were detected between either the mutant and marker genes or among the marker genes. The topiary mutant has potential for improving common beans. Its single stem growth habit may allow closer row spacing leading to higher planting populations and may enhance the efficiency of mechanical harvest. Pod formation at higher nodes may escape disease. Currently, the thin stems cause lodging. Development of thick and upright forms will be the subject of future studies.

039

The Blotchy Gene, *bl*, is Linked to the *R* and *Y* Loci in Table Beet

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The primary pigments in red beet are the betalains, which are comprised of the red-violet betacyanins and the yellow betaxanthins. Modification of betalain content and distribution in table beet has been practiced by breeders for many years, although little is known about the genetic control of these traits. The presence of dominant alleles at two linked loci (*R* and *Y*) condition production of betalain pigment in the beet plant. Red-pigmented roots are observed only in the presence of dominant alleles at the *R* and *Y* loci, while white roots are conditioned by recessive alleles at both loci and yellow roots by the genotype *rrY*-. A newly described gene, 'blotchy' (*bl*), conditions a blotchy or irregular pigment patterning in either red or yellow roots. The objective of this investigation was to

characterize the linkage relationships between the *R* and *Y* loci and the *bl* gene by evaluating segregating progenies developed from a series of matings of colored and white table beets. Segregation data indicate the *bl* gene is independent from *R* and *Y* and that this locus is linked to *R* and *Y*. The two-point linkage estimate between the *R* and *Y* loci pooled over eight crosses was 7.4 (1.7 cM). Linkage between *R* and *Bl* was estimated from a pooled sample of four crosses at 16.7 (10.8 cM). The most likely gene order was *R-Y-Bl*. These data suggest the *RYBl* genomic region plays a critical role in the genetic control of betalain biosynthesis in table beet.

040

Pedigree of Publicly Released Onion Germplasm in the United States, 1931–1997

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Since the 1930s, more than 130 inbred lines and 60 hybrid cultivars of onion have been released in the public sector in the United States. Other than breeder's reports from the period 1946–1965 and anecdotal information kept by onion workers, no systematic treatment of the pedigree of public onion germplasm releases has been developed. The objective of this research was to collect, characterize, and display the genetic relationships among more than 200 public onion germplasm sources used in the United States since 1931. Pedigree information revealed that most modern onion cultivars in the United States descend from a few open-pollinated populations brought to this country by immigrants. For example, selection in the open-pollinated populations Common Yellow and Silverskin by onion farmers in the eastern U.S. resulted in the formation of Yellow Globe Danvers, which was a precursor to virtually all Eastern storage onion germplasm in the U.S. Open-pollinated populations such as Yellow Globe Danvers, Valencia, Sweet Spanish, Bermuda, and Grano formed the foundation germplasm for the first public U.S. onion breeding programs. Findings from this study suggest a relatively narrow germplasm base of public onion germplasm in the United States; however, this narrow pool coexists alongside significant gains through scientific breeding efforts, particularly during the past 75 years.

041

Okra (*Abelmoschus esculentus*) Germplasm Evaluation for Earliness in Fruiting and High Fresh Fruit Yield

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A total of 45 varieties of okra (*Abelmoschus esculentus*) were evaluated for earliness in fruiting and high fruit yield. In Nigeria selection in okra is for large, spiny fruit with high drawing ability. So far the variety (cultivar) NHAC 47-4 has been well-accepted by both the Nigerian farmers and consumers. It fruit within 42 days and draws and retains fresh color when boiled. These new cultivars, NHAC147 and NHAC 148, were found to fruit within 38 to 40 days and they are of comparable yield of up to 40 fruit per plants. They were found to be drought-tolerant and carry fruit of up to five of same age and size—high degree of uniformity. They are therefore being recommended because they have short stems and NHAC148 has fewer spines than NHAC47-4 AND NHAC 147.

042

Identification of High-yielding Grain Amaranth (*Amaranthus* spp.) Cultivars

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Having established that the white-seeded amaranth (grain amaranth) can supply both green leaves and seeds (grains) for the Nigerian consumers, there was a need to find cultivars that could yield enough grains to be profitable for an amaranth farmer. Several lines (>100) were screened, with the opaque and creamy-colored seed as the ultimate target. These cultivars, NHAm 261-1 and NHAm258, were selected for yield trials. It was possible to have a high seed rate of 100 plants/m², and thinning to 22 plants/m² at the end of 6 weeks. These 22 plants were left to mature, and a maximum of 20 plants/m² were evaluated for grain yield. These two cultivars were found to give good fresh shoot yields as well as capacity for up to 3000/m².

043

New Honeydew Melons for Commercial Production in Western Mexico

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Since 1980, farmers from western Mexico have cultivated melon cantaloupe; however, during the past few years, they have seen the better advantages of honeydew melon. Some of them represent a good alternative to farmers because chemical products and labor costs are reduced, and because they are tolerant to several diseases. The purpose of this experiment was to evaluate 15 new hybrids of honeydew melon in western Mexico. The hybrids evaluated were: Dey Break, Hmx 4596, Hmx 4595, Hmx 4607, Sunex 7051, Rocio, creme de menthe, Silver world, Emerald sweet, Sme 5303, Sme 5302, Santa Fé, PSR 10994, and PSR 8994, Honey Brew was test. Fifteen -day-old plants were transplanted by hand. Treatments were replicated four times in a randomized complete-block design. Beds 1.2 m wide and 7.0 m long were prepared, 1.5 m between beds, distance plant–plant 0.5 m (plant density ≈13,332 plant/ha). Results show that yield of SME 5302, SME 5303, HMX 4596, Rocio, Dey Break, PSR 8994, Sunex 7051, and HMX 4607 had a yield higher of 50 t/ha, Emerald sweet had more number fruit (59 per 10 plants), whereas SME 5303, SME 5302 and Silver world had higher fruit weight (>1.719 gr). We suggest the evaluation of these hybrids in other regions to know the adaptation to different conditions and to select the best in commercial quality and production.

044

Selection for Floret Glucoraphanin Concentration Among Inbred Broccoli

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Broccoli (*Brassica oleracea* L. Italica Group) is a rich source of the aliphatic glucosinolate glucoraphanin. The glucoraphanin breakdown product, sulforaphane, has been shown to induce Phase II detoxication enzymes (e.g., Quinone Reductase) and has attracted attention as a potential chemoprotector against cancer. The objectives of this research were to evaluate the concentration of glucoraphanin in an array of diverse broccoli inbreds (doubled-haploids) largely derived from commercial germplasm and to determine if expression of glucoraphanin level in this initial evaluation is correlated with expression in a subsequent environment. In 1996, individual florets from single broccoli heads were sampled from 75 inbred lines grown in the field at Charleston, S.C., and glucoraphanin concentration was assayed. In this test, concentrations ranged from 0.04 to 2.94 μmol glucoraphanin per g fresh weight of florets and the mean concentration was 0.86. In 1997, a subset of 22 inbreds analyzed the first year were grown again in a replicated field trial. This inbred subset was made up of lines with diverse pedigrees and with high, low, or intermediate glucoraphanin concentrations. In this second year, glucoraphanin concentration had a range from 0.24 to 2.99 μmol per g fresh weight of florets and a mean of 1.37. Correlation of entry mean glucoraphanin concentration in 1997 with that in 1996 was positive ($r = 0.79$) and highly significant ($P < 0.001$) indicating that floret glucoraphanin concentration was relatively consistent between years. These observations provide evidence that floret glucoraphanin concentration has a significant genetic component.

045

Carotenoid Antioxidant Levels in Spinach

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Interest in the health benefits of vegetables prompted an investigation of the levels of carotenoids in commercial varieties and UA breeding lines of spinach. Plant carotenoids perform a critical function as antioxidants, providing protection against a variety of reactive oxygen species generated primarily during photosynthesis. When ingested by humans, these compounds maintain their antioxidant activities and are receiving considerable attention in relation to multiple health benefits, including cancer prevention. While the best-known and most-studied carotenoid is beta-carotene, other carotenoids are now receiving attention due to their higher antioxidant activity compared to beta-carotene. Most dark-green leafy vegetables, such as spinach and kale, are relatively high in carotenoids, espe-

cially lutein. In this study, significant differences in average content of both lutein and beta-carotene were found between genetic lines of spinach. Some lines exhibited considerable variation between plants, while others were highly uniform. There was a very high correlation ($r^2 = 0.96$) between lutein content and beta-carotene content. The significant difference between spinach lines suggests that improvement of general carotenoid antioxidants and lutein could be obtained through a breeding program.

046

Intra-specific Variability of Feverfew: Correlation Between Parthenolide, Morphological Traits, and Seed Origin

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Parthenolide, a biologically active sesquiterpene lactone found in feverfew [*Tanacetum parthenium* (L.) Schultz. Bip.], has been indirectly linked to the anti-migraine action of feverfew preparations. Commercial products of feverfew leaves vary widely in parthenolide content (0–1.0%/g dwt). No comprehensive studies have quantified parthenolide variation among feverfew populations or cultivars, and whether morphological traits are correlated with this natural product. In this study, 30 feverfew accessions were examined for parthenolide content, morphological traits, and seed origin. Statistically significant differences in parthenolide levels were found among the populations studied. Parthenolide content ranged from (0.012% \pm 0.017 to 2.0% \pm 0.97 /g dwt) as determined by HPLC-UV-MS. Higher parthenolide levels tended to be in wild material (0.41% \pm 0.27) as opposed to cultivated material (0.19% \pm 0.09). Parthenolide levels correlated with flower morphology: disc flower (0.49% = B1 0.36), semi-double (0.38% \pm 0.13), double (0.29% \pm 0.16), and pompon-like flower (0.22 \pm 0.14). Leaf color also appeared to be indicative of parthenolide levels, with the light-green/golden leafed accessions showing significantly higher parthenolide content than darker-leafed varieties, but whether this was due to inadvertent original selection of a high parthenolide-containing golden leaf selection is not yet known. This study does show that further selection for improved horticultural attributes and natural product content is promising to improve feverfew lines for the botanical/ medicinal plant industry.

047

Inheritance of Volatile Oil Constituents in Basil (*Ocimum basilicum* L.)

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To determine the mode of inheritance of citral, linalool, methylchavicol, and methylcinnamate in basil, controlled crosses were made between chemotypes rich in each of these constituents. Four stable *Ocimum basilicum* populations selected for high methylcinnamate (79%), methylchavicol (95%), linalool (82%), and citral (65%) respectively, served as parents. Crosses were made using chemotypes rich in terpenes (linalool x citral), in phenylpropanoids (methylchavicol x methylcinnamate), and a third that combines chemotypes from both biosynthetic pathways (linalool x methylchavicol). True hybrids were selfed in isolation and one hundred F₂ plants were analyzed for their oil composition. The parents, the F₁ hybrids and the F₂ generation of all plants were evaluated in a field trial under identical environmental conditions. Plants were harvested at full flowering, and dried at 380 °C. Identification of essential oil constituents were confirmed by GC/MS. The F₂ segregation data for each major oil constituent trait will be examined by χ^2 analysis tests. Preliminary results indicate that methylcinnamate segregates in a 3:1 ratio, and is a dominant major gene. In the two crosses using methylcinnamate chemotype as a female parent, the F₂ population segregates in 80:22 and 65:28 methylcinnamate:non-methylcinnamate plant types, with $P = 0.42$ and 0.25 and $\chi^2 = 0.64$ and 1.29 , respectively. Analysis of the other crosses are being processed, evaluating qualitative and quantitatively the presence or absence of each constituent in their F₂ population.

048

Collection and Evaluation of Four Varieties of *Celosia trigyna*

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Celosia trigyna has become an underutilized species of *Celosia* in Nigeria, it is known to be medicinal and very nutritive. It is therefore intended that with their

collection and evaluation, they could be domesticated. So far four varieties have been identified and described. All of them have a high tendency of shattering of the seeds from the inflorescence. The plant structure for all of them is prostrate, the varieties described are: NHcta01, NHcta03, NHcta4, and NHcta7. It was discovered that compared with *C. argentea*, they branch profusely and the leaves are smaller and ovate rather than lanceolate.

049

Development of Molecular Markers Linked to High Pigment (*hp*) and Dark Green (*dg*) Loci in Tomato

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The carotenoids have an important influence on tomato fruit quality and enhance the fruit contribution to human nutrition. Expression of the high pigment (*hp*) locus in tomato results in increased total carotenoids and increased efficiency of utilization of the polyenes. A similar mutant, dark green (*dg*), contains higher level of chlorophyll in immature fruit and results in darker red pigmentation, both externally and internally in ripe fruit. Random amplified polymorphic DNA (RAPD) and amplified fragment length polymorphism (AFLP) analyses were performed using two pairs of near isogenic lines (NILs) designed to be isogenic at the *hp* and *dg* loci. Sixty-four AFLP primer pairs and more than 1000 RAPD 10-mer primers were screened for polymorphism between each pair of the NILs. One RAPD marker was identified to be linked to the *hp* gene, and two AFLP primer pairs showed polymorphic fragments which distinguished the *dg* NILs. The markers identified in this study will be converted to allele specific SCAR (sequence characterized amplified region) markers, which are more useful in marker-assisted selection breeding programs.

91 POSTER SESSION 10 (Abstr. 050–084) Genetics/Breeding/Biotechnology

Friday, 30 July, 1:00–2:00 p.m.

050

Heritage Pears of the National Clonal Germplasm Repository

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The pear, *Pyrus* L., originated in prehistoric times. Records of its cultivation date back 3000 years both in Europe, with the ancient Romans and Greeks, and in Asia, with the Chinese. Pear culture was significant in France and England by the 16th century. The European golden age of pear improvement occurred from the 17th through the 19th centuries. The pear genetic resource collection for the United States Department of Agriculture, Agricultural Research Service, National Plant Germplasm System is maintained at Corvallis, Ore. This collection preserves more than 2000 diverse pear accessions, represents 26 species, and includes more than 410 heirloom cultivars. At least 10 of the cultivars have obscure origins from the ancient Roman, Greek, or Chinese cultures. Another dozen are at least 400 years old, and more than 250 were introduced during the European golden age. Another 120 "antique" cultivars of the collection were introduced during the first half of the 1900s. The "big four" economically important *Pyrus communis* L. cultivars in the United States, 'Bartlett', which originated in 1777; 'Anjou', late 1700s; 'Bosc', 1807; and 'Comice', 1845; are also represented. Origin and background information for these heirloom clones is web accessible through the Germplasm Resource Information Network (GRIN) database. Although many ancient pear genotypes have been lost, the Repository staff continues to search for significant heirloom cultivars that are not yet represented. Besides having direct value in crop improvement, these plants are a significant part of our human heritage. Their preservation is a sacred trust.

The USDA-ARS/Cornell University Apple Rootstock Breeding and Evaluation Program

William C. Johnson^{1,2}, Herb S. Aldwinckle, Phil L. Forsline^{1,2}, H. Todd Holleran², John J. Norell³, and Terence L. Robinson²; ¹USDA-ARS Plant Genetic Resources Unit, NYSAES, Geneva, N.Y.; ²Cornell University, Dept. of Horticultural Sciences, Geneva, N.Y.; ³Cornell University, Dept. of Plant Pathology, Geneva, N.Y.

In 1998, the USDA-ARS and Cornell Univ. instituted a cooperative agreement that mobilized the resources for a jointly managed apple rootstock breeding and evaluation program. The program is a successor to the Cornell rootstock breeding program, formerly managed by Emeritus Professor of Horticultural Sciences James N. Cummins. The agreement broadens the scope of the program from a focus on regional concerns to address the constraints of all the U.S. apple production areas. In the future, the breeding program will continue to develop precocious and productive disease-resistant rootstock varieties with a range of vigor from fully dwarfing to near standard size, but there will be a renewed emphasis on nursery propagability, lodging resistance, tolerance to extreme temperatures, resistance to the soil pathogens of the sub-temperate regions of the U.S., and tolerance to apple replant disorder. The program draws on the expertise available at the Geneva campus through cooperation with plant pathologists, horticulturists, geneticists, biotechnologists, and the curator of the national apple germplasm repository. More than 1000 genotypes of apple rootstocks are currently under evaluation, and four fire blight- (*Erwinia amylovora*) resistant cultivars have been recently released from the program. As a service to U.S. apple producers, rootstock cultivars from other breeding programs will also be evaluated for productivity, size control, and tolerance to a range of biotic and abiotic stress events. The project will serve as an information source on all commercially available apple rootstock genotypes for nurseries and growers.

052

Characterization of Somaclones and Apple Rootstocks (*Malus* sp.) by Using Isoenzymatic Systems

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This work aimed to evaluate apple rootstock somaclones by characterizing the genetic variability among them. The isoenzymatic systems were used for analyzing variability as follows: FAC (acid phosphatase), PRX (peroxidase), and 6-PGD (6-phosphogluconate dehydrogenase). The migration were performed by applying a potential difference around 10 volt/linear cm. A data matrix was built so that the genotypes were placed in the lines and the bands in the columns. The scores were attributed as follows: band present (1) and band not present (0). By the gel analyses in relation to the presence/absence and band intensity, we observed marked differences among the somaclones and within somaclones as well. In the peroxidase system a higher band polymorphism was detected with 18 enzymatic patterns. The group analyses for the 73 apple somaclones revealed a large variability through the enzymes (18 peroxidases, 8 FAC, and 6 6-PGD), which were classified into two groups. Group I was represented by M.7 somaclones with seven subgroups with 43% similarity among the clones. Differences among M.9 and M.111 cultivars and two clones referred to as M9_b and M9₂₅ were fitted within somaclones M.111. The remaining somaclones of cultivar M.9 showed a higher variability bearing 43 subgroups. Clones M9₂₉, M9₃₀ and M9₃₂ presented 100% similarity.

053

Graft Union Strength of Apple Trees

William C. Johnson^{1,2}, Karl J. Niklas³, Terence L. Robinson², H. Todd Holleran², Steve A. Hoying⁴, Martin Goffine², and Mary J. Welser²; ¹USDA-ARS Plant Genetic Resources Unit, Geneva, N.Y.; ²Dept. of Horticultural Sciences, Cornell University, NYSAES, Geneva, N.Y.; ³Dept. of Plant Biology, Cornell University, Ithaca, N.Y.; ⁴Cornell Cooperative Extension, Wayne County, Newark, N.Y.

An increased incidence of graft union failure of apple trees during high wind events has been noted by researchers participating in the NC-140 regional rootstock testing project for certain rootstock–scion combinations. By measuring the strength of graft unions in a survey of mature apple trees in multiple stock–scion combinations, we have determined that there are significant differences. These differences may be attributable to genotype specific characteristics of rootstocks,

scions, and/or rootstock–scion interactions. We are presently exploring potential biophysical and anatomical differences related to weak graft unions of apple rootstock and scion varieties. As traits correlated with weak graft unions are identified, they will be useful to help growers avoid the rootstock–scion combinations that are particularly susceptible to tree failure.

054

Characterization of *Malus hupehensis* (Tea Crabapple) with DNA Simple Sequence Repeats

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Simple sequence repeats (SSRs) are highly polymorphic regions of DNA that can be used for the molecular characterization of apple (*Malus*) germplasm. SSR markers are sufficiently variable to distinguish between individual plants in wild *Malus* species. In this study, accessions of *Malus hupehensis* were screened for fragment length variation in PCR amplified simple sequence repeat regions of DNA. The fragment length phenotype produced by five SSR primer pairs showed no variation between two lineages of *M. hupehensis* collected in the Changjiang (Yangtze) River valley. One lineage was collected by E.H. Wilson in 1908 near the city of Ichang, Hubei Province. The second lineage was collected by cooperators at China's Southwest Agricultural University (SWAU) in 1997 near the city of Chongqing (Chungking). *M. hupehensis* Plant Introduction No. 588760 from the National Plant Germplasm System lacks provenance, but displays a fragment length phenotype identical to both the Wilson and SWAU lineages. The spread of a clone may be aided by asexual reproduction through seed, which is not uncommon in polyploid apples. Two seedlings each of 15 maternal trees from the SWAU lineage were assayed for ploidy level by flow cytometry. The DNA content per nucleus for all SWAU progeny fell within the range for triploids, 2.19 to 2.68 pg DNA/nucleus. It appears that plant explorers in China separated by almost 90 years have succeeded in sampling a single clonal lineage of *M. hupehensis*.

055

An Apple Linkage Map with SSRs and Other Sequence Tagged Sites Suitable for Comparative Mapping

Minou Hemmat, Norman F. Weeden*, Frank S. Cheng, and S.K. Brown; Dept. of Horticultural Sciences, Cornell Univ., Geneva, NY 14456

The positions of over 500 SSR loci and other sequence tagged sites (STSs) have been located on the linkage maps of five apple cultivars (Rome Beauty, White Angel, Golden Delicious, Liberty, McIntosh) and two New York accessions. In most cases, the primers used produced single amplification products, permitting identification of homologous loci in the different cultivars and the precise alignment of the linkage maps generated for each. Based on this information, we present a general linkage map for apple with STS markers on each linkage group. The map consists of 17 linkage groups (equal to the haploid chromosome number for the species) with over 500 markers. The positions of several resistant gene analogues have been located on this linkage map. None of these sequences map near genes conferring resistance to scab or powdery mildew. SSR loci exhibited a tendency to cluster in certain regions of the linkage map. This clustering slightly reduces their effectiveness as genome markers for comparative mapping or germplasm diversity. However, the SSR markers definitely displayed a high level of polymorphism, making them particularly useful for genetic studies.

056

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

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

A New Plumcot Adapted to the Southeastern United States

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Plumcots are hybrids of plums (usually Japanese-type) and apricots. In recent years, several new plumcots have been released, but most of these have been unreliable croppers and tree health of those tested in the Southeast has been poor. Some do have very high quality fruit, combining the best features of both parents. BY88Z1092 appeared as a chance hybrid in a lot of open-pollinated seedlings from the plum selection BY8111-6, which was a hybrid of BY4-601 (=Queen Anne*×Santa Rosa)*×Frontier. BY8111-6 was a high-quality, midseason plum with black skin and amber flesh. BY88Z1092 blooms about with 750 chill hour peaches, and appears to be somewhat self-fertile. Cropping is heavy at Byron in absence of severe spring frosts. Tree health is good, comparable to local adapted plums such as 'Black Ruby'. Trees are upright in growth habit. Fruit of BY88Z1092 ripen in late May, when quality of other adapted plums is insipid. It has firm yellow-orange flesh and a purple-black skin with light pubescence. Flavor is acidic until the fruit begins to soften, at which time it is very good. Fruit size will reach 4 to 5 cm in diameter if properly thinned. BY88Z1092 is in the final stages of testing and will likely be named within the next year.

Cloning of a Defensin-related Gene and Its Expression during Dormancy and Fruit Development in Peach [*Prunus persica* (L.) Batsch]

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During the past several years we have been involved in identifying seasonally regulated proteins and genes from peach bark. In the present study, we describe the cloning of a protease inhibitor from a cDNA library made from winter bark tissues. A partial clone obtained from the library was extended to full length by 5' RACE. The full-length cDNA clone (final3b) is 613 bp in length, not including the poly A+ tail. The open reading frame of 237 bp codes for a 79 amino acid protease inhibitor related to the defensin family of proteins. This family of small, cysteine-rich, extracellular proteins play a role in the plant's defense response through their antifungal properties. Sequence comparison of the encoded protein using BLAST analysis revealed significant homology to protease inhibitors from *Glycine max*, *Arabidopsis thaliana*, and a defensin protein from bell pepper (*Cap-sicum annuum*). Similar to these other cysteine-rich proteins, the peach defensin contains a consensus cys arrangement and is predicted to have an amino terminal signal peptide, presumably targeting it for extracellular transport. RNA-blot analysis indicated that the gene is seasonally expressed in bark tissues of 1-year-old shoots. Transcript abundance of final3b increased in the fall, reached a peak in midwinter and then decreased. The gene was also expressed during early stages of fruit development. RNA-blot analysis of the gene in other tissues, and in response to environmental stress and wounding, is in progress.

Performance of 'Guardian' Peach Rootstock Selections in Alabama

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Twelve peach rootstocks including 'Lovell', 'Nemaguard', 'Flordaguard', '14DR51', five 'Guardian' (BY520-9) selections, and three BY520-8 selections, were evaluated under field conditions to determine their effect on performance of 'Cresthaven' peach. The trees were planted in 1994. Trunk cross-sectional area of BY520-8 selections SL1923 and SL4028 was 28% larger than the rest of the rootstocks, which were similar. There was no crop in 1996 due to late spring frost. Yield in 1997 and 1998 was higher for SL1923 because of higher croplod than the rest of the rootstocks, which were similar. Yield efficiency varied across years and rootstocks. Fruit weight varied among rootstocks but all were commercially acceptable. Harvest date was advanced by two days for some rootstocks compared to Lovell and none were delayed. Percent red blush, soluble solids and firmness varied among rootstocks, but none demonstrated superior quality in all of these parameters as compared to Lovell. Ring nematode population densities were above the threshold considered to be critical for onset of PTSL for all

rootstocks in 1997 and 1998. Tree survival was at or above 86% for all rootstocks and death was not correlated with ring nematode density. No trees developed symptoms characteristic of Peach Tree Short Life disease complex. Guardian selections performed adequately compared to the commonly used commercial rootstocks in this study, however, the yield date are from 2 years only.

'Blake's Pride' Fire Blight-resistant Pear Cultivar

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'Blake's Pride' has been released jointly by USDA and The Ohio State Univ. as a new fire blight-resistant cultivar. The original seedling tree was selected in 1977 at the Ohio Agricultural Research and Development Center in Wooster by R.C. Blake and T. van der Zwet from a cross of US 446 x US 505, performed in 1965 by H.J. Brooks, and was tested under the original seedling number, OHUS 66131-021. The fruit of 'Blake's Pride' is pyriform to round-pyriform in shape, and is moderate in size, averaging ≈2.75" to 3" in diameter, and 3.25" in height. The stem is short, medium in thickness, and upright. Skin undercolor is yellow, the finish is glossy, and 20% to 30% of the fruit surface is covered with a smooth, light tan russet. Harvest maturity occurs about 3 weeks after 'Bartlett', and the fruit will store in air storage for at least 3 months without core breakdown or superficial scald. The flesh texture is moderately fine, juicy, and buttery. Grit cells are moderately small and occur primarily around the core and in a thin layer under the skin, similar to 'Bartlett'. The flavor is subacid and aromatic. The tree is moderate in vigor on 'Bartlett' seedling rootstock, and upright-spreading in habit. Yield has been moderate to moderately high. Fire blight infections are rare, and extend no further than 1-year-old growth. Artificial blossom inoculations indicate a moderate degree of resistance of blossoms to fire blight infection. Resistance of 'Blake's Pride' to both shoot and blossom infection is much greater than that of 'Bartlett'.

Novel Sources of Genetic Resistance to Eastern Filbert Blight in Hazelnut

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A survey of hazelnut (*Corylus avellana* L.) genotypes for response to the eastern filbert blight pathogen [*Anisogramma anomala* (Peck) E. Müller] was performed. Seven varieties were discovered that did not display disease signs or symptoms when subjected to severe inoculation with *A. anomala* in the greenhouse and assayed for infection. These cultivars are 'Closca Molla', 'Ratoli', 'Yoder #5', 'Potomac', 'Medium Long', 'Grand Traverse' and 'Zimmerman'. 'Ratoli' and 'Closca Molla', both minor varieties from Spain, are superior agronomic types to the resistant cultivar Gasaway, which has been the main resistance source used in the breeding program. Only 'Zimmerman' carries the RAPD marker linked to resistance in populations segregating for the 'Gasaway' gene. Three populations were created using 'Zimmerman', as the pollen parent in controlled crosses. These populations were inoculated with spores of the pathogen and assayed by indirect ELISA and by observation of canker incidence. Resistant phenotypes make up 84% of the populations, indicating that 'Zimmerman' possesses resistance either distinct from or additional to that found in 'Gasaway'. A RAPD marker linked to the resistance gene in crosses with 'Gasaway' cosegregates with the resistant phenotype in all three populations (0 cM, 3 cM, 4 cM). Mechanisms to explain the distortion in these populations are discussed. Further studies are required to characterize the mechanism and inheritance resistance in these other clones.

Genetic Relationships among *Corylus* Species

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Interspecific hybridization, pollen-stigma incompatibility, and DNA sequence analysis were used to study the relationships among hazelnut (*Corylus*) species. Interspecific crosses resulted in a wide range of cluster set from 0% to 65%. Reciprocal differences were common. In general, crosses involving *C. avellana* and *C. heterophylla* were more successful when used as pollen parents, but crosses involving *C. americana* were more successful when it was the female parent. *C. cornuta*, *C. californica* and *C. sieboldiana* intercrossed freely in both directions, as did *C. colurna* and *C. chinensis*. The Asian species, *C. sieboldiana*,

C. heterophylla, and *C. chinensis*, were not cross-compatible with each other. Fluorescence microscopy showed that pollen–stigma incompatibility exists within and among wild hazelnut species, in addition to the cultivated European hazelnut *C. avellana*. Pollen–stigma incompatibility and embryo abortion (blank nuts) appear to be major blocks to interspecific gene flow. In addition, the chloroplast matK gene and the Internal Transcribed Spacer (ITS) region of the nuclear ribosomal DNA (nrDNA) were amplified and sequenced. The matK sequence was highly conserved and thus was not informative. However, the ITS sequence was highly informative and parsimony analysis agreed with morphological similarities. *Corylus* species were placed into four groups: 1) *C. avellana*, *C. maxima*, *C. americana* and *C. heterophylla* 2) *C. colurna*, *C. chinensis*, and *C. jacquemontii* 3) *C. cornuta*, *C. californica* and *C. sieboldiana* 4) *C. ferox*.

063

Biological Basis for Noninfectious Bud-failure in Almond (*Prunus dulcis*)

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Noninfectious bud-failure (BF) is a genetic disorder in almond, associated with nursery source selection. Previously (Kester, PASHS, 1968), the latent potential for BF (BF_{pot}) was shown to be heritable but its phenotypic expression (BF_{exp}) varied among individual seedlings of a populations as a function of age. Vegetative propagation perpetuates BF_{pot} of individual propagules (Kester and Asay, JASHS, 1978b) but the subsequent age of BF_{exp} within individual plants is a function of accumulated exposure to high summer temperature and growth (Kester and Asay, JASHS 1978a). A recent 7-year “somatic heritability” study of 12 commercial nursery sources (Kester et al., HortScience 1998abst) portrays the total range of variability of BF_{pot} and BF_{exp} within the entire ‘Carmel’ almond clonal population and includes a pattern of BF increase in consecutive vegetative propagation cycles that mimics patterns produced by phase change (i.e., juvenile > mature) phenomena (Hartmann et al., 1997). Although phase change potential is heritable in seedling populations, phase change expression is not (Kester, HortScience 1983). Furthermore phase changes can be reversed under particular conditions during consecutive vegetative propagations (Hartmann et al., 1997). In contrast, evidence shows that BF produces permanent changes in genotype that are heritable and irreversible. High correlations exist between BF_{pot} of individual source blocks, individual trees and individual budsticks and the age and severity of BF_{exp} in progeny trees. The apparent continuous change in BF_{pot} and BF_{exp} within clones appears to be the pattern of expression of different populations of increasingly defective (?) somatic cells that result from consecutive sequences of change during annual cycles of growth and generations of vegetative propagation.

064

The History of Macadamia Nut Introduction and Development in Kenya

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The macadamia nut was introduced to the Kenyan highlands from Australia in the early 1960s. Seedlings were propagated at a nursery near Kiambu in central Kenya by Bob Harris and were subsequently distributed in the central and eastern highlands and later the western highlands. The majority of seedlings planted were one two species, *Macadamia integrifolia* Maiden and Betche or *M. tetraphylla* L. S. A less common species, *Macadamia ternifolia*, was also planted. Several hybrids of *M. integrifolia* and *M. tetraphylla* have been identified in the central and eastern highlands. A macadamia improvement research program was launched in the early part of 1980 by the Ministry of Agriculture. Since then, 30 trees of the seedlings planted in the later part of 1960s have been selected and evaluated in trial orchards located in the Kenyan highlands. Most of the recently planted orchards constitute of 10 clones that yield between 40 to 90 kg of nuts annually. Five high-yielding macadamia varieties from Hawaii were introduced to Kenya in the early 1980s. To date >90% of the cultivated macadamia trees in Kenya are either *M. integrifolia* or hybrids of *M. integrifolia* and *M. tetraphylla*. Until the late 1970s, there was no market for macadamia nuts in Kenya. Since then, several companies market this crop, which is mainly exported to Japan and Europe.

065

Genetic Diversity of the Allegheny Chinkapin (*Castanea pumila* var. *pumila*)

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American species in the genus *Castanea* are susceptible to chestnut blight, caused by the Asian fungus *Cryphonectria parasitica*. This disease spread throughout the natural range of the American chestnut and reduced the species from a timber and nut producing tree to an understory shrub. The lesser known member of the genus, the chinkapin, has also been affected by this disease and a conservation plan is needed. Genetic diversity within and between geographic populations of the Allegheny chinkapin was evaluated to provide baseline genetic information pertinent to conservation of the species. Nuts of Allegheny chinkapin trees from populations in Mississippi, Florida, Alabama, Virginia, and Ohio were collected and evaluated for isozyme and RAPD marker polymorphism. The genetic diversity of these populations will be compared with that of Ozark chinkapin and American chestnut populations. Conservation strategies will be discussed.

066

Development of Simple Sequence Repeat DNA Markers for Use in Pecan Genetic Studies

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A microsatellite library has been developed from ‘Halbert’, a native pecan selection from Coleman County, Texas, using methods developed at the Texas A&M Univ. Crop Biotechnology Center. A total of 6144 DNA fragment clones were archived in 384 well plates for screening. Four-hundred-thirty-nine clones were positive after Southern hybridization using di- and tri-nucleotide repeats as probes. One-hundred-twenty-five positive clones were sequenced on an ABI 377 automated DNA sequencer. Of these, 24 repeats had enough sequences at the two ends to design primers. Primers were designed using Primer Express software, and were synthesized by Genosys, USA. The simple sequence repeats (SSRs) chosen for primer analysis include di- (CA and GA) and tri-nucleotide repeats (CTT, GAA and GAT). The SSRs were amplified under high stringency conditions with temperatures based on length and GC content. Reproducibility was verified using ‘Halbert’ DNA isolated from different inventories. Of the 24 primer pairs tested, 20 successfully amplified microsatellites from ‘Halbert’. DNA was isolated from 48 pecan and hickory accessions selected to strategically represent the genetic diversity of the NCGR *Carya* collections (a core collection). The accessions included parent–progeny combinations, individuals from geographically distant native populations, species, and interspecific hybrids. The 20 SSR primers that produced good amplification products in ‘Halbert’ were used to evaluate the collection, with 11 revealing multiple sizes of the repeat. The number of bands amplified with different primer combinations ranged from 4 to 32 in the 48 genotypes tested. We used RFLPscan software to aid in gel scoring (sizing amplified fragments, and comparing amplification profiles), and NTSYSpc software to evaluate genetic similarities. Evaluation of the data confirms the utility of the primers in delimiting known relationships.

067

A Long-term Comparison of Six Rootstocks for ‘Nonpareil’ and ‘Carmel’ Almond Cultivars

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A rootstock comparison trial for almond was planted in sandy soil near Atwater, Calif., in Feb. 1989. The study consisted of five replications of five trees each for six rootstocks, each with two cultivars. The rootstocks were ‘Nemaguard’ peach, ‘Nemared’ peach, ‘Hansen 536’ peach x almond hybrid, ‘Bright’s hybrid’ (peach x almond), ‘Halford’ peach seedling, and ‘Lovell’ peach seedling. Two cultivars, ‘Nonpareil’ and ‘Carmel’, were used with each rootstock. The accumulated kernel production from ‘Nonpareil’ through the 1998 harvest was highest for trees on ‘Hansen 536’, second highest for those on ‘Nemaguard’, and third highest for trees on ‘Bright’s Hybrid’. The accumulated kernel production from ‘Carmel’ was greatest for trees on ‘Bright’s Hybrid’ and second highest for those on ‘Hansen 536’. The hybrids have produced the largest trees, as indicated by trunk circumference, for both ‘Nonpareil’ and ‘Carmel’. The greater production of trees on the hybrid rootstocks over those on the peach seedling rootstocks was probably a result of their greater size and not that the trees on the hybrid rootstocks were inherently higher-yielding.

QTL Analysis of Solid Content, Pungency, and Antiplatelet Activity of Onion (*Allium cepa* L.)

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Solid content is an important characteristic related to onion flavor, texture, and storability and has practical importance for the dehydration industry. Among the salutary effects of *Allium* vegetables on the cardiovascular system is the inhibition of platelet activity. Platelets play a key role in thrombosis and acute coronary syndromes because they facilitate blood coagulation. Pungency is also an important commercial trait. A 138-point genetic map is being used to identify and estimate the magnitude of quantitative trait loci controlling solid content, pungency, and health-enhancing attributes of onion. QTL controlling pungency, total solids, soluble solids, and antiplatelet activity were estimated using 54 F₂ families, derived from the cross between Brigham 'Yellow Globe 15-23' (BYG15-23) and 'Ailsa Craig' (AC43). The families, the two parents, and controls were evaluated in four environments, at Palmyra or Randolph, Wis., during 1997 and 1998, on muck soils. For the analyzed traits there is evidence of transgressive segregation, the distributions are, in general, skewed towards the BYG 15-23 parent. Our results confirmed the existence of strong phenotypic correlations among the traits under study. QTL data available also suggest the existence of significant correlations between markers and the traits under study. Most of the markers that are significant for pungency and antiplatelet activity are also significant for solids, suggesting that these characteristics may be controlled by the same chromosome regions.

069

Molecular-facilitated Selection of Maintainer Lines in Edible Onion (*Allium cepa* L.)

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Cytoplasmic-genic male sterility (CMS) is used to produce hybrid onion seed. For the most widely used source of CMS in onion, male sterility is conditioned by the interaction of sterile (S) cytoplasm and the homozygous recessive genotype at a single nuclear male-fertility restoration locus (Ms). Maintainer lines used to seed-propagate male-sterile lines possess normal fertile (N) cytoplasm and the homozygous recessive genotype at the Ms locus. Presently, it takes 4 to 8 years to establish if maintainer lines can be extracted from an uncharacterized population or family. We previously developed a PCR marker useful to distinguish N and S cytoplasm of onion. To tag the nuclear male-fertility restoration locus (Ms), we evaluated segregation at Ms over at least three environments. Segregations of AFLPs, RAPDs, and RFLPs revealed molecular markers flanking the Ms locus. We are working to convert these linked molecular markers to nonradioactive-PCR-based detection. The organellar and nuclear markers were used to select plants from open-pollinated onion populations and determine if the number of test-crosses required to identify maintaining genotypes.

070

Non-autonomous Maize Transposable Element, Dissociation (Ds) Transposed in Carrot (*Daucus carota* L.)

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Maize transposable elements, Activator (Ac) and Ds transformed into several heterologous plant species for transposon tagging of genes. Several genes in Arabidopsis, flax, petunia, tobacco, and tomato have been tagged and cloned by using Ac and Ds. We have double transformed carrot lines, B493 and B7262 with stabilized autonomous Ac and non-autonomous Ds element to develop a two-element based transposon tagging system. PCR and Southern hybridization indicated that Ds element transposed from T-DNA in calli, somatic embryos and transgenic plants. The insertion of Ds element into new sites in carrot genome after excision verified by GUS assay, Southern hybridization and inverse-PCR. Currently, the behavior of non-autonomous Ds element is being studied. Ds induced mutation will be screened in transgenic plants. These initial results demonstrate that the Ac/Ds-based transposon tagging system may work in carrot.

071

A Saturated Linkage Map for the Garden Pea

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A linkage map for a set of 51 F₂-derived recombinant inbred lines has been constructed from the segregation data of ~850 morphological, isozyme, RFLP, STS, RAPD, and AFLP markers. The final map consists of seven clear linkage groups with a total length of nearly 900 cM. The wide variety of loci placed on this map permits its comparison with partial maps that have been developed in other programs. For the most part, the arrangement of loci agrees with that in previous maps, and no evidence for translocation heterozygosity in this cross is apparent. Although some clustering of markers is observed, for the most part the markers are well-distributed, and few gaps greater than 5 cM are found in the coverage. The availability of this first "complete" and highly saturated map for pea should permit more efficient comparison of the partial maps that have been generated in a number of different crosses, as well as provide a firm basis for future mapping and molecular studies in this species.

072

Backcross Breeding with RAPD Molecular Markers to Enhance Resistance to Common Bacterial Blight in Pinto Beans

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Common bacterial blight (CBB) in common bean (*Phaseolus vulgaris* L.), caused by *Xanthomonas campestris* pv. *phaseoli* (Xcp), reduces bean yields and quality throughout the world. Pinto 'Chase' is a high-yielding variety with moderate resistance to Xcp derived from great northern Nebraska #1 selection 27, whose resistance is derived from an unknown tepary (*P. acutifolius*) bean source. XAN-159 is a black mottled small seeded breeding line with different genes for high resistance to Xcp derived from a different tepary source (PI 319443). Our objective was to pyramid different genes for Xcp resistance from the donor parent XAN-159 into the rust-resistant recurrent parent Pinto 'Chase' using the classical backcross breeding method with confirmation of resistance using RAPD molecular markers. Resistance was confirmed in some BC₁F₂ generation plants. Seven RAPD markers and the V locus (flower color) previously identified were confirmed in the BC₁ and BC₂ populations. Smaller seed size, purple flower color, and black mottled seed coat color were coinherited with resistance to Xcp. However, a recombinant plant with enhanced CBB resistance and moderate-sized pinto seed was identified. Backcross breeding is being continued.

073

Determining Genomic Regions Associated with Common Bean Reaction to *Agrobacterium tumefaciens* Infection

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Resistance genes (QTLs and major genes) to various pathogens tend to occur in clusters at specific locations in plant genomes. In common bean (*Phaseolus vulgaris*), common genomic regions associated with host response to the bacterial pathogen *Xanthomonas campestris* pv. *phaseoli* and to the symbiont *Rhizobium* have been identified. *Agrobacterium tumefaciens* causes crown gall disease in common bean, and shares similar gene activation mechanisms and host recognition signals with *Rhizobium*. Genotypic differences in tumorigenesis have been observed and could restrict *Agrobacterium*-mediated bean genetic transformation. The objectives of this research were: 1) to identify wild *Agrobacterium* strains inducing contrasting response in bean genotypes; and 2) to identify genomic regions in a core linkage map associated with host response to *Agrobacterium* infection, in comparison with the position of other symbiont or pathogen resistance genes. Among 10 wild *A. tumefaciens* strains tested under controlled inoculations of 1-week-old seedlings, Ach5, R10, and mainly Chry5 were virulent to the genotypes tested. The genotype BAT93 was susceptible to Chry5, even at low inoculum concentration, in contrast with JaloEEP558. Increasing levels of N enhanced susceptibility to Chry5, R10 and Ach5. Fifty recombinant inbred lines of BAT93 x JaloEEP558 were inoculated with Chry5 and segregated for tumor formation, with 21 lines not forming tumors. Analysis of variance identified 25 markers in five linkage groups of the core linkage map, significantly associated with *Agrobacterium* resistance, sharing the same location with QTLs identified for other host-bacteria interactions. (Financed by FAPESP 97/12066-1).

074

Molecular Markers Linked to the *Ur-7* Gene Conferring Specific Resistance to Rust in Common Bean

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Bean rust, caused by *Uromyces appendiculatus*, is a major disease of common bean (*Phaseolus vulgaris*). The objective was to identify RAPD markers linked to the gene (*Ur-7*) for specific resistance to rust race 59 using bulked segregant analysis in an F₂ segregating population from the common bean cross GN1140 (resistant to rust) x Nebraska #1 (susceptible to rust). A single dominant gene controlling specific resistance to race 59 was found in the F₂ and was confirmed in the F₃. Seven RAPD markers were detected in a coupling-phase linkage with the *Ur-7* gene. Coupling-phase RAPD markers OAA11.500, OAD12.550, and OAF17.900 with no recombination to the *Ur-7* gene were found. Three RAPD markers were identified in a repulsion-phase linkage with the *Ur-7* gene among the three markers at a distance of 8.2 cM. This is the first report on RAPD markers linked to the *Ur-7* gene in common bean. The RAPD markers linked to the gene for specific rust resistance of Middle American origin detected here, along with other independent rust resistance genes from other germplasm, could be used to pyramid multiple genes into a bean cultivar for more-durable rust resistance.

075

Confirmation of Molecular Markers and Flower Color Associated with QTL for Resistance to Common Bacterial Blight in Common Beans

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Common bacterial blight, incited by *Xanthomonas campestris* pv. *phaseoli* (*Xcp*), is a serious disease of common bean (*Phaseolus vulgaris*). RAPD markers and flower color (*V* gene) previously had been reported to be associated with six QTL affecting leaf and pod resistance to *Xcp*. However, the markers for the QTL were not confirmed in different populations and environments to indicate their merit in breeding. Our objective was to determine if the associations of RAPD markers and the *V* gene with QTL for leaf and pod resistance to *Xcp* in a RI backcross population from the cross BC₂F₆ 'PC-50' x XAN-159 and for leaf resistance to *Xcp* in a F₂ population from a different cross Pinto 'Chase' x XAN-159 could be confirmed. Among six QTL previously detected, five in the RI backcross population and three in the F₂ population were confirmed to be associated with resistance to *Xcp*. The *V* gene and RAPD marker BC437.1050 on linkage group 5 were most consistently associated with leaf and pod resistance to two to five XCP strains in the RI backcross population and with leaf resistance to two *Xcp* strains in the F₂ population. The confirmed marker BC437.1050 and *V* gene on linkage group 5, along with other resistance genes from other germplasm, could be used to pyramid the different genes into a bean cultivar to enhance the resistance to *Xcp*.

076

Geographical Variation of Solanidane Aglycone Glycoalkaloids and Levels of Variability Detected by AFLP Analysis in the Wild Potato Species *Solanum chacoense* Bitter

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The Colorado potato beetle is a serious pest of the cultivated potato. Natural resistance has been found in a few wild species, including *Solanum chacoense* Bitter, in which resistance is attributed to the presence of foliar specific leptine glycoalkaloids. Production and accumulation of these compounds within *S. chacoense* varies widely and appears to be inherited in a quantitative fashion, but high leptine producing clones occur rarely. In the present study, 15 different accessions from various locations and altitudes of origination were analyzed for foliar glycoalkaloid content in order to determine the frequency and distribution of genes for leptine production/accumulation, and to see if we could find a center, or core, of leptine production. Leptines were detected in eight of the 15 accessions, and the amounts within each accession varied widely, but none of the individuals produced high amounts of leptine (defined as greater than 62% of total glycoalkaloids). All of the leptine-containing accessions originated from western Argentina. There was no relationship between elevational level and leptine,

but there was a negative trend with total glycoalkaloids and elevation; this was due to levels of solanine and chaconine decreasing with increasing elevation. In addition, nine unidentified glycoalkaloids were detected, in very high proportions in some individuals and accessions. AFLP marker frequency and diversity were used to compare subpopulations of these accessions. AFLP markers revealed substantial diversity among clones. The relationship of marker distribution to glycoalkaloid content is discussed. The results raise interesting questions about glycoalkaloid biosynthesis and inheritance, and point the direction for new avenues of leptine and glycoalkaloid research.

077

Identification of Molecular Markers Linked to Crown Rot Resistance (*Fr*) in Tomato

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Fusarium crown and root rot (crown rot) develops on tomato from the fungus *Fusarium oxysporum* f.sp. *radicis-lycopersici* (FORL). Genetic resistance to crown rot was previously introduced into the cultivated tomato from the wild species *Lycopersicon peruvianum* and found to be a single dominant gene, *Frl*, on the long arm near the centromere of chromosome 9 of the tomato genome. In an effort to identify molecular markers tightly linked to the gene, Ohio 89-1 Fla 7226, Fla 7464, 'Mocis', and 'Mopèrou', lines homozygous for *Frl* (resistant), were screened with restriction fragment length polymorphism (RFLP) markers in comparison to Fla 7482B and 'Monalbo', lines homozygous for *Frl*^{*} (susceptible). *Frl* was determined to be between the RFLP markers CT208 and CD8. These two markers are separated by a genetic map distance of 0.9 cM according to Pillen et al. (1996). In addition, we screened a pool of eight resistant plants against a pool of nine susceptibles from a BC₁ population segregating for *Frl* for amplified fragment length polymorphism (AFLP) markers. Fazio et al. (1998) previously determined that crossover events occurred in these 17 plants between *Frl* and a rapid amplified polymorphic DNA (RAPD) marker, UBC194. Our research has indicated that UBC194 is also between CT208 and CD8 on the centromeric side of *Frl*. Of the 62 AFLP primer combinations tested, 34 showed more than 63 strong polymorphisms in linkage to resistant phenotypes.

078

Mapping of the *Citrullus* Genome using Populations Segregating for *Fusarium* Wilt Resistance

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Fusarium wilt, caused by the soilborne fungus *Fusarium oxysporum* f.sp. *niveum* (FON), is a serious disease of the watermelon (*Citrullus lanatus*). Three races of this pathogen (races 0, 1, and 2) have been identified based on differential pathogenicity assays. Most commercially available cultivars are resistant to races 0 and 1. Inheritance for resistance to these races is thought to be controlled by a single dominant gene. No cultivars are resistant to race 2 and resistance is thought to be a quantitative trait. F₂ lines derived from a cross between the *Fusarium*-resistant *Citrullus lanatus* PI296341, and the *Fusarium*-susceptible watermelon cultivar 'New Hampshire Midget' were used to generate a RAPD-based map of the *Citrullus* genome. F_{2,3} families were assayed in the greenhouse for resistance to races 1 and 2. Those families that were either highly resistant or highly susceptible were used in identifying markers linked to *Fusarium* wilt resistance. A preliminary map of the *Citrullus* genome based on random amplified polymorphic DNA (RAPD) markers has been expanded with the inclusion of simple sequence repeats (SSRs), amplified fragment length polymorphisms (AFLPs), and isozymes.

079

Molecular Tagging of ZYMV Resistance in Squash (*Cucurbita moschata*)

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Marker-based selection for resistance to zucchini yellow mosaic virus in squash (*Cucurbita* spp.) would allow breeders to screen individual plants for resistance to multiple viruses. The *C. moschata* landrace Nigerian Local is widely

used as a source of resistance in *C. pepo* breeding programs. We used RAPDs and bulk-segregant analysis to screen two BC₁ populations for a marker linked to the dominant major gene for resistance from Nigerian Local. The initial cross was Waltham Butternut x Nigerian Local; the test populations were created from reciprocal backcrosses to Waltham Butternut. Both populations segregated 1:1 for resistance when hand-inoculated with ZYMV. RAPD primers were screened on a resistant bulk and a susceptible bulk from each population, and Waltham Butternut and Nigerian Local. Primers that gave bands linked to resistance were further screened using DNA from individual plants in each population. The potential markers will be tested on several populations derived from crosses between summer squash (*C. pepo*) and Nigerian Local to determine if they would be useful for selection in a *C. pepo* background.

080

Postharvest Longevity Analysis of Advance Generations in *Antirrhinum majus* L.

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Cut flowers of *Antirrhinum majus* L. (snapdragon) P₁, P₂, F₁, F₃, and F₂ x F₂ plants were harvested after the first five flowers were open and were evaluated for postharvest longevity to further evaluate genes conditioning postharvest longevity. F₃ progeny evaluated were derived by selfing F₂ selections of long keeping, mid-range, and short keeping types. F₂ x F₂ progeny evaluated were derived from crosses within and between postharvest longevity categories. Populations for evaluation were grown in the greenhouse in winter 1998–1999 in a randomized complete-block design according to standard forcing procedures. Thirty plants of each genotype were held in the laboratory in deionized water under continuous fluorescent lighting at 22 °C for postharvest assessment. The end of postharvest life was defined as 50% of the flowers drying, browning, or wilting. Data will be presented on postharvest longevity and allelic relationships within populations.

081

Genetic Analysis of Direct Shoot Organogenesis on Hypocotyls of *Antirrhinum majus* L.

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Direct shoot organogenesis (DSO) on *Antirrhinum majus* L. (snapdragon) was evaluated in vitro to determine the inheritance of genes conditioning this response. One-centimeter-long hypocotyls excised from 2-week-old seedlings started in vitro in the dark on Murashige and Skoog medium served as explants. Optimal conditions for DSO on explants included hypocotyl excision from 10-day-old seedlings, 2.22 μmol BA in the culture medium, and a 21-day culture duration. An adventitious shoot was counted once it developed a stem terminated by at least one leaf appearing to have originated from an apical meristem. Seven populations were evaluated for DSO: parent 1 (P₁) with lowest DSO (0.3 shoots); parent 2 (P₂) with highest DSO (13.9 shoots); F₁ (P₁ x P₂); F₁ (P₂ x P₁); F₂ (self-pollination of F₁); P₁ x [P₁ x P₂]; and P₂ x [P₁ x P₂]. P₁ and P₂ were chosen as parents based on DSO counts being lowest and highest, respectively, of inbreds evaluated. DSO appears to be a trait under nuclear genetic control. High DSO appears to be dominant over low DSO. The trait appears to be simply inherited through one or two genes.

082

Infection and Transformation of *Rhododendron* by *Agrobacterium tumefaciens* Strain B6

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The objective of this study was to determine if selected strains of *Agrobacterium* could infect microshoots of *Rhododendron catawbiense*. Fifteen microshoot stems of *R. catawbiense* var. *album* 'America', 'Joe Paterno', and 'Cunningham's White' were inoculated with two drops (about 25 μL) of wild type *Agrobacterium tumefaciens* strains C58 or B6 or with wild type *A. rhizogenes* strain E8/73. Five control shoots were inoculated with 1.2 mM KH₂PO₄ buffer. Microshoots were grown on woody plant medium (WPM) supplemented with 4.9 μM 2iP. Six weeks after inoculation galls that formed were excised from the microshoots and placed on WPM that lacked plant growth regulators but contained 300 mg • L⁻¹ cefotaxime. In another study, these wild-type bacterial strains were genetically modified by inserting the pBINm-gfp5-ER plasmid, which contained genes coding for NPTII

and green fluorescence protein (GFP), into the bacteria. These modified strains were inoculated on 15 stems of the three rhododendron cultivars and one variety. Calluses that formed were excised, placed on basal WPM with cefotaxime, and allowed to proliferate. Wild type C58 induced galls to form on 'Joe Paterno', *R.c. album*, and 'Cunningham's White' stems, whereas wild type B6 caused galls to form only on the latter two types of rhododendron. Wild-type E8/73 failed to induce gall formation on the rhododendrons. Only genetically modified B6 caused galls to form on only 'Cunningham's White' microshoots (seven of 15 inoculated stems). Three of these galls fluoresced green under ultraviolet light. Physical presence of the NPTII and GFP genes in the plant genome was determined by polymerase chain reaction. This study demonstrated that *R. catawbiense* is susceptible to *Agrobacterium* infection, and this plant can be genetically transformed.

083

Modification of Plant Architecture in Chrysanthemum: Reduction of Height and Increase of Branch Angle through Ectopic Expression of a Phytochrome B1 Gene

Zhi-Liang Zheng¹, Zhenbiao Yang², Jyan-Chyun Jang¹, and James D. Metzger*¹;

¹Department of Horticulture and Crop Science, Ohio State University, 2021 Coffey Road, Columbus, OH 43210; ²Department of Plant Biology, and Plant Biotechnology Center, Ohio State University, 1060 Carmmack Rd, Columbus, OH 43210

Plant architecture is a major consideration during the commercial production of chrysanthemum (*Dendranthema grandiflora* Tzvelev). We have addressed this problem through a biotechnological approach: genetic engineering of chrysanthemum cv. Iridon plants that ectopically expressed a tobacco phytochrome B1 gene under the control of the CaMV 35S promoter. The transgenic plants were shorter, greener in leaves, and had larger branch angles than wild-type (WT) plants. Transgenic plants also phenocopied WT plants grown under light condition depleted of far-red wavelengths. Furthermore, the reduction of growth by the expressed PHY-B1 transgene did not directly involve gibberellins. The commercial application of this biotechnology could provide an economic alternative to the use of chemical growth regulators, and thus reduce the production cost.

084

Plant Preservative Mixture (PPM) can Reduce Shoot Regeneration from Leaf Explants of Selected Plants

M.W. George and R.R. Tripepi*; Plant Science Division, University of Idaho, Moscow, ID 83844-2339

Plant preservative mixture (PPM) is a new broad-spectrum biocide that may be useful for plant tissue culture. The objective of this study was to determine if PPM interfered with adventitious shoot regeneration on leaf explants from several plant species. Leaf explants from *Dendranthema grandiflora* 'Iridon', *Betula pendula*, *Rhododendron catawbiense* var. *album* and *R.c.* 'America' were made from the top two apical leaves on the microshoots. In the first experiment, 0, 0.5, 1, 2, or 4 mL • L⁻¹ PPM were added to species-appropriate regeneration media. In the second experiment, only mum leaf explants were placed on regeneration media containing 0, 0.1, 0.2, 0.3, or 0.4 mL • L⁻¹ PPM. The percentage of explants forming shoots and the number of shoots per regenerating explant were recorded after 4, 6, and 10 weeks, for mum, birch, and rhododendron leaves, respectively. The percentages of shoot regeneration from birch and rhododendron leaf explants were unaffected by up to 4 mL • L⁻¹ PPM, and the number of shoots formed per *R.c. album* explant were also unaffected by the tested concentrations of PPM. In contrast, the numbers of shoots formed on birch and 'America' explants were reduced 48% and 25%, respectively, when 4 mL • L⁻¹ PPM was used in the media. The percentages of shoot regeneration and number of shoots per explant were drastically reduced on mum explants when only 0.5 mL • L⁻¹ PPM was used in the medium. In fact, 0.3 mL • L⁻¹ PPM or higher reduced shoot formation by more than 5-fold. This study demonstrates that the effects of PPM on shoot regeneration from leaf explants are species specific.

**143 POSTER SESSION 16 (Abstr. 085–097)
Genetics/Breeding/Biotechnology**

Saturday, 31 July, 1:00–2:00 p.m.

085

Horticultural (Cultivated Plant) Taxonomic Research within ASHS

Paul R. Fantz*¹ and Donglin Zhang²; ¹Dept. of Horticultural Science, North Carolina State Univ., Raleigh, NC 27695; ²Dept. of Biosystems and Engineering, Univ. Maine, Orono, ME 04469

Horticultural Science in the past quarter of a century has been shifting to increased emphasis on ornamental plants due to the growth of the modern green industry. Numerous species are being introduced into the exterior and interior landscapes. For popular species, the cultivar, as defined by the International Code of Nomenclature for Cultivated Plants (ICNCP), has become the basic taxon of cultivated plants. Named ornamental plant cultivars are rising at a rapid rate creating identification and segregation problems in the landscape industry, nurseries, botanic gardens, arboreta, and breeding programs. Government regulations and legal issues are beginning to infringe as solutions to the problems. There is a critical need existing for taxonomic research on ornamental cultivars utilizing classical morphological analysis supplemented with modern biotechnological techniques (e.g., anatomical, chemical, cytological, DNA, Sem analysis). Taxonomic research on existing and newer cultivars can provide quantitative botanical descriptions, keys of segregation, correct identification, determination of correct names and synonymy, improved cultivar documentation, and grouping of similar cultivars in large complexes. The taxonomic research is basic science that has immediate applied application within the horticultural society, and results should be published in the journals of ASHS.

086

Preservation and DNA Fingerprinting Historic *Prunus x yedoensis* Germplasm from the Tidal Basin in Washington, D.C.

Margaret R. Pooler* and Ruth L. Dix; USDA/ARS/U.S. National Arboretum, 3501 New York Ave., NE, Washington, DC 20002

The historic Japanese flowering cherry trees planted around the Tidal Basin in Washington, D.C., were given to the United States in 1912 as a gift from Japan, and have become a popular tourist attraction. Unfortunately, only a small portion of the original trees remain, and these trees are in various states of decline due to old age and stress. In cooperation with the National Park Service, we have propagated from cuttings nine trees that are known to be original and 10 trees that are thought to be original. DNA from these and other *P. x yedoensis* were compared using RAPD markers. Twenty-one 10-nucleotide primers yielded 80 repeatable bands that were used to assess genetic distance among the accessions. Twenty of these bands were monomorphic across all 28 accessions tested, so were not informative. The frequency of the remaining 60 bands varied from 0.04 to 0.96, with an average frequency of 0.58. Thirteen of the accessions, including six of the nine that are known to be original germplasm, were identical at all loci tested. Other accessions that are thought to be original trees were similar, with similarity values of 0.93 to 0.99. The most genetically dissimilar trees were *P. x yedoensis* accessions from our collection that were collected as seed in Japan. Accessions obtained from commercial nurseries including 'Afterglow', 'Akebono' and Yoshino were also dissimilar to the Tidal Basin trees. This study indicates that most of the older trees planted around the Tidal Basin are genetically very similar, but that variability in *P. x yedoensis* exists, especially in accessions collected as seed from Japan.

087

Localization of ENOD2 Transcript Accumulation in Indeterminant Nodules of *Maackia amurensis* Rupr. & Maxim. (Amur Maackia)

Carol M. Foster*^{1,2,3}, William R. Graves^{1,2}, David J. Hannape^{1,2}, and Harry T. Horner^{1,3}; ¹Interdepartmental Plant Physiology Program, Departments of ²Horticulture and ³Botany, Iowa State University, Ames, IA 50011

Early nodulin genes, such as ENOD2, play a role in the first stages of nodulation. Although ENOD2 is conserved among nodulating legumes studied to date,

its occurrence and activity have not been studied among woody legumes such as *Maackia amurensis* Rupr. & Maxim. Our objective was to localize MaENOD2 transcripts during nodule development and describe the anatomy of nodules formed on the roots of *M. amurensis* in relation to ENOD2 mRNA accumulation. Nodules (<1 mm, 1–2 mm, >2 mm in diameter, and mature) were prepared for light microscopy, sectioned, and stained with safranin and fast green for structural contrast or with the periodic acid Schiff's reaction for starch. The location of ENOD2 transcripts was determined by using in situ hybridization with DIG-labeled sense and antisense RNAs transcribed from a 602-bp fragment of the coding region of MaENOD2. Mature nodules from *M. amurensis* possessed peripheral tissues, a distal meristem, and a central infected region characteristic of indeterminant development. In situ hybridization showed that MaENOD2 transcripts accumulated in the distribution layer and uninfected cells of the central symbiotic region. Amyloplasts that contained starch grains were identified in these tissues and in the inner parenchyma of the nodule. Throughout nodule development, transcripts were restricted to areas with high levels of stored starch that surrounded cells actively fixing N₂. Our results suggest that ENOD2 in *M. amurensis* may be a cell wall component of tissues that regulate nutrient flow to and from sinks, such as symbiotic regions of a nodule. These data may lead to a better understanding of the role of the ENOD2 gene family during nodulation.

088

Microprojectile Bombardment-mediated Transformation of *Rhododendron* 'Catawbiense Album' L.

Jane E. Knapp* and Mark H. Brand; Department of Plant Science, University of Connecticut, Storrs, CT 06269-4067

Horticultural improvements in *Rhododendron* require long periods of time to produce flowering plants by traditional breeding methods. In addition, new trait development by conventional genetics is limited to existing germplasm. Genetic engineering approaches to horticultural improvement offer the possibility for introduction of new traits using foreign DNA from any source. To this end, we have developed a system for the genetic transformation of *Rhododendron* based on microprojectile bombardment. Leaves from in vitro-grown plantlets of *R. 'Catawbiense Album'* L. were bombarded with the marker genes *uidA* (GUS) in combination with *nptII* or *hph*. Two days post-bombardment, explants were transferred to shoot initiation medium containing either 50 mg/L kanamycin or 2.5 mg/L hygromycin. After 4 weeks, proliferating tissues were transferred to media containing increased levels of selective agent (100 mg/L kanamycin or 5 mg/L hygromycin, respectively). Shoots that regenerated were then excised from necrotic tissues and transferred to shoot proliferation medium containing the high level of selective agent. PCR analysis of putative transformants revealed the presence of the transgenes. Southern blot hybridization confirmed stable transgene integration. Histochemical GUS assays of transformed tissues indicated uniform expression throughout the transgenic plant. With the development of an efficient transformation system, the introduction of genes to confer useful horticultural traits becomes feasible.

089

Biolistic Transformation of Zoysiagrass for Glufosinate Resistance

B.J. Ahn*¹, J.S. Cho¹, K. Kamo², and J.W. King³; ¹Dankook University, Cheonan, Korea 330-714; ²USDA, ARS, FNPRU, Beltsville, MD 20705; ³Department of Horticulture, University of Arkansas, Fayetteville, AR 72701

Biolistic transformation methods for zoysiagrasses (Korean lawngrass) were developed and used to introduce a herbicide-resistant trait. Embryogenic calli were induced from mature caryopses on MS medium supplemented with 2 mg/L of 2,4-D, and used to establish liquid agitation cultures. The cultures have been maintained over a year without loss of the embryogenic competence. A particle bombardment method was optimized for zoysiagrass based on transient *gusA* gene expression. The most transient *GUS* expression upon bombardment treatments occurred at 1100 psi of helium pressure with 10 cm of particle flying distance and 0.125 M sorbitol preculture treatment. Promoters suitable for zoysiagrass were compared, and actin and ubiquitin promoters were found effective in expressing *gusA* gene. Vector DNAs containing a herbicide resistant gene (*bar*), *pBY505*, were introduced into embryogenic cells of zoysiagrass using the optimized method. Total 194 putatively transformed plants were regenerated from 60 biolistic plates for over 6 months through selection culture containing 4–10 mg/L of phosphinothricin. Regenerants were grown in potting soil in greenhouse and sprayed with 1.7 g/L of Ignite herbicide. The transgenic plants showed various

levels of resistance to the herbicide, while untransformed control plants were all dead. Recombination of the *bar* gene into the genomes of the transformants were confirmed through PCR and Southern blot analysis.

090

Pollen Viability in Inland Saltgrass

Scott Reid*, Judy Harrington, and Harrison Hughes; Department of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO 80523

Distichlis spicata var. *stricta* (Torrey) Beetle is a native grass that tolerates salt, high pH, and some heavy metals. It has been proposed for use in several challenging environments, including mine spoils and salt-impacted areas of golf courses. But, its widespread use has been hindered by several factors, one of which is poor seed set. Because chromosome numbers are variable and some genotypes are aneuploids, there was concern that pollen viability in some genotypes was low. Pollen from several genotypes failed to germinate in vitro on four artificial media prepared with various levels of osmoticum. However, hand pollination in vivo resulted in profuse pollen germination for all genotypes tested. Germination on pollinated stigmas was observed at intervals beginning 2 h after pollination with a fluorescence microscope using aniline blue and acridine orange stains and in bright field using toluidine-O stain. Very young stigmas seemed unreceptive and, while pollen would germinate, the pollen tubes would not grow down through the style. On receptive stigmas, many pollen tubes grew down toward the egg and some reached it within 24 h. There was no evidence of impaired fertility. Aniline blue was the best method for observing pollen tube growth through the style, although toluidine-O was adequate for observing germination on the stigmatic surface.

091

Cytogenetics of Inland Saltgrass

Scott Reid*, Judy Harrington, and Harrison Hughes; Department of Horticulture and Landscape Architecture, Colorado State University, Fort Collins, CO 80523

Inland saltgrass, *Distichlis spicata* var. *stricta* (Torr.) Beetle, is a native western U.S. grass that has potential in turf situations. Elite clones with outstanding potential have been selected. Poor seed production appears to be the main limiting factor for its use as turf in saline conditions. In order to better understand seed set, 40 genotypes were examined for chromosome number and morphology. Chromosome numbers of root tip metaphase spreads varied with the most common being $2n = 38$. However, chromosome numbers of 39, 40, 42, and 74 were also observed. Meiotic examination of anthers revealed 19 bivalents for those with 38 chromosomes while those with 42 had 20 bivalents with 2 unpaired chromosomes. The unpaired chromosomes lagged at anaphase. Crosses among genotypes of different chromosome number have resulted in good seed set. Harvested seed are germinable and plants from these crosses are being grown for further studies.

092

RNA Localization of a Strawberry MADS-Box Gene (*SAG1*) Involved in Fruit Development

Faye M. Rosin* and David Hannapel; Molecular, Cellular, Developmental Biology Program, Department of Horticulture, Iowa State University, Ames, IA 50011

MADS-box genes are an important family of highly conserved regulatory genes in plants, animals, and yeast. Genetic analyses have shown that plant MADS-box genes are homeotic and control both the spatial and temporal location of specific organs. While MADS-box genes have been extensively studied and characterized in floral organ development, their involvement in other developmental processes, such as fruit development, is not well understood. From a strawberry fruit cDNA library, we have identified a strawberry *AGAMOUS*-like MADS-box gene (*SAG1*) that is expressed in developing fruit, but not in leaves. This is the first MADS-box gene to be isolated from strawberry. The hypothesis guiding this research is that *SAG1* plays an important role in the development of the fruit. Nucleotide sequence analysis showed that this cDNA had the highest sequence match to genes from the *AGAMOUS* family. Comparison of amino acid sequence similarity between *SAG1* and members of this family ranged from 70 to 75% overall, and between 98% to 100% within the MADS-box. Involvement in stamen and carpel identity is one function of this family of MADS-box genes. Northern hybridizations were performed in order to analyze the expression of this gene at the RNA level. RNA was extracted from various organs of *Fragaria xananassa*, c.v. Calypso. *SAG1* RNA expression was specific to stamens, carpels and all stages of fruit and seed development. No expression was detected in roots, leaves, or se-

pals. Thus, we conclude that *SAG1* RNA is involved in reproductive organ and fruit development.

093

Putative Sources in Strawberry for Resistance to Bacterial Angular Leafspot

J.L. Maas*, C. Gouin-Behe, J.S. Hartung, and S.C. Hokanson; Fruit Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD 20705

Bacterial angular leafspot disease (BALD) of strawberry, caused by *Xanthomonas fragariae* Kennedy & King, has dramatically affected commercial fruit and plant production throughout the world. Leaf lesions may kill leaves, while lesions on sepals make fruit unmarketable. The bacterium can kill stolon-tip plantlets that are being rooted for transplanting. Since plants become systemically infected, there is no adequate chemical control for BALD under conditions that favor development and spread of the disease. Strawberry is the only host and no cultivars or advanced selections have proven resistant to this disease. We screened 23 *Fragaria xananassa*, 13 *F. chiloensis*, 56 *F. virginiana*, and 2 *F. vesca* genotypes for resistance to two pathogenic isolates of *X. fragariae* (ATCC-33239, the original strain from Minnesota and Xf-3 from North Carolina). Leaves were inoculated by forcing bacterial suspensions into leaves under pressure with a syringe barrel and plunger. Plants were incubated in a moisture chamber for 3 days, followed by 1 week under mist and then placed on a greenhouse bench. Experiments were done twice for obviously susceptible reactions and three and four times for questionable and resistant reactions, respectively. Only two genotypes were found to show a resistant reaction: 80-4-38 ('Earliglow' (*F. virginiana* clone SG-26 from Georgia) and *F. virginiana* clone SG-89 (=Luby MS 7-7 from Minnesota). Each of these genotypes exhibited typical hypersensitive responses by walling-off inoculation areas. All other genotypes exhibited typical BALD symptoms 5 weeks after inoculation with both isolates.

094

Cloning Blueberry Dehydrins and Their Expression under Stress Conditions

Ganesh R. Panta*^{1,2} and Lisa J. Rowland²; ¹Department of Horticulture, University of Georgia, Athens, GA 30602; ²Fruit Laboratory, Beltsville Agricultural Research Center, Agricultural Research Service, Beltsville, MD 20705

Dehydrins are major plant proteins that increase with cold or drought. Using a previously identified 2.0-Kb blueberry dehydrin cDNA, additional dehydrin clones were isolated and characterized. Experiments were conducted to determine effect of drought and cold treatment on dehydrin gene expression in several blueberry cultivars. Besides previously characterized 65, 60, and 14 kDa dehydrins in floral buds additional less abundant dehydrins were observed in stem and root tissues. The same major dehydrins were induced by both drought and cold stress but at different levels. Dehydrin expression was positively correlated with cold and drought tolerance. In addition, photoperiod was observed to affect dehydrin expression. Dehydrins were induced to higher level in cold treated plants kept in total dark than in plants kept at a short photoperiod of 10 hours of light/14 hours dark.

095

'Jupiter' Seedless Table Grape

John R. Clark* and James N. Moore; Dept. of Horticulture, University of Arkansas Fayetteville, AR 72701

'Jupiter' is the fifth table grape cultivar released from the Univ. of Arkansas grape breeding program. 'Jupiter' originated from a cross of Ark. 1258 x Ark. 1672 made in 1981. The original seedling vine was selected in 1984, and 'Jupiter' was tested as Ark. 1985. 'Jupiter' was tested at two locations in Arkansas (Fayetteville and Clarksville) and at West Lafayette, Ind. Fruit of 'Jupiter' are reddish-blue, and berry weight averaged 5.5 g over 12 years of evaluation at Clarksville. Fruit are seedless, have a non-slipskin texture, ripen early mid-season, and averaged 19.8% soluble solids. Flavor is a mild muscat, a noteworthy character of this new cultivar. Clusters averaged 257 g over 12 years and are well-filled. Yields of 'Jupiter' have been very good, exceeding 29 t/ha at Clarksville. Hardiness of 'Jupiter' was greater than 'Einset Seedless', 'Himrod', or 'Vanessa Seedless', but less than 'Mars' or 'Reliance' at West Lafayette. 'Jupiter' is recommended for trial where other eastern U.S. table grape cultivars are adapted.

096

Muscadine Traits Potentially Useful in Breeding

C.L. Gupcion; USDA-ARS Small Fruit Research Station, P. O. Box 287, Poplarville, MS 39470

A muscadine vineyard planted at McNeil, Miss., in 1990 included 23 cultivars and a planting in 1992 included nine cultivars. Each entry was evaluated for eight useful traits over 4 years. The regressions of certain traits on others were performed to determine relationships that might be useful in selecting for valuable traits such as phyto-chemicals in seed. Ranges among cultivars for the traits were: harvest date—20 days, yield—33 kg per vine, berry weight—11.2 g, percent dry scar—38, °Brix—5, pH—0.5, seed per berry—1.2 and seed weight—5.5 g. The best relationship was between berry weight and seed weight.

097

Aspects of Self- and Cross-fertility in Recently Released Highbush Blueberry Cultivars

Mark K. Ehlenfeldt*; U.S. Department of Agriculture, Agricultural Research Service, Rutgers Blueberry and Cranberry Research Center, 125A Lake Oswego Road, Chatsworth, NJ 08019

Self- and cross-fertility was evaluated in the highbush blueberry cultivars Bluegold, Duke, Legacy, Nelson, Sierra, Sunrise, and Toro, all released since 1987, by comparing them to standards of 'Bluecrop' and 'Rubel'. Percent fruit set increased with cross-pollination in all cultivars except 'Bluecrop', which decreased by 13%. The average increase in the recently released cultivars was 43%. Fruit weight also increased in cross-pollinations for all cultivars except 'Rubel', which showed a decrease of 2%. Average increase in fruit weight on cross-pollination in the recently released cultivars was 27%. Fruit set and fruit weight measurements suggest that 'Duke', 'Legacy', and 'Nelson' could perform well in solid stands, but 'Sierra' and 'Toro' are more likely to need cross-pollination for best yields. Investigations were also made on a group of 10 cultivars, to evaluate whether ripening time of the pollen source cultivar had any effect on the ripening time of the fruiting parent. No single pollen source had consistent general effects on ripening, although specific combinations of females and males appeared to either hasten or delay ripening. The largest deviations were seen in delays of ripening, suggesting that poor pollination may have been the greatest factor contributing to the observed variation in ripening times.

44 POSTER SESSION 3 (Abstr. 098–108) Propagation/Tissue Culture

Thursday, 29 July, 1:00–2:00 p.m.

098

High Regeneration Ability of Benzyladenine and Naphthalene Acetic Acid Induced Callus of Eastern Hibiscus

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The ability of *Hibiscus syriacus* explants to produce regenerable callus was investigated. Fragments of cotyledons, hypocotyl, and roots were cultured on MS media supplemented with two different auxins (2,4-D and NAA, both 0.3 mg/L) and three different cytokinin (BA, 2iP and kinetin, all 0.1 mg/L). Plants were regenerated on McCown media with three different cytokinins at two different concentrations (0.1 and 1.0 mg/L). The biggest volume of callus was produced on medium containing 2,4-D/2iP (2.821 mm³/explant). The smallest mass of callus was induced on medium with NAA/kinetin (120 mm³/explant). On BA-supplemented media, the auxin type had no significant influence on the amount of callus produced. The highest number of shoots and leaves was produced on callus induced on NAA/BA supplemented media and regenerated on medium with 0.1 mg/L BA (4.2 shoots and 20 leaves/explant). Callus cultured on medium with 1.0 mg/L of BA produced significantly less shoots (2.4 shoots/explant). The lowest number of shoots was observed on callus originating from NAA/kinetin and NAA/2iP callus media and grown on medium with kinetin or 2iP (both 1.0 mg/L). The highest number of roots was produced by cultures originating from NAA/BA cal-

lus medium grown on the BA regeneration medium, irrespective of the cytokinin level. The longest shoots were observed on medium supplemented with 1.0 mg/L BA (18 mm). In this study, the best plant regeneration results were obtained for callus initiated on NAA/BA supplemented medium and regenerated on medium with 0.1 mg/L BA, however, the highest production of callus was observed on medium with 2,4-D/2iP.

099

Indirect and Direct Regeneration of *Kalmia latifolia*

Mark H. Brand*; Dept. of Plant Science, University of Connecticut, Storrs, CT 06269-4067

To introduce desirable trait genes into *Kalmia latifolia*, efficient adventitious shoot regeneration methods are needed. Silver Dollar (S\$) callus induction and growth in the dark was compared on Woody Plant (WP) medium containing 2,4-dichlorophenoxyacetic acid (2,4-D) (1, 5, 10, 20 μM) or naphthaleneacetic acid (NAA) (1, 10, 20, 40 μM) with and without 5 μM isopentenyladenine (2iP). Both 2,4-D and NAA produced >450 mg of callus from leaf explants in 8 weeks. The addition of 2iP tripled growth for 2,4-D and doubled growth for NAA. Greatest callus growth was obtained on 20–40 μM NAA or 5–20 μM 2,4-D. Shoot regeneration on callus was achieved on WP medium containing 30 μM 2iP or 1 μM thidiazuron (TDZ), but a combination of the two was best, with 68% of dark-grown calli regenerating shoots in 4 weeks. 26% more dark-grown calli regenerated shoots than light-grown calli. The type of auxin (2,4-D or NAA) used to grow the calli did not affect shoot regeneration. For direct shoot regeneration, S\$ leaf explants were tested on WP medium containing 5, 15, 30, 45 and 60 μM 2iP. The addition of 1 μM indole-3-butyric acid (IBA) doubled the percentage of leaves that regenerated shoots. 2iP concentrations between 15 and 45 μM supported excellent shoot regeneration, but optimal regeneration (95% of explants, 5.1 shoots/leaf) occurred on 30 μM 2iP+1 μM IBA. Leaf explants of six cultivars were grown on optimal medium with shoot regeneration ranging from 17% to 93% of leaves and 1.8 to 8.2 shoots per leaf, depending on the cultivar.

100

A Comparison of Two Media on Growth of Deciduous Azalea Shoots In Vitro

Carol D. Robacker* and Betty Robicheaux; Dept. of Horticulture, Univ. of Georgia, Georgia Station, Griffin, GA 30223

Micropropagation is a useful technique to propagate species such as deciduous azaleas, which are difficult to root from cuttings. To develop a micropropagation protocol that would be effective with a wide range of species and cultivars of native azalea, two culture media, Woody Plant Medium (WPM) (Lloyd and McCown, 1980) and ER medium (Economou and Read, 1994) were evaluated for ability to support growth of 11 species and four cultivars of deciduous azalea. Shoot tips were obtained from the first flush of growth in the spring on plants growing in the greenhouse or field. Following disinfection, the terminal and basal ends were removed from each explant. The explants were placed in culture tubes containing either WPM or ER medium with 12 mg/L 2iP and solidified with agar. Cultures were transferred to fresh medium every 4 to 6 weeks. Initial evaluations were made in 1996, and the experiment was repeated in 1997. In 1998, six of the taxa were evaluated for a third year. For most of the taxa evaluated, growth was superior on ER medium. On WPM, many of the cultures browned and died. *R. canescens*, *R. viscosum*, *R. prunifolium*, and *R. austrinum* are examples of species that preferred ER medium. *R. alabamense*, *R. arborescens*, and 'My Mary' performed similarly on either medium.

101

Propagation of *Juglans cinerea* L. (Butternut)

Paula M. Pijut* and Melanie J. Barker; USDA—Forest Service, North Central Research Station 1992 Folwell Ave., St. Paul, MN 55108

Butternut trees are becoming endangered as a result of butternut canker disease; thus, it is desirable to propagate disease-resistant trees for screening and provenance tests. The objective of this study was to determine the conditions necessary for successful cutting propagation. In 1998, 10 trees were selected from a 4-year-old butternut plantation located in Rosemount, Minn. Hardwood cuttings were collected 30 Mar., 21 Apr., and 6 May. The auxins, indole-3-butyric acid-potassium salt (KIBA) in water at 0, 29, or 74 mmol • L⁻¹ were tested for root induction. The basal end of cuttings were dipped in treatment solutions for 10 to 15 s and placed in a 1 peat : 1 perlite mixture in Deepots™ (D40) in a mist bed. Mist was applied for 5 s every 15 min. Greenhouse conditions were: 12-h

photoperiod provided by high-pressure sodium lamps ($60 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$), 22 °C, and bottom heat of 27 °C (heating pads). Softwood cuttings were collected 20 May, 18 June, 30 June, and 23 July. Rooting treatment solutions and greenhouse conditions were the same as for the hardwood cuttings, except no heating pads were used. Rooted cuttings were planted in Treepots™ (10 x 10 x 36 cm) and gradually hardened off from the mist bed. Hardwood cuttings from the first two collection dates did not initiate roots. Best rooting (12.5%) was achieved on hardwood cuttings collected 6 May using 29 mmol · L⁻¹ KIBA. Softwood cuttings rooted to some degree at all concentrations of rooting solution and at every collection date. The greatest rooting (70%) was achieved using 74 mmol · L⁻¹ IBA. In general, best rooting percentages were achieved with softwood cuttings collected 18 June and 23 July and treated with 62 mmol · L⁻¹ KIBA or 74 mmol · L⁻¹ IBA. Both rooted hardwood and softwood cuttings were successfully acclimatized from the mist bed and many have initiated new growth.

102

Container Production of Ornamental Grasses: The Effects of Propagation Time on Winter Survival and Sale Date

Bruce A. Cunliffe*; University of Minnesota, Bloomington, MN 55437

It is common practice to propagate grasses by division in the spring rather than the fall. This is particularly true of warm-season grasses. Production schedules for grasses do not often fit the general production pattern of other herbaceous perennial or woody crops. Five ornamental grass species were studied: *Schizachyrium scoparium*, *Sporobolus heterolepis*, *Calamagrostis x acutiflora* 'Karl Foerster', *Miscanthus sinensis* 'Purpurascens', and *Miscanthus sinensis* 'Variegatus'. Uniform divisions based on species were planted in 4-inch (480-ml) pots, #1 (2780-ml), and #2 (6240-ml) containers. Fall divisions were done between 28 Oct. and 10 Nov. 1997. Spring divisions occurred between 30 Apr. and 7 May 1998. The experiment is a randomized complete-block design blocking on pot size. All containers were over-wintered under the same cover of plastic, straw, and plastic. Plants were evaluated for post-winter survival and growth. Plants were given a visual rating (0–3) every 2 weeks to assess salability. Spring survival of fall divisions was 99% for *S. scoparium*, *C. x acutiflora* 'Karl Foerster', and *M. sinensis* 'Purpurascens'. *M. sinensis* 'Variegatus', and *S. heterolepis* each had ≈50% survival. Fall divisions reached a salable rating a minimum of 2 weeks ahead of spring divisions. These results indicate that some ornamental grass species may benefit from fall rather than spring handling.

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Optimizing the Propagation of the Ornamental Grass *Hakonechloa macra* 'Aureola'

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Studies initiated in Spring 1998 analyzed the influence of division size, shade, and temperature on the growth rate of the ornamental grass *Hakonechloa macra* 'Aureola' in nursery-container production. To determine the optimum division size for production, container-grown stock plants were used to make early spring divisions of four sizes (1–2, 4–6, 8–10, and 12–15 buds). Divisions were established in 325-ml pots for 1 month before being transplanted to 3.7-L nursery containers. Plants were grown outdoors and received topdressed 17–6–10 slow-release fertilizer (containing micronutrients) and drip irrigation from June through September. Average leaf area, shoot number and bud count increased linearly as division size increased, but average height remained the same between each treatment. Plants of all division sizes exhibited healthy growth, with 50% of the plants in the 4–6 buds/division treatment growing to marketable size compared to 45%, 35% and 15% in the 8–10, 12–15, and 1–2 buds/division treatments, respectively. Four shade densities (0%, 30%, 50%, and 70%) were tested to determine which promoted optimum growth. As shading increased, average shoot number per plant decreased, average height and shoot length increased and bud count remained the same. To determine the optimum growing temperature for *Hakonechloa*, divisions were grown in 325-ml pots under four different day/night temperatures (15/10, 21/16, 27/22, and 33/28 °C) for 12 weeks in growth chambers. Plants were fertigated daily with a 5–25–5 liquid fertilizer. Average bud count, leaf area, plant height, plant width, shoot length, and shoot number increased as temperature increased to 27/22 °C, then decreased significantly beyond this temperature optimum.

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

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Spigelia marilandica, an herbaceous perennial native to the temperate eastern United States, has great potential for the sunny garden; however, its availability is limited due to propagation difficulties. The effect of stock plant environment on the rooting capability of the cuttings is the primary focus of this research. Shoot-tip cuttings were collected monthly from stock plants maintained under high-intensity sodium lamps providing a 16 hr day/8 hr night photoperiod. Cutting bases were dipped in Hormodin I (1000 IBA), placed in a perlite:peat (4:1) mix, and placed under mist for 8 weeks. Preliminary data indicates that 95.5% of the cuttings rooted with an average of 39 roots per cutting.

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Propagation of *Taxodium mucronatum* (Montezuma Cypress)

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Indigenous stands of *Taxodium mucronatum* Ten. are found in North and Central America, but relatively little is known about the propagation of the species. Progeny from one tree in the Mesilla Valley near Las Cruces, N.M., and from two trees in the Gila National Forest, New Mexico, were observed to be relatively cold-hardy. I initiated this research to find the best conditions for asexual and sexual propagation of those three trees. Terminal softwood cuttings were collected on 16 Oct. 1998 from a half-sibling of the Mesilla Valley tree, and from two half-siblings from the trees in the Gila National Forest. Cuttings were treated with two concentrations of IBA and rooted under intermittent mist in the greenhouse for 13 weeks. Cuttings taken from the Mesilla Valley source and from one of the half-siblings from the Gila did not root. The other half-sibling plant from the Gila showed 82% rooting when cuttings were treated with 8 g IBA/kg. Fifty percent of cuttings rooted when they were treated with 3 g IBA/kg. Root number and root length were greatest for cuttings treated with 8 g IBA/kg. Replication over time will determine whether stock plant environment and the time of taking cuttings affect rooting. Strategies that optimize seed germination and seedling development of asexually and sexually propagated material are being evaluated.

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Propagation of *Alnus maritima* from Softwood Cuttings

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Alnus maritima [Marsh.] Nutt. (seaside alder) is a rare, North American species with strong potential for use in managed landscapes. Information on the propagation and production of this species is not available. Our objective was to evaluate the potential for using softwood cuttings to propagate *A. maritima*, with emphasis on how IBA and plant provenance affect rooting success. Propagation trials were conducted with cuttings from seven trees native to the Delmarva Peninsula and seven trees from Oklahoma. Cuttings from both provenances were collected on 14 June and 23 Aug. Cuttings were wounded; treated with 0, 1, or 8 g/kg IBA; and placed under intermittent mist in a greenhouse for 9 weeks. The highest percentage of rooting (67.9) was achieved for the Oklahoma provenance by using 8 g/kg IBA in June. Across IBA treatments, rooting of cuttings from Oklahoma, 54.8% (June) and 12.4% (August), was higher than rooting of cuttings from Delmarva, 27.1% (June) and 3.1% (August). IBA at 8 g/kg caused a higher rooting percentage than the other IBA rates at both times of the season. More cuttings collected 14 June rooted (41%) than those collected 23 Aug. (7.7%) over IBA treatments. Another experiment involved cuttings from one juvenile, greenhouse-grown seedling from Oklahoma that showed 100% rooting with both 1 and 8 g/kg IBA. Shoot growth appeared more vigorous on rooted cuttings from these juvenile stems than on plants derived by rooting mature tissue collected in nature. We conclude that using softwood cuttings can be an effective way to multiply clones of *A. maritima*, particularly when stock plants are juvenile and cuttings are treated with IBA.

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Silver Thiosulfate (STS) Alone and in Combination with Gibberellic Acid (GA₃) in the Forcing Solution Influences Budbreak and Shoot Elongation of Dormant Woody Plant Species

Bahget T. Hamooh* and Paul E. Read, Univ. of Nebraska, Lincoln, NE 68583

Research was conducted to further modify the forcing solution system in order to expedite the propagation of woody plants, such as *Spiraea canescens*, *Lonicera maakii*, and *Cornus alba*. Time of immersion in solutions containing 5 mM silver thiosulfate (STS) was compared with the basic forcing solution reported by Yang and Read (1989), a solution containing 200 mg 8-hydroxyquinoline citrate per liter and 2% sucrose. Other treatments employed were gibberellic acid (GA₃) 50 mg per liter for 24 h and a combination of STS and GA₃ for the same amount of time. Increasing the time in STS solution up to 24 h led to higher percent budbreak and shorter time to budbreak for all the three species examined. The combination of STS and GA₃ was the most effective treatment overall in reducing time of budbreak and increasing percent of budbreak. All STS treatments studied showed similar responses in shoot elongation. However, treatments with GA₃ alone, and in combination with STS showed more than a doubling in shoot length compared to all STS treatments studied and the control. Implications based on SEM observations will be presented.

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Shoot Regeneration from Ovaries of Various Cultivars of *Hosta*

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The objective of this study was to evaluate the ability of various cultivars of *Hosta* ovary explants to generate adventitious shoots and obtain variegated plants in vitro. Immature inflorescences along with 8 to 10 cm of scape were harvested from *Hosta* cultivars. The ovaries were prepared for culture by cutting immature florets before anthesis. The florets were first cut just above the top of the immature ovary to remove the stigma, style, corolla, and anther. Then the calyx and filament bases were also removed. Ovaries were transversely cut into halves and transferred to baby jars containing *Hosta* initiation medium supplemented with naphthaleneacetic acid (NAA) at 0.5 mg/L and 6-benzylamino purine (BA). The explants produced adventitious shoots from ovary base via organogenesis. The number of shoots regenerated from shoot tips and callus increased linearly with repeated subculturing on MS medium. This method would provide an effective alternative to conventional propagation crown division of *Hosta*, an expensive and slow process. The long-term goal of this project is to improve *Hosta*.

144 POSTER SESSION 17 (Abstr. 109–119) Propagation/Tissue Culture

Saturday, 31 July, 1:00–2:00 p.m.

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Enhancing Rooting of In Vitro-propagated Chestnut Shoots

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American chestnut (*Castanea dentata*) is one of the United States' most valuable resources for its nuts and timber. Many scientists are exploring genetic transformation techniques to improve chestnut blight resistance in addition to conventional breeding. In vitro shoot production must be first obtained and optimized in order to establish an efficient transformation system. Although shoot proliferation has been achieved, chestnut is still considered difficult for tissue culture with poor rooting. Therefore, this research has focused on improving rooting ability of micropropagated chestnut shoots. In vitro shoot production was established and maintained in WPM supplemented with 0.1 mg/l BA, 3% sucrose, and 0.7% agar with the pH adjusted to 5.8. The shoots were then transferred to rooting medium containing the same components as for shoot proliferation plus an auxin at various concentrations. Right after placing shoots onto root-

ing medium, a very thin layer (5 ml) of the same auxin (diluted) was added to provide a quick stimulation of rooting. Detailed discussion will be presented.

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Callogenesis and Organogenesis of the Apple Rootstock (*Malus prunifolia*) cv. Marubakaido under Different Aluminum Concentrations and Different Locations of Explants in the Leaf

Adriana C. de M. Dantas¹, Adriano N. Nezi¹, and Gerson R. de L. Fortes^{2*}: ¹Federal University of Pelotas, P.O.Box 354,96001-970-Pelotas, RS,Brazil; ²Embrapa Temperate Climate, P.O.Box 403,Pelotas, RS, Brazil

Three different leaf segments (apical, basal, and middle) were treated in combination with aluminum at 0, 5, 10, 15 and 20 mg • L⁻¹. Three kinds of leaf segments were inoculated in flasks in 12 replicates, with the adaxial surface touching the medium composed by basic macro- and micronutrient and MS vitamins added to 2,4-D (1.0 mg • L⁻¹); BAP (5.0 mg • L⁻¹); sucrose (30.0 g • L⁻¹); myo-inositol (100.0 mg • L⁻¹) and agar (6.0 g • L⁻¹). The pH was adjusted to 4.0 before autoclaving. After inoculation, the explants were incubated in a dark growth room for 21 days and then, placed during 80 days, at 25 ± 2 °C, 16-h photoperiod provided by white fluorescent lamps under 19 µE • m⁻² • s⁻¹ radiation. At the end of this period, the explants were evaluated. It was observed that basal leaf explants provided greener callus and that the heavier ones came from the middle leaf explants. Absence of Al or high Al concentrations favored the number of adventitious buds, whereas intermediate concentrations inhibited them. The absence of Al favored basal explants to form adventitious shoots, while lower concentrations favored apical and basal segments. High Al concentration appear to stimulate adventitious shoots in the basal and middle explants. Although it was evident that callus intensities were lower in higher Al concentration, Al is not so harmful to callogenesis and organogenesis.

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Successful In Vitro Micropropagation of Purported Blight-resistant Chestnuts (*Castanea* spp.)

Virginia Miller-Roether*, Paul E. Read, and Erika Szendrak, Univ. of Nebraska-Lincoln, Dept. of Horticulture, Lincoln, NE 68583-0724

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*). We developed a protocol for in vitro micropropagation and multiplication of candidate blight-resistant plants from the ACF breeding program. The protocol included forcing dormant shoots to budbreak, culture establishment, shoot multiplication, inducing a functional root system on the microcuttings produced by this system and establishment of autotrophic plants. Because *Castanea* spp. is recalcitrant to rooting, a unique bilayer method of rooting was developed. The unique bilayer consisted of a clear basal medium of 50% DKW and 50% WPM (Long and Preece), with a continuous level of 0.01 mg IBA/L and 0.2 mg BA/L. The clear basal medium was overlaid with an opaque layer. Rooting response occurred for 27 of the 31 genotypes at various frequencies. Rooted plantlets were planted in 50% peat: 50% perlite in order to become autotrophic and acclimated. Acclimated trees were planted in 10" x 2" Deepots® and placed in the greenhouse. These trees exhibited a very vigorous functional root system. Acclimated trees were hardened off, placed in cold storage (≈4–5 °C) for 5 months. All trees placed in cold storage broke dormancy for spring growth and ≈100 trees were sent to ACF for planting into field trials.

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The Influence of Plant Growth Regulators and Light Levels on Shoot Morphogenesis from Leaf Explants of Highbush Blueberry

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As part of a program to develop transgenic highbush blueberry (*Vaccinium corymbosum* L.) cultivars, studies were conducted to determine optimum conditions for high efficiency shoot regeneration from leaf explants of in vitro-propagated shoot cultures. The effect of either thidiazuron at 1 or 5 µM, or zeatin riboside at 20 µM, and two lit levels (18 ± 5 or 55 ± 5 µmol • m⁻² • s⁻¹) on shoot organogenesis were investigated. With the exception of 'Bluecrop', which did not regenerate shoots, maximum shoot regeneration of 13, 12.7, 12.6 and 4.6 shoots per explant for cultivars Duke, Georgiagem, Sierra, and Jersey, respectively,

occurred on regeneration medium with zeatin riboside and under a light intensity of $55 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$. Whereas 'Duke' regenerated equally well on regeneration medium with either zeatin riboside or $5 \mu\text{M}$ thidiazuron, regeneration frequencies for 'Georgiagem' and 'Sierra' were significantly higher on zeatin riboside. A light intensity of $55 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ significantly increased regeneration of cultivars Duke, Jersey, and Sierra on zeatin riboside, but inhibited regeneration of Duke on $5 \mu\text{M}$ thidiazuron.

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Preliminary Study on Grafting between *Vitis rotundifolia* and *V. vinifera* Grapes

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Non-native grape species such as *V. vinifera* and *V. labrusca* can not sustain the hot and humid environment of Florida due to their susceptibility to various diseases. *Vitis rotundifolia* (muscadine grapes) is native to Florida and the southeastern United States and adapted well to this climate condition. They are highly resistant to almost all grape foliage diseases and root pests such as nematode and phylloxera. Theoretically, muscadine grapes may become a valuable rootstock for bunch grapes. Unfortunately, most previous studies found that muscadine grapes were graft-incompatible with bunch grapes by normal grafting techniques. This study was to look for an alternative technique to graft *V. vinifera* onto muscadine rootstocks. A preliminary study indicated that bunch grape scions were successfully grafted on adult muscadine grapes. Two *V. vinifera* grape cultivars, 'Thompson Seedless' and 'Chardonnay', and two muscadine grape cultivars, 'Carlos' and 'Alachua', were used for this study. The muscadine grapes used as rootstocks are 6-year old field-grown vines and *V. vinifera* was used as scions. Using the common V-type grafting method was completely failed in more than 150 attempts. We then tried to insert the first-year buds of *V. vinifera* into 1- to 3-year-old muscadine canes. Surprisingly, the survival rate of the inserting buds was moderately high when 'Carlos' was used as the rootstock. 'Thompson Seedless'/'Carlos', 'Chardonnay'/'Carlos' reached 53% and 33%, respectively. Successful grafting but lower survival rate was also obtained when 'Alachua' was used as the rootstock (10% in 'Thompson Seedless'/'Alachua' and 3% in 'Chardonnay'/'Alachua'). The average survival rate of 'Thompson Seedless' on the muscadine rootstocks was 36%, and 'Chardonnay' was 12%. Regardless the cultivar of the scions, buds survived on 'Carlos' and 'Alachua' rootstocks were 44% and 5%, respectively. Results from this study indicated that *V. vinifera* grapes could be successfully grafted onto muscadine rootstocks. The survival rate varied depending on cultivars used for both scion and rootstock. It would be very interesting to see if resistance to certain diseases such as the Pierce's disease can be improved in those *V. vinifera* grape with muscadine roots and trunks derived from this preliminary study.

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In Vitro Multiplication of Potato (*Solanum tuberosum* L.) as Affected by the Microcutting Characteristics

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This work was carried out in the Tissue Culture Laboratory of Embrapa Temperate Climate aiming to maximize the protocol for in vitro culture of potato cv. Baronesa. The treatments consisted of multiplication of microcuttings with one, two, or three buds with/without leaves and originated from different regions of the shoot: apical, middle, or basal. Each treatment was repeated five times with each replication composed of five explants that were inoculated in 250-ml flasks with 40 ml of the medium containing MS salts and vitamins added to: sucrose ($30 \text{ g} \cdot \text{L}^{-1}$), myo-inositol ($100 \text{ mg} \cdot \text{L}^{-1}$), agar ($6 \text{ g} \cdot \text{L}^{-1}$). The pH was adjusted to 5.6 before autoclaving. After inoculation, the flasks remained in a growth room at $25 \pm 2 \text{ }^\circ\text{C}$, 16-h photoperiod, and $19 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ light intensity provided by cool-white fluorescents lamps. Observations were done every 5 days. Final evaluation was performed after 30 days. It was observed that basal microcuttings provided longer shoots and that microcuttings with leaves bore the best ones. This kind of explant also favored a higher number of shoots, axillary buds, and better multiplication rate. The presence of leaves in the microcutting is important when basal explants are used once it can improve the number of axillary buds and the rate of multiplication. The higher the number of buds in the microcutting the lower the rate of multiplication. The in vitro multiplication of potato could be improved by using one-leaf bud basal microcutting.

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Micropropagation of a Rare *Cucumis* Species

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Cucumis hystrix Chakr. is a rare cucurbit species native to Asia. The species is valued by breeders because of its multiple branching habit and has been used in interspecific crosses with *Cucumis sativus*. However, individual *C. hystrix* plants have not been identified in the wild since 1990. Therefore, it was our objective to develop a micropropagation protocol that would allow us to clonally propagate plants in cultivation. Shoots tips (2 cm) were excised from a single *C. hystrix* plant grown in the greenhouse. All tendrils and leaves were removed before surface-sterilization in 1.25% NaOCl for 5 or 10 min and rinsed six times with sterile distilled water. Shoot tips were trimmed to 1 cm (meristem with two to three young leaf primordia) and placed into 25 x 125-mm test tubes containing 25 ml of initiation medium [MS plus (per liter) 100 mg inositol, 30 g sucrose and 5 g Agargel; pH 5.7–5.8]. PGR combinations tested were initiation medium with $1 \mu\text{M}$ BA, and initiation medium with $1.7 \mu\text{M}$ IBA, $0.5 \mu\text{M}$ kinetin and $0.3 \mu\text{M}$ GA₃ (IKG). Explant survival was greater when shoot tips were surface-sterilized for 5 min (75%) compared to 10 min (33%). More axillary shoots formed when shoot tips were cultured in IKG medium (10.8) than in medium with BA (5.5). Shoots were considerably longer (10 mm) when cultured in medium with IKG compared to BA (1.5 mm). About 64% of shoots place in medium containing $8 \mu\text{M}$ NAA formed roots and were acclimatized to greenhouse conditions.

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Somatic Embryogenesis and Organogenesis in Cowpeas

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Four cowpea [*Vigna unguiculata* (L.) Walp.] genotypes; IT 82E-18, IT 82E-16, Pinkeye Purple Hull, and Coronet were tested for somatic embryo formation and embryogenesis. Explants were 3-week-old cotyledons from which the embryonic axes were removed. Cotyledons were cultured in eight media combinations representing modifications of two media, one containing Murashige and Skoog Basal salt with B5 vitamins (MSB), 500 mg/L casein-hydrolysate (CS), 500 mg/L sodium chloride, 3% sucrose, 0.7% agar, 2mg/L 2,4-dichlorophenoxyacetic acid (2,4-D) and 0.5 mg/L benzylamino purine, and the other containing (MSB), 3% sucrose, 40 mg/L 2-4-D and 0.2% gellan gum. After 1 month, 40% to 100% of explants produced calli and few produced shoots. Subcultured shoots in MS with 0.1 mg/L indole-3-butyric acid (IBA) or with IBA and 0.5mg/L kinetin (KT) failed to produce roots. The only green cotyledonary stage embryo was produced on this latter medium. Subculture of calli in MSB containing CS, mannitol, sucrose, agar, indoleacetic acid, and KT produced cream-colored globular embryos, roots, and a few leaves.

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An In Vitro Regeneration System for Basil (*Ocimum basilicum* L.)

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A plant regeneration protocol was successfully developed for basil (*O. basilicum* L.). Explants from 1-month-old seedlings yielded the highest frequency of regeneration of shoots (37%) with an average number of 3.6 shoots per explant. Calli and shoot induction were initiated on Murashige and Skoog (MS) basal medium supplemented with thidiazuron (TDZ) (4 mg/L) for ≈ 30 days. Shoot induction and development was achieved by refreshing the induction medium once after 14 days. The most morphogenetically responsive explants were basal leaf explants from the first fully expanded true leaves of greenhouse-grown basil seedlings. Developing shoots were then rooted on MS media in the dark without TDZ. Within 20 days, rooted plantlets were transferred and acclimatized under greenhouse conditions where they developed normal morphological characteristics. This is the first report of a successful in vitro regeneration system for basil through primary callus. The establishment of a reliable regeneration procedure is critical when developing a transformation protocol for enhancing the production of basil for insect and disease resistance and improved essential oil constituents.

The Effect of Hydroponics on the Yield and Quality of Sweet Basil

Susan Kreder* and Albert H. Markhart, III; Department of Horticultural Science, University of Minnesota, St. Paul, MN 55108

Environmental conditions are known to affect the growth and quality of culinary and medicinal herbs. Hydroponic growing conditions often produces greater yields for many leafy crops compared to growth in more-traditional media. The objective of this investigation was to compare the yield and quality of sweet basil grown in continuous flow solution culture or well-irrigated Universal Mix. Sweet basil plants were germinated under mist and then transplanted to a continuous-flow hydroponics system or to 6-inch pots containing Universal Mix. Rows of pots alternated with a row of hydroponic plants in a temperature-controlled greenhouse. Temperatures were maintained between 20 and 25 °C, the relative humidity was not controlled, pot-grown plants were irrigated as needed. HID lights added sublimetry irradiation and maintained a photoperiod of 18 h. Cohorts of plants were harvested at five time points between transplanting and maturity. Plants were divided into leaves, stems, and roots, dried, and the data subjected to mathematical growth analysis. Several leaves from each plant were harvested and analyzed by gas chromatograph for essential oils. Plants grown in hydroponics grew faster and produced more harvestable leaf material than the media-grown plants. Details of the plant growth analysis and the essential oil composition will be presented.

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Rapid Somatic Embryogenesis and Plant Regeneration in American Ginseng (*Panax quiquefolium* L.)

X.Wang, J.T.A. Proctor*, S. Krishna Raj, and P.K. Saxena; Division of Horticultural Science, Dept. of Plant Agriculture, Univ. of Guelph, Guelph, Ontario, Canada, N1G 2W1

Ginseng is a very valuable agricultural species grown for its root, which contains pharmacologically active constituents. One limiting factor for expansion of ginseng production is an efficient method for mass propagation. Currently, seeding is the principal method of propagating ginseng, but the embryo of ginseng seeds at harvest is immature. A stratification schedule consisting of a cool-warm-cool temperature treatment over 18–22 months is required for embryo development and seed germination. An alternative for the efficient production of ginseng is mass propagation through the use of in vitro culture techniques. The objective of this work was to develop a highly efficient system for regeneration of ginseng. The efficacy of three auxins, viz. 2,4-D, NAA and dicamba, were compared for the induction of somatic embryogenesis in American ginseng. Somatic embryos formed on ginseng cotyledonary, zygotic embryo, and shoot explants after 8 weeks of induction by the auxins. Significantly more somatic embryos were induced by culture of any of the ginseng explants on media supplemented with 5 $\mu\text{mol} \cdot \text{L}^{-1}$ 2,4-D than any other auxin treatment. Histological and SEM studies confirmed that the regenerants were somatic embryos. Somatic embryos germinated and developed into normal plants in 3–6 months. The development of a regeneration system for ginseng using somatic embryogenesis is a necessary first step for mass propagation and the improvement of American ginseng.

45 POSTER SESSION 4 (Abstr. 120–132) Nutrition

Thursday, 29 July, 1:00–2:00 p.m.

120

Controlled-release Fertilizer Effects on Growth and Quality of Herbaceous Perennials

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Herbaceous perennials are the hottest item in the ornamental industry, yet relatively little is known about the most appropriate management and cultural practices for many of these species. The response of selected perennials to controlled-release fertilizer (CRF) rates was evaluated in this study. Liners of *Coreopsis* 'Early Sunrise' and 'Zagreb', *Astilbe* 'Bridal veil', *Hemerocallis* 'Stelladoro',

Phlox 'Franz Schubert', and *Rudbeckia* 'Goldstrum' were transplanted to 5.7-L pots filled with a 2 peat : 1 perlite (v/v) medium amended with dolomite and Micromax (2 and 0.6 kg $\cdot \text{m}^{-3}$, respectively). Plants were topdressed with Osmocote 18N–2.7P–10K at rates of 0, 1.8, 3.6, 5.3, 7.1 (industry standard) and 8.9 kg $\cdot \text{m}^{-3}$, and grown over a 3-month period. Plant biomass and quality ratings (including chlorophyll levels) followed an asymptotic behavior with CRF applications for *Coreopsis* 'Early Sunrise' and *Astilbe* 'Bridal veil', leveling at $\approx 1.8 \text{ kg} \cdot \text{m}^{-3}$. The rest of the species showed increases in plant growth and quality with CRF rates of 1.8–3.6 kg $\cdot \text{m}^{-3}$, followed by sharp, and significant, reductions at higher CRF rates. Observations of optimum growth and quality at CRF rates 1/2 to 3/4 below commercial recommendations were partially attributed to the use a peat medium, with relatively higher nutrient holding characteristics in relation to the more common pine bark mixes. This observation was confirmed the following season, where plants grown in a 4 pine bark : 1 sand medium (v/v) required higher CRF rates to have similar growth and quality responses to those grown in a 4 peat : 1 bark : 1 sand medium (v/v).

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Fertilizer Formulation, Placement, and Tex-R Geodiscs Influence the Growth of 'Compacta' Holly

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A study was conducted to compare four different controlled-release fertilizers when used in conjunction with Tex-R Geodiscs on the growth of *Ilex crenata* Thunb. ex J.A. Murray 'Compacta' in 3.8 L (#1) containers. The fertilizers used were Osmocote Plus Southern Formula (18N–3.9P–10K), Osmocote Plus Northern Formula (18N–3.9P–10K), Wilbro (15N–1.7P–7.5K), and Nutricote T-360 (17N–2.6P–6.6K) all applied at the rate of 1.8 kg N/m³. Geodisc treatments were: 1) no disc, 2) fertilizer placed on top of the disc, and 3) fertilizer placed beneath the disc. At 2 and 4 months after the initiation of the study, the growth indices for plants grown with both Osmocote Plus fertilizers were larger than for either of the other two fertilizers. After 7 months, final growth indices were greater for the Osmocote Plus and Wilbro treatments compared to Nutricote. Final leaf, stem, and root dry masses were all greater for the Osmocote Plus fertilizers compared to the other two, as was final plant quality. Plants with fertilizer placed on top of the disc were smaller compared to the no disc or beneath the disc treatments. Geodisc treatment had no influence on shoot dry mass or final plant quality. Data for leachate nutrient analysis and evapotranspiration will also be presented.

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Minimizing Fertilizer Input for Nitrate Management and Optimum Growth of *Ilex verticillata* L.

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Nitrate nitrogen is becoming a major pollutant in much of our nation's water supply. High levels of nitrate runoff are commonly found to occur from intense agricultural areas such as container nurseries. The objective of this study was to investigate combinations of liquid fertilizer (LF) plus controlled-release fertilizer (CRF) that would both minimize nitrate runoff and provide nutrient levels for optimum growth of *Ilex verticillata* L. The experiment was established in 1998 at the Iowa State Univ. Horticulture Research Station, Ames. Six fertilizer treatments were arranged in a randomized block design with eight replications. Treatment combinations of liquid fertilizer (LF) and controlled-release fertilizer (CRF) were [LF (mg/L)/CRF (g)]: 90/0, 90/8.5, 90/17, 180/0, 180/8.5, 180/17 (Peter's Excel 21–5–20 and Osmocote 18–6–12, 9-month release, respectively). Analysis of nitrate leaching showed that in 12 out of 16 weeks, the 180 mg/L LF treatments resulted in twice the amount of nitrate leached compared to the 90 mg/L LF. In 3 out of 16 weeks, treatments containing 0 g CRF leached significantly less nitrate than those containing 17 g CRF. None of the treatments produced a difference in total dry weight or caliper of *Ilex verticillata* L. This data suggests that plant growth remains similar over a range of fertilizer input and higher rates of applied LF result in higher nitrate leaching.

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The Potential Use of Spent Mushroom Compost as a Soil Amendment for Nursery Crop Production

Jay Young*, Charles Heuser, and E.J. Holcomb; Department of Horticulture, Pennsylvania State University, University Park, PA 16802

The use of spent mushroom compost (SMC) as a media amendment for containerized greenhouse and nursery crop production is a promising alternative to

disposal of this by-product of mushroom production. Fresh SMC is the compost that is removed from the mushroom house and used without further weathering. The objectives of this study include first, identification of key factors involved in its successful use and second demonstration of the effective use of SMC by nurserymen. The plant material used includes both bedding plants and woody perennial species. Results demonstrate that the key factor in the use of SMC for plant production is high soluble salts. Leaching can reduce the high soluble salts. In addition, special consideration should be given to the reduction in potted media volume over time due to composting that continues after the material is removed from mushroom production. SMC as the sole growing media was not as effective as when SMC was amended with a commercial nursery growing mix. Several species were grown in 0%, 25%, 50%, 75%, and 100% mixtures of SMC and a commercial nursery mix. All species grew well in 50% SMC/50% nursery mix.

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Evaluation of the Chemical Characteristics of Three Organic Residues and the Effect of Their Use on the Environmental Medium

Mondher Bouden* and Jacques-Andre Rioux; Environtron Building, Horticulture Research Center, Laval University, Ste-Foy, Quebec, Canada, G1K7P4

The richness of the organic residues in certain fertilizing elements justifies their valorization in horticulture. However, their contents in pathogenic and toxic elements can restrict their use. In this context, this study was conducted in order to evaluate the effect of three organic residues on the environmental medium and the risks of water contamination by the release of heavy metals. *Physocarpus opulifolius* 'Nanus' was transplanted into four substrates. The control substrate contained 4 peatmoss : 5 composted conifer bark : 1 fine crushed gravel (by volume). The three other substrates (25% of peatmoss was substituted by organic residue) contained 10% of fresh bio-filters (FBF), 10% of composted sewage sludges (CSS), or 10% of de-inking sludges (CDS). The pots (5l) were placed in plastic vats and the drainage water was recovered in vessels (17l). The experimental design was in complete blocks with six replications. Samples of the drainage water were collected every 2 weeks for analysis. The pots were fertilized every week (400 mg/L of N) and growth parameters were statistically analyzed by ANOVA. The chemical analysis of the residues proves that they contain weak concentrations in organic contaminants. There is an accumulation of NO_3^- in drainage water following the fertilization; the same applies to sulfates and potassium. On the other hand, heavy metals are not released in important concentrations and so the lead, zinc, manganese, and copper contents do not exceed the desirable limits. Moreover, the *Physocarpus* plants produced in CSS substrates had a growth significantly larger than those plants produced in FBF or CDS substrates. The three organic residues do not constitute a risk of pollution for the environment.

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Substrates and Hydrophylic Polymers Influence Growth of Surfinia

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Low water retention in hanging baskets is a constraint in urban floriculture and hydrogel addition is an alternative. However, growth may be reduced with such a product depending on the substrate used. This study was conducted to determine the combined effects of substrate and type of hydrogel on the growth of Surfinia plants produced in hanging baskets. During Spring 1998, three rooted cuttings of Surfinia (*Petunia x hybrida* 'Brilliant Pink') were transplanted into 30-cm hanging baskets. Plants were transplanted into one of the following substrates: 1) Pro-Mix BX, 2) a blend of 4/5 Pro-Mix BX and 1/5 compost, or 3) 1/3 perlite 1/3 vermiculite and 1/3 compost (v/v). These three substrates were amended with two types of hydrogels. The first type, Soil Moist, is an acrylic-acrylamide copolymer and the second type is Aqua-Mend, an acrylic polymer. Plants were grown for 8 weeks under standard irrigation and fertilization practices. Plant growth characteristics, percent dry weight, mineral nutrition, and growth index were determined. Substrate physical properties such as available water content, unsaturated hydraulic conductivity and total porosity were measured. The dry weight and growth index of plants in Pro-Mix BX amended with both types of hydrogels were greater than those plants growing in Pro-Mix BX without hydrogel. Plants growing in substrates 2 and 3 with hydrogels were smaller or similar respectively than those plants growing in substrates without hydrogel. Their effects on physical properties of substrates and plant growth will be discussed.

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Nutrient Analysis of Organic Fertilizers for Greenhouse Vegetable Production

Robert G. Anderson* and Robert Hadad; Department of Horticulture and Landscape Architecture, University of Kentucky, Lexington KY 40546

A segment of the greenhouse crop market would like to obtain vegetables and herbs that are certified organic. The technology for the use of biological controls for insects and diseases is well-developed and a significant part of greenhouse vegetable production. Organic fertilizers, however, have not been well-utilized in organic greenhouse vegetable production. Common organic fertilizers were analyzed for the levels of nutrients when mixed with water for use in greenhouse fertigation. Products derived from algae—Algamin (liquid) and Ohrstrom's Garden Maxicrop (powder), Bat Guano, and products derived from fish waste—GreenAll Fish Emulsion (liquid) and Mermaid's Fish Powder, demonstrated nutrient levels comparable to typical water-soluble fertilizers used for greenhouse plant production. Although the organic fertilizers could not be used as a concentrate for injector systems, readings from a conductivity meter were directly related to nitrate nitrogen levels and could be used for fertilizer management in the capillary mat subirrigation system used for plant production.

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Growth of Impatiens 'Accent Orange' in Substrates Containing Compost with Four Slow-release Fertilizer Concentrations

Kimberly Klock-Moore*; Univ. of Florida, Fort Lauderdale Research and Education Center, 3205 College Ave., Fort Lauderdale, FL 33314

The objective of this experiment was to compare the growth of impatiens 'Accent Orange' in substrates containing compost made from biosolids and yard trimmings with four slow-release fertilizer application rates. Plugs of impatiens were transplanted into 400-ml pots filled with 100% compost as a stand-alone substrate or with 60%, 30%, or 0% compost combined with control substrate components. Six days after transplanting, all plants were top-dressed with 0.5, 1, 2, or 4 g of Nutricote 13N-5.7P-10.8K (type 180) per pot. Shoot dry mass increased as the percentage of compost in the substrate increased from 0% to 100%. Shoot dry mass also increased as the fertilizer application rate increased from 0.5 to 4 g per pot. Plants grown in 30% and 60% compost with 0.5 g of fertilizer were similar in size to plants grown in 0% compost with 4 g of fertilizer per pot. Plants grown in 100% compost at all of the fertilizer rates were larger than all other plants in this study.

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Release of Zinc from Shredded Waste Tires Designed for Use as a Substrate Amendment

Amy Dallman, H. Taber*, M. Evans, and D. Shogren; Department of Horticulture, Iowa State University, Ames, IA 50011

Shredded rubber from automotive waste tires has been proposed as a potential component for use as a potting root substrate. One of the problems with using shredded rubber as a root substrate is that it releases potentially phytotoxic levels of Zn. Therefore, we were interested in washing the rubber particles with either distilled water, 0.1N HCl, or 0.05N DTPA before inclusion of the rubber in the potting mix. A coarse and a fine grade were used. Seventy-two percent (% w/w) of the particles in the coarse grade were within a particle size range of 2.8–6.3 mm, while only 52% of the particles in the fine grade were within this range. The ratio of extractant to shredded rubber was 2:1 (v/v). The soaking time varied from 1 to 96 hours with the extractant changed every 1, 2, 12, or 24 hours. For either particle size, the 0.1N HCl extractant removed 25 times more Zn than the water and 1.5 times more than the DTPA. With the 0.1N HCl extractant, three times more Zn was removed from the fine rubber as compared with the coarse material. Seventy-five percent of the Zn extracted was removed in the first hour of soaking and 92% removed within 72 hours.

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High Nitrate Fertilizers Control Shoot Growth through Low Phosphate Stress

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The greenhouse industry successfully uses high NO_3^- fertilizers to produce plants with short, compact shoots. It is commonly assumed that NO_3^- results in

compactness while NH_4 or urea stimulate large shoot growth. However, high NO_3 fertilizers contain little or no phosphate. Four sets of treatments were applied to five species of bedding plant plug seedlings in two experiments to differentiate the effects of N source vs. phosphate supply on growth. Seedlings were established on 20–4.4–16.6 fertilizer until 10 days into stage 3, when the following treatments began. Set 1: phosphate-P was held at 22 mg/L and total N at 100 mg/L with NH_4 comprising 40%, 13%, 7%, or 0% of total N, the remaining being NO_3 . Differences in shoot size did not occur as a consequence of the shift in NH_4 : NO_3 ratio. Set 2: N was supplied at a concentration of 100 mg/L from 40% NH_4 plus 60% NO_3 while PO_4 -P was varied over the series of concentrations of 21.9, 6.6, 3.3, and 0 mg/L. Set 3: the same as Set 2 except that N was supplied entirely as NO_3 . Height and weight of shoots in Sets 2 and 3 were positively related to PO_4 supply. Set 4: three commercial fertilizers containing 0 PO_4 -P and 8, 13, or 20% of N in the NH_4 form. Compact shoots developed in these treatments. When 22 mg phosphate-P/L was added to one of these fertilizers, compactness was reversed. Shoot suppression by high NO_3 fertilizers was concluded to be a function of low phosphate and not N form.

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Impact of Fertilizer N Forms on Bedding Plant Development

Dharmalingam S. Pitchay* and Paul V. Nelson; Dept. of Horticultural Science, P.O. Box 7609, North Carolina State University, Raleigh, NC 27695

It is a common practice in greenhouses to apply fertilizers with a high proportion of N in the NO_3 form to achieve short, compact shoots and a moderate (25% or greater) proportion of NH_4 or urea for large shoots. However, this practice is not substantiated in the scientific literature. Two experiments were conducted in a greenhouse to assess effects of N form on development. In the first, *Petunia hybrida* 'Mid-night Dreams' was treated with five ratios of NH_4 : NO_3 or urea: NO_3 in a factorial arrangement with three concentrations of N (50–low, 100–adequate, and 200–high mg/L at each irrigation). In the second experiment six species of bedding plants were treated in a factorial arrangement of five ratios of NH_4 : NO_3 and two pH levels (acceptably low, 5.4–5.8, and unacceptably low, 4.6–5.2). In all comparisons, height and dry weight of shoots grown with 100% NO_3 were equal or larger than the plants grown with combinations of N. There was a general trend for plants to be shorter and lighter at higher NH_4 or urea proportions. These results refute the hypothesis that shoot size is under the control of N form. Depth of green foliar color correlated positively with proportion of NH_4 or urea. Reputed NH_4 toxicity symptoms of chlorosis, necrosis, and curling of older leaves occurred only at adversely low pH levels below 5.2 in experiment 2. Resistance of plants to this disorder under conditions of pH levels in the range of 5.4 to 5.8, high N application rates, and applications of 100% NH_4 indicates that bedding plants during commercial production are fairly resistant to this disorder.

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Effect of Blended Composts and N Rates on Growth Performance of Potted Poinsettia

Catherine S.M. Ku* and John C. Bouwkamp; Department of Natural Resource Sciences and Landscape Architecture, University of Maryland, College Park, MD 20742-4452

Growth performance of potted 'Peterstar Pink', 'Top White', 'Red Sails', and 'Red Success' were evaluated in eight substrates and three fertilization rates. The substrates included Sunshine Mix 1 and Pro Gro 300S as control, and compost blends at 33%, 50%, and 67% of final substrate volumes mixed with peat and perlite (1:1). The blends included 2:1, 1:1, or 1:2 ratio of polymer dewatered biosolids (PDB):poultry litter (PL) and PDB: yard wastes (YW). Fertilization was applied twice weekly at 75, 100, and 150 mg/L N from 19N–2.2P–16.6K. Plants grown in Sunshine Mix 1 performed better than those grown in Pro Gro 300S. The growth parameters measured improved as the N rates increased for both controls. Plant diameter, grade, and dry weight of plants grown in 150 mg/L N treatment were usually similar to those in 100 mg/L N and were not 11% more than those at the lowest N treatment. The 1 PDB: 1 PL blend at the high N treatment produced premium-quality plants, and all remaining PDB:PL treatments produced good quality plants. The PDB:YW blends that received 100 and 150 mg/L N produced premium quality plants. The PDB:YW blends at the low N treatment produced slightly better quality plants than those grown in PDB:PL at the 75 mg/L N and were similar in quality as those grown in Sunshine Mix 1 at the 150 mg/L N treatment.

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Fertilization Methods to Match Nutrient Supply with Demand for Potted Chrysanthemum

C.J. Catanzaro* and R.J. Sauve; Cooperative Agricultural Research Program, 3500 John Merritt Blvd., Nashville, TN 37209-1561

A greenhouse study was conducted in Autumn 1998 using standard cultural practices for potted chrysanthemum [*Dendranthema x grandiflorum* (Ramat.) Kitamura] to determine how fertilization affected plant growth and quality and nutrient leaching. Fertilization treatments included constant liquid fertilization until anthesis (LFA), constant liquid fertilization until disbud (LFD), slow-release resin-coated fertilizer (SRF), and no-fertilizer control. Frequency of irrigation was determined gravimetrically, and leaching fractions maintained near 0.2. Plant growth and quality for LFA, LFD, and SRF met commercial crop standards. Nearly 60% of the total nitrogen applied with LFA was applied during the 4 weeks between disbud and anthesis, due to increased water demand. During the same period when liquid fertilization was discontinued for LFD, leachate electrical conductivity (EC) levels dropped from 4 to $<1 \text{ dS} \cdot \text{m}^{-1}$. Leachate EC levels for LFA at anthesis remained high, but were $<1 \text{ dS} \cdot \text{m}^{-1}$ for the other treatments. LFD and SRF drastically reduced the total amount of nutrients applied during the course of production compared with LFA. Use of an appropriate slow-release fertilizer or discontinued use of liquid fertilizer at disbud allow soluble salt levels to decrease during the latter weeks of the mum production cycle, when nutrient demand is low and water demand is high.

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Agronomic and Economic Evaluation of Seven Organic Nitrogen Fertilizers Applied to Bell Peppers

Mark Gaskell*; University of California Cooperative Extension, 624 West Foster Rd., Santa Maria, CA 93455

Organic vegetable production acreage is expanding in California, but little research-based information is available to guide growers. Several new organic fertilizer materials are available but little data exists on efficient use of these materials. During 1998, the following materials: compost (C), pelleted chicken manure (PCM), fish meal (FM), liquid fish (LF), liquid soybean meal (LSM), feather meal (FTM), and seabird guano (SG) were evaluated. Each material was applied at treatment rates of 0, 60, 120, and 180 kg nitrogen (N)/ha to transplanted, sprinkler irrigated bell peppers. The materials were applied as 30N pre-transplant (PRE) and 30N at 20 days post-transplant (POST) for the 60N treatment; 60N PRE and 30N at 20 days POST and 30N at 40 days POST for the 120N treatment; and 60N PRE, 30N at 20 days POST, 45N at 40 days POST, and 45N at 70 days POST for the 180N treatment. Weekly soil nitrate nitrogen (SSN) over 16 weeks POST and fresh pepper yield was determined for all treatments. Weekly SSN varied from lows of $4 \text{ mg} \cdot \text{kg}^{-1}$ in 0N-treated plots to over $80 \text{ mg} \cdot \text{kg}^{-1}$ in FTM 180N-treated plots. Highest SSN was observed in FTM-, SG-, LSM-, LF-, and FM- treated plots at 180N and peaks in SSN lagged fertilizer application 3 to 4 weeks. Total pepper yield was not as markedly affected as early yield and size. Highest early yield and largest sizes were observed in FTM 180N-treated plots. Compost treated plots at 180N produced highest economic return per fertilizer dollar.

145 POSTER SESSION 18 (Abstr. 133–141) Nutrition

Saturday, 31 July, 1:00–2:00 p.m.

134

Growth, Photosynthesis, Fruit Yield, and Quality of Greenhouse Tomato Grown in Open or Closed Rockwool Production Systems with Different Nutrient Feedings

Xiuming Hao* and Athanasios P. Papadopoulos; Greenhouse and Processing Crops Research Centre, Agriculture and Agri-Food Canada, Harrow, Ontario, Canada NOG 1G0

Two long-season tomato crops (*Lycopersicon esculentum* Mill. cv. Trust; in 1996 and 1997) were grown in an open rockwool system (conventional culture method) and in closed rockwool culture systems with different nutrient feedings

to develop a closed tomato production system with zero discharge of nutrient solutions to the environment. The tomato grown in the closed rockwool systems with a modified rockwool or nutrient film technique (NFT) feeding formula achieved similar marketable yield as the tomato grown in the conventional open rockwool system. Similarly, there were no differences in early plant growth and photosynthesis, total plant biomass and biomass partitioning, fruit yield, or fruit size and grades. The tomato plants grown in the closed rockwool systems senesced slower, as demonstrated by higher photosynthesis in old leaves, and had better root systems than the plants grown in the conventional open rockwool system. The fruit quality of tomato produced in the closed rockwool systems was better than that of tomato produced in the open rockwool system in one of two crops. These results demonstrated that the closed rockwool system with optimized nutrient feeding is an economically and environmentally sound alternative to the conventional open rockwool production method.

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Tillage Systems and Fertilization Methods for Staked Tomatoes

Jim E. Wyatt¹, Don D. Howard¹, Don D. Tyler¹, and Craig H. Canaday²; ¹Dept. of Plant and Soil Sciences, ²Dept. of Entomology and Plant Pathology, The Univ. of Tennessee, West Tenn. Experiment Station, 605 Airways Blvd., Jackson, TN 38301

Reduced and no-tillage vegetable production is gaining in acceptance in the Southeastern United States. Conventional till, strip-till, and no-tillage systems with different methods of nitrogen application in staked tomatoes were studied in Tennessee. Conventional tillage plots were prepared by disking and harrowing, strip till plots were cultivated ≈ 16 cm deep with a rear-tine tiller (≈ 50 cm wide), and no-till plots were established in chemically killed wheat with no cultivation. Four nitrogen treatments were applied at $67.2 \text{ kg} \cdot \text{ha}^{-1}$ N using liquid KNO_3 . The treatments included applying the N either 1) in a 54-cm strip or 2) in a 108-cm strip over the row, 3) by banding ≈ 10 cm on each side of and ≈ 10 cm below the row, or 4) by injecting into the drip irrigation system in increments of 11.2, 22.4 and $33.6 \text{ kg} \cdot \text{ha}^{-1}$ N at 2, 4, and 6 weeks after transplanting, respectively. Tillage had little effect on tomato yield but the strip till and no-till plots allowed cultivation or spraying soon after a rainstorm. The improved trafficability was a distinct advantage over the conventionally tilled plots in the study. Total yield was significantly higher in strip tilled plots, but within fruit size categories (small, medium, large and extra large) no differences were found due to tillage system. The fertilizer treatments in which N was placed in 54- or 108-cm strips over the row produced the highest yield of early large and early extra large fruit, which are usually the most valuable portion of the crop. Banded and injected nitrogen treatments tended to produce large amounts of fruit late in the season, a period when tomato prices are generally lower.

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Limitations to the Use of Poultry Litter as a Fertilizer for Vegetables

Warren Roberts*, Jim Duthie, Jonathan Edelson, and Jim Shrefler; Oklahoma State University, Lane, OK 74555

Poultry litter is readily available in eastern Oklahoma. Poultry litter contains most of the essential elements for plant growth, and has long been used as a fertilizer for various crops. The ratio of N-P-K is about 1-1-1. In some areas, litter has been used excessively, and buildups of certain nutrients have occurred. There are concerns that a buildup of phosphorus (P) will lead to excessive amounts of P in water systems, which will affect water quality. There are also concerns that nitrogen (N) will leach or run off into water systems and also lower the water quality. Oklahoma has enacted legislation that will control how much litter can be applied to a given field, and regulations are being set in place to monitor and control the applications of litter. Studies have been conducted at the Lane Agricultural Center in southeastern Oklahoma over the past 6 years to determine vegetable production and soil nutrient changes when different litter application strategies are followed. In general, poultry litter has produced yields of cucumbers, collards, and corn that are equal to or greater than yields of the same crops fertilized with conventional synthetic fertilizers. Buildups of certain nutrients, particularly P, are occurring. At this time, the buildups are considered beneficial. The highest rate of litter application has resulted in levels of soil P that are about half the maximum amount allowed under present legislation.

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Evaluating PARJIB, a Model of Vegetable Crop Performance in Response to Nutrient Supply

J.B. Reid, A.R. Renquist*, A.J. Pearson, and P.J. Stone; New Zealand Institute for Crop & Food Research Ltd., Hawke's Bay Research Centre, P.O. Box 85, Hastings, New Zealand

Economic and environmental concerns have increased the need for quantitative advice on fertilizer rates. In addition, it would aid researchers to be able to estimate the degree to which nutrient availability is affecting yield in a wide variety of field experiments. All of these needs can, in principle, be addressed using the new PARJIB model. PARJIB retains the functional simplicity of much earlier analytical models of crop responses to soil test values and fertilizer application rates. However, in a key departure from previous approaches, response to scaled nutrient supply indices is dictated by the potential yield adjusted for plant population and water stress. The version currently being evaluated simulates responses to supply of N, P, K and Mg, varying either singly or in combination. We have calibrated the model for sweet corn, carrots, and snap bean crops grown under temperate conditions in a wide range of soils. Simulated yields agreed well with observed values; the root mean square error was 8% to 13%, and regressions of observed against simulated yields passed through the origin with slopes that were not significantly different from 1. After calibration, the model predicted strong interactions between nutrient supply, plant population and water stress. PARJIB appears to have substantial potential to improve nutrient management for horticultural crops.

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Evaluation of Soil Amendments for Certified Organic Pepper Production

Kathleen Delate*; Dept. of Horticulture & Agronomy, Iowa State University, Ames, IA 50011

Organic farming has increased to a \$4.2 billion industry in the U.S. and continues to expand $\approx 20\%$ annually. In Iowa alone, organic acreage for all crops has increased from 13,000 in 1995 to 120,000 in 1998. Organic farmers have requested an unbiased analysis of natural soil amendments/fertilizers and compost products on the market for certified organic vegetable and herb production. In our first-year trials at the ISU Muscatine Island Research Farm in 1998, a total of 1,120 'Hungarian wax' pepper plants were transplanted into rows at 31 x 61-cm spacing. Four replications of seven fertilization treatments were planted within the field. The goal of the fertilization program was to obtain equivalent nitrogen and calcium rates in the organic and conventional systems. Leaf height was not significantly different in plants fertilized with organic compost (poultry litter-based) at 50 and 100 kg/ha N compared with conventional fertilizers (at 100 kg/ha N). All organic and conventional treatments had greater biomass than the organic and conventional controls (no fertilizer), respectively (ANOVA, $P = 0.05$). First harvest fresh weights were greater in the organic treatments, with the greatest number of peppers and greatest fresh weight in the compost plus Bio-Cal[®] (a liming industry by-product) treatment. Total pepper fresh weight over the five harvest periods was not significantly different among treatments, demonstrating to organic farmers that comparable yields can be obtained in systems employing alternatives to synthetic nitrogen fertilizer.

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WITHDRAWN

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Influence of Potassium Nutrition on Growth and Sugar Content of Carrot

Hoon Kang*, Abbas Lafta¹, Chiwon W. Lee¹, Murray E. Duysen¹, and Larry Cihacek²; Departments of ¹Plant Sciences and ²Soil Science, North Dakota State University, Fargo, ND 58105

The influence of potassium (K) nutrition on the growth and sugar contents of carrot (*Daucus carota* L.) cv. Navajo was investigated in a greenhouse study. Seeds were germinated in 15-cm plastic pots (volume 1.5 L) containing a peat-lite mix (2 parts peat:1 part vermiculite:1 part perlite, v/v). Starting at 6 true-leaf stage (5 weeks from germination), plants were watered with nutrient solutions containing 0, 1, 2, 4, or 8 meq K/L for 10 weeks. While plants receiving no potassium had the lowest biomass yield, there was little or no difference in shoot or root biomass yields between different K concentrations. Root glucose and su-

crose contents were the highest when plants grown with 8 meq K/L and 4 meq K/L, respectively, from the nutrient solution. The influence of nutrient solution K concentration on tissue content of K and other macronutrient elements was also determined.

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Effects of Two AM Fungi on the Yield and the Quality of Carrot (*Daucus carota* L.) Grown in Field Conditions

Henriette Gotoëchan*, Jean Coulombe, Serge Yelle, and Hélène Desilets; Horticultural Research Center, Laval Univ., Ste-Foy, Quebec, Canada G1K 7P4

Two cultivars of carrot were sown in a sandy loam soil over two seasons with and without introduction of commercial inoculum of *Glomus intraradices* or *Glomus etunicatum*, which was spread with an experimental sowing machine. VAM fungi effects on the yield and the quality of carrot varied from season to season. In 1997, both of the VAM fungi enhanced the average saleable yield of the two cultivars from 66.21 t/ha to 69.85 t/ha and 80.81 t/ha, respectively, for the treatment without the introduction of VAM fungi, *G. etunicatum*, and *G. intraradices*. The slight difference (5.03%) that occurred between *G. intraradices* and the non-inoculated treatment, although not significant, represented 20.38% of the total percentage of rejected carrots. For the last season, the amount of rejected carrots was in the same range for all the treatments (13% to 14%). Nevertheless, both of the cultivars responded differently to mycorrhization. In both of the seasons, mycorrhizal colonization was high in all plots, with an average of 70% in the treatment without inoculation and 75% in those that received *G. intraradices* or *G. etunicatum*. In our experimental conditions, reduction of phosphate fertilization to 50% of the recommended quantity had no influence either on the mycorrhizal colonization or on the yields.

46 POSTER SESSION 5 (Abstr. 142–146) Extension/Technology Transfer

Thursday, 29 July, 1:00–2:00 p.m.

142

Missouri Master Gardener Demographics

Denny Schrock*¹, Mary Meyer², Peter Ascher², and Mark Snyder²; ¹University of Missouri–Columbia, Columbia, MO 65211; ²University of Minnesota, St. Paul, MN 55108

A survey was conducted of current and former Missouri Master Gardeners to identify the demographics of volunteers and to determine if Master Gardeners fit the demographic pattern of volunteers in general. Sixty-eight percent of survey respondents were active in the program, while 32% were inactive. Females accounted for 65% of respondents and males 35%. Nearly 60% of Missouri Master Gardeners were 50 years old or older; however, those in their 40s comprised the largest demographic group. The majority of Missouri Master Gardeners were married with children. Over 50% had at least a college degree, while 22% had post-graduate work. One-third had household incomes of \$60,000 or greater; in addition, just under one-quarter had household incomes between \$40,000 and \$60,000. The largest occupational group was retired persons, at 26.9%; the second largest category was homemakers at 14.6%. Missouri Master Gardeners are more likely to be from small towns or rural areas than from medium or large cities. They tend to be long-term residents of their communities; 57.2% had lived at their current residence for more than 10 years. Missouri Master Gardener volunteer demographics fit the pattern of volunteers in general, but demographic data proved to be a poor predictor of intent to continue volunteering in the Master Gardener program.

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Benefits and Values of the Master Gardener Program

Denny Schrock*¹, Mary Meyer², Peter Ascher², and Mark Snyder²; ¹University of Missouri–Columbia, Columbia, MO 65211; ²University of Minnesota, St. Paul, MN 55108

Current and former Missouri Master Gardeners were asked to respond how strongly they agreed or disagreed with a list of benefits provided by the Master Gardener program. The survey instrument was an adaptation of Rohs and

Westerfield's (1996) Master Gardener Societal and Personal Benefits survey. Questions were assigned to one of the six principal components of volunteer motivation developed by Clary et al. (1998): Understanding, Values, Enhancement, Social, Protective, and Career. Master Gardeners who are currently active volunteers in the program were more likely to respond favorably to many of the benefits provided by the Master Gardener program. Respondents most strongly indicated their agreement that the Master Gardener program, more than any other similar organization, provides benefits related to new learning experiences, exercising knowledge, skills, and abilities, categorized as understanding (U). The overall mean for U was 4.35 on the 5-point Likert scale, a significantly higher score than any other category according to Duncan's multiple range test. Benefits related to personal growth and self-esteem, labeled enhancement (E); those related to altruism and humanitarian concern, labeled values (V); and guilt reduction over being more fortunate than others and addressing one's own personal problems, labeled protective (P), formed the second tier of benefit importance. Benefits related to preparation for a new career or maintaining career-relevant skills, categorized as career (C) were next. Benefits concerning relationships with others, classified as social (S), concluded the list.

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The Ripple Effect: Training Veteran Master Gardeners to Train Incoming Volunteers

Ann Marie VanDerZanden* and Gail Gredler; 4017 ALS Bldg., Oregon State Univ., Corvallis, OR 97331-7304

Oregon State University Master Gardener volunteers are the backbone of home horticulture program delivery in Oregon. In 1997, more than 800 new Master Gardeners received between 48 and 66 hours of initial training at 17 sites throughout Oregon. A reduction in faculty available to train Master Gardeners and reduced travel budgets for existing faculty have made it difficult to effectively deliver training on a statewide basis. One solution to this problem is to train veteran Master Gardeners to assume some of the teaching duties for the initial training in their respective counties. In Sept. 1998, 45 veteran Master Gardeners attended a 2-day training seminar to learn to deliver two 3-hour training modules to Master Gardener trainees. Participants learned to use curriculum materials developed for training sessions on vegetable gardening and herbaceous ornamentals. Curriculum materials include annotated slide sets, handouts, suggested activities, entry/exit quizzes, and teaching evaluations for each module. Participants also received training on effective teaching strategies for the adult learner. Participants delivered the training in their respective counties during winter 1999 and returned an evaluation of the training experience. Benefits of this program included reduced training expense and teaching time for Extension faculty, increased volunteer commitment and participation in Master Gardener training, an advanced training opportunity for veteran Master Gardeners, availability of curriculum materials for future training, and improved retention of veteran Master Gardeners.

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Survey of Virginia Master Gardener Volunteer Management

Sheri Dorn, Diane Relf*, Alan McDaniel, and Michele James-Deramo; Department of Horticulture, Virginia Polytechnic Institute and State Univ., Blacksburg, VA 24060

Virginia Cooperative Extension's (VCE) Master Gardener volunteer program is available in 73 of 102 unit offices. The unit programs are managed by MG coordinators who currently include 10 locally funded agents, eight locally funded non-agents, and 26 volunteers. In 1998, the VCE Master Gardener Coordinator Manual was developed for use by coordinators in managing the local MG program. The 12-unit resource book was developed cooperatively with teams of MGs, coordinators, and agents to enhance coordinators' skills. The manual was the basis of four local MG coordinator training sessions conducted in 1998. Before MG coordinator training, local coordinators were asked to complete an eight-page survey about MG program management practices used locally. In addition to basic questions about coordinator status and length of time with VCE, the survey asked about techniques used in recruitment and training; motivation, retention, and recognition; individual and local MG program evaluation; and other topics. Two months after the last training, all coordinators were asked to evaluate the usefulness of the VCE Master Gardener Coordinator Manual, which was the base text for the training. Finally, 6 months following the final training session, MG coordinators were asked to again complete the eight-page survey about management practices used locally. The results of the survey information have indicated areas in which the management of MG programs are strong and can be

strengthened in order to provide enthusiastic, qualified volunteer staff to assist VCE in implementing horticultural educational programs in local communities. The results of the survey are helpful in focusing the work of the state Master Gardener coordinator to provide adequate and appropriate training and other resources for local coordinators. The results of the evaluation survey have assisted the finalization of the VCE Master Gardener Coordinator Manual, a useful resource to any state's Master Gardener program management effort.

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The Master Gardener Program in Wisconsin

*Helen C. Harrison**; University of Wisconsin, Madison, WI 53706

The Master Gardener Program in the state of Wisconsin is growing rapidly and has been in existence since the late 1970s. There are several aspects of our program(s) that make us unique. First, we are one of the very few states to service all counties within the state, not just our heavily metropolitan areas. Second, we have two major program types along with some unique county programming. We have the basic Master Gardener Program, which covers the major aspects of horticulture—this gives the learner 36 h of training with an expectation of 36 h of volunteer work in return. We now offer the general program in districts (extension has six clusters of counties in Wisconsin)—such that the counties within a district (usually around 16) will have the chance to offer the course at least once every 3 years. That is because the general course is offered once a week (3 h in the evening) for 12 weeks; and thus the basic course is offered spring and fall. If some of the counties within a particular district do not choose to participate, then other counties around the state can take part. Most of the 12 programs are high quality 2-h video productions followed by a 1-h ETN program, which is like a big conference call—everyone has an interactive session with the specialist who developed the video. The specialized program is a series of four 36-h (six 6-h days) training over a 4-year period, which covers flowers, fruit, vegetables, and turf, along with trees and shrubs. This program is offered in our four largest metropolitan areas and is still done all by live lecture. Finally, we require update training for our MGs if they want to continue to be members in good standing (wallet-size cards are issued). This involves 10 h of specified educational opportunities and 10 volunteer hours per year. We also have a day-long educational conference each spring as well as cooperating with Iowa and Minnesota to offer a 2-1/2 day workshop on the alternating years of the international conference. This is hands-on training, held usually the end of June, and rotates among the three states. We now have a strong MG association which has nonprofit status and is an integral partner with us here at the university. Not only do MGs receive members in good standing cards annually, they also receive certificates for 150, 250, 500, 750, and 1000 h of service as well as a 10-year certificate.

146 POSTER SESSION 19 (Abstr. 147–160) Extension/Technology Transfer

Saturday, 31 July, 1:00–2:00 p.m.

147

Development of a Multimedia Ornamental Plant Database for the World Wide Web

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The growth of the ornamental plant industry has rapidly increased over the past several years, creating a strong demand for well-trained graduates and industry workers. It is vital for a person entering this industry to have a solid and broad plant material background. The best ways to learn, sell, and teach plants are through visual materials. Currently, there are few cost-effective resources that provide a person with all the visual information needed to learn plants. To better serve the students and industry workers, the Univ. of Connecticut has developed a free multimedia ornamental plant database on the World Wide Web. The plant database focuses on plants for the New England area (USDA zone 6 and lower). This website brings detailed textual information, thousands of pictures, and audio pronunciations together in one complete package. Plant characteristic information (textual and pictorial) consists of habitat, habit and form, summer foliage, autumn foliage, flowers, fruit, bark, culture, landscape uses, liabilities, ID fea-

tures, propagation, and cultivar/variety. The major factors and decision processes involved in developing an educational Web site, with emphasis on usability and accessibility are considered. The target audience for this Web site is students as well as the nursery and landscape industry workers, agricultural consultants, extension personnel, landscape architects, and the gardening public.

148

Incorporating Technology Across the Curriculum: GPS/GIS for Agricultural Sciences Education

*Rick Bates**; Dept. of Plant Sciences, Montana State Univ., Bozeman, MT 59717-3140

Global positioning system (GPS) and geographic information system (GIS) technologies are at the cutting edge of an emerging agricultural revolution called site-specific management. Anticipated benefits are both economic and environmental because in this system, herbicides, fertilizers and other inputs are placed only where needed in the precise amounts required. The opportunities for site-specific management of crops, soils, and pests are innumerable. However, most students of agriculture and land resource sciences have little, if any, experience with the GPS and GIS technologies that provide these new opportunities. Beginning in 1995, efforts were undertaken to integrate GPS/GIS technology into the College of Agriculture curriculum. The process began with GPS/GIS training workshops for local and regional faculty. Key faculty modified curriculum within several departmental options and produced instructional modules for 12 different agriculture science courses. Experiential learning opportunities were developed and in some classes, farmer practitioners of site-specific management participated with students in identifying management problems and solutions. Instructional modules and active learning exercises were formally evaluated as to their effects on enhanced student decisionmaking skills and competency in GPS/GIS applications. Recently the new course LRES 357 "GPS/GIS Applications" was added to the curriculum and work is underway to place this course on-line.

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An Overview of the Clemson University/ Carolina Nurseries Research Partnership

*Jason B. London**, *Ted Whitwell*, and *R.T. Fernandez*; Dept. of Horticulture, Clemson University, Clemson, SC 29634

In 1993, Carolina Nurseries and the Dept. of Horticulture at Clemson Univ. entered into a partnership for a research and development program to solve short- and long-term production problems in the ornamental nursery industry. Carolina Nurseries, located near Charleston, S.C., is a 110-ha commercial container-grown landscape plant nursery that sells >12 million units yearly. Research is conducted on site in a specially designed area that provides nursery conditions and control of other variables, including water and pesticide applications. An on-site graduate student works cooperatively with faculty on campus and manages the research area, collects data, maintains the projects using standard nursery practices, interacts with Carolina Nurseries personnel, and initiates needed studies. Over the past 6 years, research diversity increased with cooperative efforts from faculty in the Depts. of Entomology, Pathology, and Agricultural Engineering. In addition, cooperative studies with faculty members with Univ. of Georgia, Michigan State Univ., and North Carolina State Univ. have been completed. Research results were presented to the nursery industry at research update meetings at the research area site. Approximately 200 attendees from commercial nurseries and horticulture-related companies in surrounding states attended the 1998 research update. Surveys collected at research updates are helpful in tailoring research to the specific needs of the nursery industry, and are the basis for some of the current research projects. Research results are also published in the *Southern Nursery Association Research Proceedings*, *Journal of Environmental Horticulture*, and *The South Carolina Nurseryman Newsletter*.

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Influence of Childhood Environmental Experiences on Adult Sensitivities to Urban Forests

*Virginia I. Lohr** and *Caroline H. Pearson-Mims*; Department of Horticulture and Landscape Architecture, Washington State University, Pullman, WA 99164-6414

Community involvement is critical for the continued vitality of the urban forest. To encourage this involvement, an understanding is needed of what promotes shared stewardship as well as of different cultural perspectives regarding trees. A survey of the general public in 109 large metropolitan areas across the continental U.S., a culturally and ethnically diverse group, was conducted. Two

thousand adults were surveyed to assess the extent of their childhood experiences with nature, their current attitudes toward urban forests, and their demographic backgrounds. Respondents were questioned particularly about their earliest experiences with nature and their current understanding and appreciation of the urban forest. Other researchers have examined the relationship between childhood contact with nature and attitudes toward nature among professionals in environmental fields, but this relationship has not been explored in the general public. Correlations between survey respondents' memories of childhood contact with nature, their current perceptions of the urban forest, and the influence of their cultural and ethnic backgrounds will be presented. For example, respondents who reported very easy access to nature as children were likely to agree strongly that trees should be planted in business districts to reduce smog. Results from this survey may be applied in programs to teach children about trees and gardening, thus better tailoring these programs to engender future appreciation for the urban forest. Raw data from this survey will be made available to other researchers.

151

The Effectiveness of Assessing a Vocational Horticulture School Curriculum for Juveniles on Probation

*Catherine McGuinn** and *Diane Relf*; Office of Consumer Horticulture, Virginia Tech., Blacksburg, VA 24060

A 17-week vocational horticulture curriculum was assessed for its effectiveness in changing attitudes about personal success and job preparation, presenting horticulture/landscaping as an appropriate career, developing an attitude of appreciation and fostering of the environment, and strengthen social bonds to reduce delinquent behavior. Pre-tests/post-tests based on Hirsch's tests of social bond for juvenile delinquents were developed and administered to address attitudes toward school, teachers, peers, views, and the environment. A separate pre-post test dealt with career and aspirations. Results of these tests were compared to tests administered at a comparable urban program. Behavioral records for one semester before and semester during the horticulture curriculum were compared. Daily journals maintained by service learning students volunteers were analyzed for observational themes and combined with teachers observations. Success of the program was related to students desire and ability to get summer internships and/or employment in horticultural settings. Due to the limited size of the study group (6) and the school policies limiting follow-up data collection at 6 or 9 months, the results of the study must be seen as trends suggesting future research direction and supporting the continued work being conducted at a Norfolk Botanic Gardens.

152

Festival of Color: An Extension Outreach Program

*Donald H. Steinegger**; Horticulture Department, University of Nebraska, Lincoln, NE 68583

The Festival of Color is the annual plant and landscape open house sponsored by the Univ. of Nebraska's Horticulture Dept. The festival is the culmination of many water-centered activities that have preceded the festival throughout the year. Last year's September event drew over 10,000 people to the UNL Agricultural Research and Development Center near Mead, Neb. The festival was created to increase the urban public's awareness and motivation regarding the best landscape management practices for developing environmentally compatible landscapes and reducing urban runoff of water and pesticides. The Festival of Color is an event for all ages. By including the activities for the entire family, the festival draws a large spectrum of the urban population. The festival has grown steadily from 850 visitors in 1993 to 10,000 in 1998. The festival will continue to include demonstrations and talks on selection, installation, and management of turf; irrigation equipment and management methods; pesticide selection and pest management alternatives; fertility management alternatives; low input landscaping with native and adapted species; composting; and more. At the Sixth Annual Festival of Color: 1) 42% of new attendees learned how to implement water conserving landscape techniques (66% of the previous attendees implemented water conserving landscape practices), 2) 30% of new attendees learned how to irrigate more efficiently (63% of previous attendees used water more efficiently), and 3) 29% of new attendees learned how to fertilize more efficiently (actual positive behavior change was higher than the proposed change reported by first time attendees), 4) 98% of new attendees learned how to choose plants based on site/location "Right Plant, Right Place" (86% of previous attendees have improved their plant selection skills by putting the right plant in the right place).

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The Organic Certification in Western Mexico

*Arturo Garcia**¹, *Xicolencatl Morentin*¹, and *J. Farias-Larios*²; ¹Universidad de Colima, Centro Universitario de Desarrollo Sustentable; ²Facultad de Ciencias Biológicas y Agropecuarias. Apartado postal 36. 28100 Tecoman, Colima, México

Organic production is a manner of food production whereby people relate to nature to produce healthy food in a sustainable way. Access to the organic food market requires a guarantee that the product complies with the standards and principles established by the moral and legal authorities of organic production. In Latin America, Mexico is the greatest exporter of organic products, mainly coffee. Sales are estimated at nearly 500 million dollars, and certified field surface is 15,000 ha. The objective of this work is to show the certification process of organic production carried at Colima state. The University of Colima Organic Production Certifying Committee (CUCEPRO) is an organic production certification agency, a nonprofit organization, operating since 1993. Furthermore, CUCEPRO promotes organic production, a viable alternative and offer important information on the basic principles of organic production, the procedures which producers need to go through to have their product certified organic. CUCEPRO took part in the determination of the Mexican Quality Control Norms NOM-037-FITO-1995. This agency is constituted by Univ. of Colima teachers and researchers with great expertise on the different areas and processes of organic production. Certification takes between one and 2.5 months depending on distance, kinds of analyses, and seal production and issuing. In the last years CUCEPRO has certified more 3000 hectares of products such as coffee, sesame seed, banana, and mango, as well as honey, compost, and biological pesticides. Certification demand steadily increased due to reliability and confidence on CUCEPRO and to increased acceptance of organic products on the other.

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Indiana CropMAP and New Crop Compendium: New Developments from Purdue's Center for New Crops and Plant Products

Anna Whipkey, *James E. Simon*, and *Jules Janick**; Center for New Crops and Plant Products, Dept. of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907-1165, USA

NewCROP (<http://www.hort.purdue.edu/newcrop>) is a crop resource online program that serves Indiana, the United States, and the world. This crop information system provides useful resources to encourage and assist new rural-based industries and to enhance agricultural sustainability and competitiveness. The NewCROP site currently averages 150,000 hits per month. Indiana CropMAP is the first module in a proposed nationwide, site-specific, retrievable system that will serve the crop information needs of individual growers, marketers, processors, government agencies, cooperative extension personnel, and industry. For each county in Indiana, users can access the most recent US agriculture statistics, county extension offices, lists of crops that are currently grown, recommended alternate crops, and experimental crops. Detailed crop information, much of it specific to Indiana, can be accessed directly or through a crop search. The New Crop Compendium CD-ROM was produced by the Purdue University Center for New Crops and Plant Products in cooperation with the United Nations Food and Agriculture Organization (FAO). The New Crop Compendium CD-ROM, a searchable resource of new crop information, was edited by Jules Janick and Anna Whipkey and contains the entire text and figures from the proceedings of the three National New Crop Symposia: J. Janick and J.E. Simon (eds.). 1990. *Advances in New Crops*. Timber Press, Portland, Ore.; J. Janick and J.E. Simon (eds.). 1993. *New Crops*. Wiley, New York; and J. Janick (ed.). 1996. *Progress in New Crops*. ASHS Press, Alexandria, Va. The New Crop Compendium provides a valuable source of information on new, specialty, neglected, and underutilized crops for scientists, growers, marketers, processors, and extension personnel. It employs an intuitive, easy to use interface. Purchase information can be found at the following url: <http://www.hort.purdue.edu/newcrop/compendium/order.html>.

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Farmer's Bookshelf: Evolution of an Information System for Crops in Hawaii

*Kent D. Kobayashi** and *H.C. Bittenbender*; Dept. of Horticulture, Univ. of Hawaii at Manoa, Honolulu, HI 96822-2279

In 1988, the Farmer's Bookshelf started out as a computerized information system of crops grown in Hawaii. The first version was created on an Apple Macintosh computer using a hypermedia program called HyperCard. Because

HyperCard came with each Macintosh computer, only the crop files needed to be sent to clientele. As the demand for an IBM-compatible version of the Farmer's Bookshelf increased, the Windows version was created using a hypermedia program called Plus. In addition to the crop files, the runtime version of Plus was also distributed to clientele. Later, other files were added to the Farmer's Bookshelf, including files to diagnose problems of macadamia in the field, select ground covers, select landscape trees, recommend fertilization, calculate nut loss for macadamia growers, and calculate turfgrass irrigation. Cost of analysis spreadsheets for several crops were also added. Recently, the Farmer's Bookshelf was moved to the World Wide Web, which has the advantages of reaching a worldwide clientele, easier updating and modifications, and linking to sites of related information. We have added links to newspaper articles on agriculture in Hawaii, to related sites on a particular crop, to on-line agricultural magazines and newsletters, to agricultural software, to upcoming agricultural events, and to Y2K sites. Because of the benefits of the Web version, the diskette versions (Macintosh and Windows) are no longer supported. Putting the Farmer's Bookshelf on the Web has allowed us to better meet the needs of our clientele for up-to-date information.

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Dissemination via the Internet of Information on Pawpaw (*Asimina triloba*): A New Potential Tree Fruit Crop

*Snake C. Jones** and *Kirk W. Pomper*, Atwood Research Facility, Kentucky State Univ., Frankfort, KY 40601-2355

Kentucky State Univ. (KYSU) emphasizes research on developing alternative, high-value crops and sustainable agriculture methods for use by limited-resource farmers. Since 1990, KYSU has maintained a research program to develop pawpaw into a new high-value tree fruit crop. With its high tolerance for many native pests and diseases, pawpaw shows great potential as a crop for organic and sustainable production. The objectives of KYSU's pawpaw research program include: 1) variety trials; 2) development of new or improved methods of propagation; 3) collection, evaluation, preservation, and dissemination of germplasm; and 4) sharing of information on pawpaw with scientists, commercial growers and marketers, and the general public. To aid in dissemination of information on pawpaw, a web site has been developed (<http://www.pawpaw.kysu.edu>) that includes information on current and past pawpaw research at KYSU and information on the PawPaw Foundation. On this site, there are a selected bibliography of publications on pawpaw and related species; pawpaw recipes and nutritional information; a guide to buying and growing pawpaws; photos of pawpaw trees, flowers and fruit; and links to other web sites with pawpaw information. In the future, the site will include results from the pawpaw regional variety trials and the database for the National Clonal Germplasm Repository for *Asimina* spp., located at KYSU. The pawpaw information web site will be an increasingly useful aid in the introduction of pawpaw as a new, potentially high-value, tree fruit crop.

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Estimation of Environmental Impact of Two Cropping Systems Using PLANETOR

A. Kalo¹, *S.B. Sterrett²*, *P.H. Hoepner¹*, and *J.F. Diem³*; ¹Dept. Ag. & App. Econ., ²Eastern Shore AREC, ³Virginia Coop. Ext.: Virginia Tech, Blacksburg, VA 24061

Long-term goals of reducing environmental impacts associated with agricultural activities must include economic sustainability as well as production feasibility. This study compared the potential economic and environmental impact of two specific cropping systems [wheat/soybeans (w/s) vs. selected vegetable crops with wheat/soybeans (veg/w/s)]. Profitability of w/s was lower than the veg/w/s system but demanded a smaller, less extensive resource base of labor and machinery with fewer conflicts in resource utilization rates. The PLANETOR computer program (Univ. of Minnesota) was used to analyze the potential negative environmental effects of growing a particular crop mix within these two systems. Although some of the vegetable crops exceeded the targeted soil loss tolerance value (T-value) of 3 t/ha, the weighted average of the veg/w/s system was below the target T-value for soil erosion. Analyses suggest that the profits from vegetables in the veg/w/s production more than offset the negative impacts on soil erosion and the veg/w/s system would be more economically feasible than w/s. Potential impact of pesticide leaching and runoff from vegetable production as calculated by PLANETOR was less than that from w/s. Specific cultural practices, including soil/tissue testing to manage nutrient applications, could reduce nitrogen/phosphorus movement. The veg/w/s system may offer the necessary profit margins to allow adoption of more environmentally friendly production alternative.

158

Oklahoma Department of Agriculture Inspector Training

*Mike Schnelle**, *Scott Palmer*, and *Jim Criswell*; Departments of Horticulture and Landscape Architecture and Entomology and Plant Pathology, Oklahoma State University, Stillwater, OK 74078

Oklahoma Dept. of Agriculture field inspectors are rarely horticulturists. Yet, they are often expected to provide inspections and suggestions to nursery, greenhouse, and garden center operators. Because of their lack of formal training in ornamental horticulture and related fields, Oklahoma State Univ. extension faculty set out to provide training in horticulture, entomology, and plant pathology-type issues. Results of statewide training workshops will be discussed, including, but not limited to, specific topics such as plant identification and culture, phytotoxicity in the greenhouse and nursery, and worker protection standards. Last, evaluation feedback regarding inspectors' interest for future training workshops will be addressed.

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Ornamental Treatment-production Wetlands for Water Quality Improvement

*Thomas C. Holt**, *Brian K. Maynard*, and *William A. Johnson*; Department of Plant Sciences, Univ. of Rhode Island, Kingston, RI 02881

Degraded water quality is a growing concern across the northeast and in many cases may be linked back to agricultural operations as nonpoint sources of nitrate and phosphorous pollution. Constructed wetlands have emerged as effective, low-cost methods of water treatment that have the potential to reduce agricultural nonpoint source pollution and contribute to agricultural sustainability. However, the costs of implementing treatment wetlands as a BMP are high, with little opportunity for cost recovery. We have initiated, at a wholesale plant nursery in Rhode Island, an economical solution to treating nursery runoff that incorporates into a treatment wetland the wholesale production of native and ornamental wetland plants. Our goal is to demonstrate how nursery growers may produce a high-demand crop while addressing nonpoint source pollution on their land. Over the next few years, we will evaluate the economic impact of converting nursery production space into treatment wetland production space. We also will research the feasibility of enclosing treatment wetlands in passively heated polyhouses to facilitate the year around treatment of agricultural runoff. Information gathered from both the on-farm demonstration and research sites will be extended to farmers and other agricultural businesses or professionals through outreach programming. The theory, objectives, and construction of the demonstration treatment-production wetland will be presented.

160

A Closed-capture Irrigation Effluent Apparatus for Large Nursery Containers

*Edward W. Bush**, *Ann L. Gray*, *Paul W. Wilson*, and *Allen D. Owings*; Louisiana State University Agricultural Center, Department of Horticulture, Baton Rouge LA 70803

A closed capture irrigation apparatus was designed and constructed for the purpose of monitoring irrigation effluent volume and nutrient analysis from 121-L redwood tree boxes. Measurements were taken monthly from Apr. 1997 to Oct. 1998. Tree boxes were filled with either a 3 pine bark : 1 sand : 1 peat or 3 pine bark : 1 soil media and planted with 'Little Gem' magnolia [*Magnolia grandiflora* (L.) 'Little Gem'] or Southern live oak (*Quercus virginiana* var. *virginiana* Mill.). In-line, pressure-compensated drip emitters provided irrigation water at the rate of 2 L/h. Daily irrigation volume ranged from 8 L in the fall and spring to 16 L during the summer months. The collection apparatus was constructed from 1-cm angle iron, neoprene rubber, a small drain assembly, and a 22-L plastic container. A square metal frame (43 x 43 cm) was supported by 31-cm legs and draped by a neoprene rubber mat with a drain assembly installed in the center. The drain was positioned into the plastic container creating a closed system to reduce effluent evaporation. The container capacity was adequate to store at least 24 h of collected effluent. This apparatus proved to be an efficient method of collecting irrigation effluent from large containers.

92 POSTER SESSION 11 (Abstr. 161–167) Undergraduate Education

Friday, 30 July, 1:00–2:00 p.m.

161

Using a Controlled Water Table Irrigation for Class Demonstrations of Plant Growth

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In class demonstrations, it is almost impossible to maintain the same water : air ratio in growing media. If some treatments result in greater plant growth than others, treatment effects on plant growth are often confounded with the effect of water : air ratio in the growing media. In a laboratory demonstration of nutrient deficiency symptoms in plants, a controlled water table irrigation system maintained a constant water : air ratio in the growing media regardless of the nutrient deficiency effect on plant growth. The modified capillary mat irrigation system consists of one mat edge extending over the edge of the bench into a narrow trough on the side of the bench. The nutrient solution level in the trough is controlled by a liquid level controller, so it is at a fixed distance below the bench surface. The nutrient solution is drawn upward by capillarity to the bench surface and then moves by capillarity over the bench. The system automatically maintains a constant air : water ratio in the growing media. A standard Hogland solution was modified to demonstrate deficiencies in N, P, K, Mg, Ca, Cu, Fe, and Zn on corn, squash, radish, soybeans, and marigold. Seeds were germinated and grown to maturity in either a 10- or 15-cm pot. Students set up the demonstration, were provided instruction in preparing solutions, regularly observed plant growth, and answered questions at the end of the study about differences in plant growth observed. However, possibly because low concentrations of some minor elements in the capillary mat, Zn deficiency was not observed and other elements, although resulting in poor growth compared to the control, did not show severe deficiency symptoms.

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Use of Bush Morning Glory and Ornamental Sweetpotato 'Blackie' as a System for Teaching Grafting Principles in Undergraduate Horticulture Courses

Douglas Maxwell* and R. Daniel Lineberger; Department of Horticultural Sciences, Texas A&M University, College Station, TX 77843

Bush morning glory (*Ipomoea carnea* ssp. *fistulosa*) and the ornamental sweetpotato cultivar Blackie (*Ipomoea batatas*) were used to demonstrate various grafting methods to students in an undergraduate horticulture class at Texas A&M Univ. Grafting the vining species onto the upright shrubby species produced an attractive ornamental plant and illustrated that graft union formation was independent of plant morphology. Graft "take" was high, ranging from 83% to 100%. Stock plants of both species are easily maintained in the greenhouse and can be rooted readily to "batch up" plants for laboratory sessions. Cuttings from both species can also be used in various rooting experiments, with cuttings of sweetpotato rooting in days rather than weeks, as with some species. The wide difference in morphology and coloration of these two plants also creates an easily distinguishable division between stock and scion.

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Fostering Active Learning through Cooperative Learning Techniques

U.K. Schuch* and G.R. Nonnecke; Dept. of Horticulture, Iowa State University, Ames, IA 50011

Iowa State Univ. is committed to improve student learning and supports faculty and staff through Project LEA/RN (Learning Enhancement Action/Resource Network) workshops and continuous training. Project LEA/RN teaches cooperative learning techniques that are known to improve student interest in the subject, allow active participation, improve understanding and retention of the material, and encourage learning inside and outside the classroom. Three learning techniques that have been used successfully in our lecture and laboratory classes ranging from 20 to 100 students per class are: turn to your partner (TTYP), note-

taking pairs (NTP), and jigsaw. In TTYP, the instructor asks a question and students formulate an answer individually, then share the answer with a partner, listen to the partner's answer, and finally create a new answer through discussion. NTP can be used after new material has been presented. A student compares notes with their partner, both add/correct their notes, share key points with a partner, and carefully listen to the partner's key points. In the jigsaw exercise, students who had the same assignment compare information they have prepared with each other and then with the entire class. In all exercises students are made accountable by the instructor who calls randomly on individuals to share their answers with the class. Examples of how to use these techniques and the interpersonal skills acquired and practiced during these exercises will be discussed.

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Mandatory and Elective Internships: Are They Different?

Dennis B. McConnell*, Jennifer C. Bradley, and Svoboda V. Pennisi; Department of Environmental Horticulture, University of Florida, Gainesville, FL 32611

In 1975, the Environmental Horticulture Dept. initiated a work experience program. Students who work full time for an environmental firm of institution may register for ORH 4941 Practical Work Experience. Although ORH 4941 was not required, 241 students participated in the program during the 22 years when it was an elective course. In 1998, the departmental education committee changed the status of ORH 4941 from an elective to a required course. The objectives of this study were to determine if any differences have occurred since the status of the course has changed. The following were examined: 1) selected student characteristics (GPA, gender, age, etc.), 2) employing firms participating in the work experience program, and 3) required administrative procedures.

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Learning Communities in Horticulture Enhance Student Learning

Gail R. Nonnecke*; Department of Horticulture, Iowa State University, Ames, IA 50011

A learning community was developed for first-year students majoring in horticulture at Iowa State Univ. in 1998. Learning communities are a curriculum design that schedules courses for both students and faculty to encourage community and connections among students, between students and faculty, and among faculty. Learning communities can offer students more opportunities for interactions among each other, academic assistance through supplemental instruction and/or group study sessions, and planned horticulture-related activities, all of which are important for success and retention of first-year students. First-year students in the horticulture learning community enrolled in the same courses and sections of five courses. The first-year English composition course was linked to the second-year principles of horticulture course that requires writing-across-the-curriculum activities. Faculty mentoring was provided through local field trips to horticultural sites of keen interest to the students. Academic environment survey results showed students rated their expectations highly for developing a network of other students as a resource group and for learning cooperatively in groups. Iowa State Univ. supports learning communities by providing faculty development and facilitating course registration, peer mentoring, supplemental instruction for challenging core courses, and academic and student services, to strengthen undergraduate teaching programs within and outside of the classroom.

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An Internet Course Tool for Teaching Landscape Horticulture Courses

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A World Wide Web course tool (WebCT) developed by the Univ. of British Columbia was used as an aid in teaching landscape plant identification and landscape construction at New Mexico State Univ. WebCT is a set of educational tools that are easily incorporated into the teaching of classes. Course assignments, slides of plant materials, and course grades were posted on the Web. A chat tool provided real-time communication among students and the electronic mail facility allowed personal communication with a student or communication to all course participants. Access to WebCT is controlled by username and password, so course material is restricted to course participants. Student progress through materials posted on the Web site can be monitored because WebCT maintains records about student access to web pages. Course statistics, such as the total number of hits per page, time spent on each Web page, and the date and time when student first accessed or last accessed the Web site, are kept by WebCT.

Students were able to review highly visual material such as slides of landscape plants at their own pace. Also, students had quick access to their grades.

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Promoting the Value of Community Service by Involving Students in Landscape Improvement Projects

Martin R. McGann, Dan T. Stearns, and Larry J. Kuhns^{*}; Department of Horticulture, Pennsylvania State University, University Park, PA 16802

In discussions among industry representatives, faculty, and graduates of the department of horticulture at Penn State community service was identified as an important attribute of successful landscape contracting companies. To foster a sense of community service responsibility among students, service projects were integrated into three horticulture courses. Fifty-four students in a planting design course worked with township officials to develop a planting plan for a new park located 10 miles from campus. Students planted 120 trees, which were obtained from a nursery operated by the Pennsylvania Dept. of Corrections. Eighty-eight students in two classes, landscape planning and issues in landscape contracting, volunteered to work on a farm being developed as an environmental education center. Work included mechanical and chemical control of invasive species and planting of natives. In discussions following these projects, students expressed personal satisfaction and a willingness to participate in future community service projects.

147 POSTER SESSION 20 (Abstr. 168–183) Sustainable Agriculture

Saturday, 31 July, 1:00–2:00 p.m.

168

Agronomic Performance and Ear Nutrients of Two Sweet Corn Cultivars Grown by Conservation Tillage

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In Spring 1998, two sweet corn (*Zea mays* var. *rugosa*) cultivars were grown under three tillage systems, conventional cultivation, ridge tillage (RT), and no tillage (NT), which had been in continuous management since Fall 1994. Nitrogen (as NH_4NO_3), the only fertilizer used, was applied twice at 60 kg/ha. Sweet corn yields were not influenced by tillage system, but average ear weights tended to be smaller under NT ($P < 0.17$). Ear quality attributes, which included ear weight, length, diameter, dry matter, and incidence of earworm damage, were greater in the later-maturing 'G-90' cultivar than in 'Sensor'; but tillage system had no influence on these attributes. Cultivars supported different weed species underneath their canopies. 'Sensor' allowed more light penetration and sustained higher weed biomass than did the taller 'G-90' plants. Weed biomass was higher under RT and NT. Seasonal soil moisture was lowest in the RT plots, but only in the 0- to 15-cm profile. Soil temperatures (unreplicated) at the 15-cm depth were similar between cultivars and tillage treatments over the growing season. The earlier-maturing 'Sensor' generally accumulated more ear mineral nutrients (P, S, NO_3 , Ca, Na, Zn, Mn, Al, and B; dry weight basis), but had lower dry matter (percentage) than did 'G-90'. Cumulative nutrient levels tended to be lowest in NT-grown ears ($P < 0.08$). Soil sampled at 0- to 5-, 10- to 15-, and 25- to 30-cm depths generally had higher concentrations of nutrients toward the surface, and NT soils had the steepest nutrient gradients, with the exception of Na and NO_3 . Total soil salts were reduced by RT and NT, but C : N ratio remained unchanged between tillage systems.

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Progress in the Development of a Sustainable Production System for Fresh-market Tomatoes

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In the production of fresh-market vegetables, off-farm inputs, such as plastic, nitrogen fertilizer, fungicides, insecticides, and herbicides are routinely used. One aim of the sustainable agriculture program at the Beltsville Agricultural Research Center is to develop systems that reduce these inputs. We have completed

the second year of a study designed to examine foliar disease progress, foliar disease management, and marketable fruit yield in staked fresh-market tomatoes grown in low- and high-input production systems. Specifically, four culture practices (black plastic mulch, hairy vetch mulch, dairy manure compost, and bare ground) were compared in conjunction with three foliar disease management treatments (no fungicide, weekly fungicide, and a foliar disease forecasting model, TOMCAST). Within all culture practices, use of the TOMCAST model reduced fungicide input nearly 50%, compared with the weekly fungicide treatment, without compromising productivity or disease management. With regard to disease level, a significant reduction of early blight disease severity within the hairy vetch mulch was observed in 1997 in relation to the other culture practices. Early blight disease severity within the black plastic and hairy vetch mulches was significantly less than that observed in the bare ground and compost treatments in 1998. In addition, despite a 50% reduction in synthetic nitrogen input, the hairy vetch mulch generated yields of marketable fruit comparable to or greater than the other culture practices. It appears that low-input, sustainable, production systems can be developed that reduce the dependence on off-farm inputs of plastic, nitrogen fertilizer, and pesticides, yet generate competitive yields.

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Tomato Flowering and Fruiting under Reduced Tillage

Bharat P. Singh^{*} and Wayne F. Whitehead; Agricultural Research Station, Fort Valley State University, Fort Valley, GA 31030-4313

Reduced tillage saves energy and safeguards soil against erosion. While it is widely used for these reasons in producing agronomic crops, it has yet to find acceptance in vegetable cultivation. The main obstacle is the lack of knowledge of the growth and developmental responses of intensively managed vegetable crops to reduced tillage operations. Therefore, this study was performed to determine the effect of different tillage levels on vegetative growth and flowering and fruiting of tomatoes. The following tillage treatments were applied in a randomized complete-block design to a field that was cover cropped with vetch during winter: T₂ produced maximum vegetative dry weight/plant: 1) fall mold-board + spring no-till (T₁), 2) fall mold-board + spring chisel (T₂), and 3) fall chisel + spring chisel (T₃). The number of flowers/plant were highest in T₁, followed by T₂ and T₃, respectively. There was a 14 : 1 ratio between the number of flowers and fruit set. The number of fruit in T₁ and T₂ were similar, and significantly greater than in T₃. The fruit weight of T₁ was similar to T₂ but significantly greater than T₃.

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Improving Tomato Production with Summer Cover Crops in South Florida

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Cover crops have become an integral part of vegetable production practices in south Florida for weed control and retaining nutrients during the heavy summer rains. A wide variety of plants are used as cover crops in south Florida. Obviously, legumes contribute more nitrogen by fixing N compared to nonlegumes such as sorghum sudan grass, which is a common cover crop in this area. We have evaluated 10 cover crops, where six were legumes in 1997. In 1998, four cover crops (sunn hemp, sorghum sudan, sesbania, and aeschynomene) were evaluated. The sunn hemp (*Crotalaria juncea* L.) stands out from other tested cover crops for 2 years. Sunn hemp produced 8960 to 11,400 kg dry weight/ha and fixed up to 285 kg N/ha. The evaluation of effects of sunn hemp and other cover crops on the following tomato growth and yield are still in progress and will be discussed.

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Changes in Quality and Maturity of Early Season Nectarines (cvs. Aurelio and Early May) during Maturation and Ripening

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The objectives of this study were to characterize the quality and maturity changes of nectarine (*Prunus persica* var. Nectarina) fruit cvs. Aurelio and Early May during maturation and ripening and to identify harvest maturity indices. After fruit set, 250 fruit of similar diameter and tree position were tagged to follow maturation and ripening on the tree. During commercial harvest, 48 fruit were randomly harvested every 2 to 3 days. Ethylene evolution rate (EER) at 20 °C, fresh weight, and peel ground and cover color (L*, a*, b*, C* and Hue value) were measured on all 48 fruit. Flesh color, firmness at several fruit points, soluble

solids (SS), pH, titratable acidity (TA) and SS : TA ratio were measured only to 24 fruit, and the rest were held for up to 7 days at 20 °C as a ripening period to measure the same parameters mentioned above. Pearson correlation coefficients were determined between variables to explore possible harvest maturity indices. The most significant changes occurred in EER, fruit firmness, and peel ground color (a^* and hue value). For 'Aurelio' nectarines the highest correlations ($P < 0.001$) were obtained between logEER-tip firmness ($r = -0.69$), tip firmness- a^* ground color ($r = -0.66$) and, tip firmness-hue ground color ($r = -0.67$). No important correlations ($r > 0.60$) were found for 'Early May' nectarines. It was also found that fruit softening varies according to the point of measurement in the fruit depending on the cultivar.

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Effects of Cover Crops and Tillage on Sweet Corn Production

Gary R. Cline* and Anthony F. Silvernail; Community Research Service, Kentucky State University, Frankfort, KY 40601

A split-plot factorial experiment examined effects of tillage and winter cover crops on 'Merit' sweet corn in 1994, 1995, and 1996. Main plots received tillage or no-tillage. Cover crops consisted of hairy vetch, winter rye, or a mix, and N treatments consisted of plus or minus inorganic N fertilization. The shoot N contents of vetch and mix cover crops ranged from 100 to 150 kg/ha, whereas N contents of rye were usually <50 kg/ha. In 1994 and 1995, vetch shoot N contents were 150 kg/ha, and corn yields following vetch were not significantly affected by addition of inorganic N fertilizer. In 1996, vetch N contents only equaled 120 kg/ha, and corn yields were significantly increased by addition of inorganic N. Supplemental N was also required to obtain maximum yields following mix and rye cover crops in all years, even though the N contents of vetch and mix cover crops were normally similar. Measurements of corn foliar N and available soil N were in agreement with the yield results. No-tillage did not significantly affect corn yields following vetch. However, no-till corn yields were reduced with rye (1995) and the mix (1995 and 1996) as a result of reduced corn plant population densities. Reliable tillage results were not obtained for 1994. It was concluded that a vetch cover crop could adequately supply N to sweet corn if vetch N content was at least 150 kg/ha. Sweet corn following rye or vetch/rye mix cover crops required additional N for optimal yields. Significant N in the mix cover crop was probably immobilized as the rye component decomposed. No-till sweet corn was grown successfully following vetch, but yields were often reduced with the mix or rye cover crops.

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Effect of Planting Method, Mulch, and Rowcover Combinations on Earliness, Yield, and Fruit Size of 'Arriba' Watermelon

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Colorado-grown watermelons command a premium price on the market based on their sweetness and overall flavor. Unfortunately, melon production is limited to mid-August through early September. This study was conducted to determine whether intensive production methods could enhance the traditional marketing period. The effects of different combinations of establishment methods, mulches, and rowcovers on 'Arriba' (Hollar Seeds) watermelon growth and productivity were investigated in a field trial at the Arkansas Valley Research Center in Rocky Ford, Colo. In 1997, the combinations of transplanting, clear plastic mulch, and perforated or slitted rowcovers produced the earliest harvest and highest yield and fruit weight. The first harvest of the earliest treatments occurred on 4 July. Direct-seeding through clear plastic mulch, both with and without rowcovers, also enhanced earliness relative to the traditional marketing period. However, compared to transplanting, yield and fruit weight were less if the crop was direct-seeded. Intensive plasticulture techniques could substantially increase the earliness of Colorado-grown watermelons. The increased cost of production would be easily off-set by higher productivity and early season prices

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Synthetic Mulches Increase Strawberry Yields Compared with Organic Mulches

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Affluent "peri-urban" populations in some areas have created new markets for small specialized growers. Although intensive growing systems using drip

irrigation and fertigation with new varieties can increase yields, there is also a desire to use systems that are viewed as more sustainable. One way to reduce the environmental impact of intensive systems is to use organic mulches that do not require disposal and can improve soil conditions. 'Chandler' strawberry (*Fragaria xananassa* Duch.) transplants were set in raised beds on 28 Oct. 1997. All plots received pre-plant P at 73 kg/ha. Treatments were: hay mulch (HY); a commercial, pelleted, recycled paper mulch (PA); polyethylene mulch (PL); or a woven weed-blocking (WB) fabric, with or without dairy manure compost (22% moisture) at 22 t/ha tilled in before bedding. A total of 184 kg/ha N was applied through the irrigation system in weekly applications during the growing season. The first bloom set was killed by cold on 9 Mar. 1998. Yields from the two synthetic mulch systems (PL = 5502 and WB = 4996 kg/ha) were significantly higher than those from the organic mulches (HY = 2824 and PA = 1735 kg/ha). Mean fruit weight was also higher with synthetic (PL = 10.6 and WB = 10.4g) than organic (HY = 9.5 and PA = 9.0 g) mulches. Factors such as increased weed growth in organic mulches and warmer temperatures in synthetic mulches contributed to increased yields from synthetically mulched plots.

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Effect of Plastic Rowcover on Watermelon Crop

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Citrullus vulgaris cv Rocio hybrid F₁ was seeded 18 Jan. 1994 and transplanted 1 month later in loam-sandy soil at the experiment station of the Complexe Horticole, 16 km south of Agadir. Watermelon plants grown under perforated plastic rowcover with 800 holes per square meter were compared to the open-field plants. The experiment design used was a randomized block design with two treatments (rowcover and open field) and four repetitions. Rowcover was put at planting and removed 90 days later. Under the rowcover the minimal and maximal temperatures were higher than the ones of the open field by 0.9 to 2.4 and 3 to 6.8 °C, respectively. Soil temperatures at 10-cm depth measured at 7:00 am and 4:00 pm were higher under cover by 1.2 and 2.7 °C, respectively. Early yield of watermelon obtained under perforated plastic rowcover and in open field were 6.55 kg/plant (78.6 t/ha) and 2.45 kg/plant (29.4 t/ha), respectively.

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A Voluntary Retrofit Program for Open Mix-load Wells in Dade County, Florida

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Southeastern Florida is underlain by the Biscayne Aquifer, an officially designated "drinking water quality aquifer." This is the sole source of water for the more than 3.5 million residents of metropolitan Miami-Fort Lauderdale. Due to the unique nature of the soils in southern Dade County, Fla., most agricultural wells for both irrigation and mix-load activities have been exempt from casing and capping requirements. Wells associated with U-Pic stands need to be capped if children are allowed in fields. The county's Dept. of Environmental Resources Management (DERM) began a study of mix-load wells in the late 1980s. They concluded that surface materials, including agrichemicals, could drain directly into the aquifer. This was particularly true in vegetable fields because most are on leased land. In the mid 1990s, a program to develop voluntary guidelines to retrofit these mix-load wells was begun. Several growers met with DERM, the Florida Department of Environmental Protection and Extension, to finalize three basic designs. Extension hosted meetings and reviewed the brochure describing the retrofit program. In 1996, one area came under close scrutiny by the U.S. EPA for potential point-source pollution. These growers were made aware of the program and have retrofitted at least 95% of the wells in the most environmentally sensitive area.

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Differences in Grape Phylloxera-related Grapevine Root Damage in Organically and Conventionally Managed Vineyards in California

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Secondary infection of roots by fungal pathogens is a primary cause of vine damage in phylloxera-infested grapevines. In summer and fall surveys in 1997 and 1998, grapevine root samples were taken from organically managed vine-

yards (OMVs) and from conventionally managed vineyards (CMVs), all of which were phylloxera-infested. In both years, root samples from OMVs showed significantly less fungal pathogen-caused root necrosis than samples from CMVs, averaging 9% in OMVs and 31% in CMVs. There was no significant difference in phylloxera populations per 100 g of root between OMVs and CMVs, although there was a trend toward higher populations in CMVs. Soil characteristics, percent organic matter, total nitrogen, nitrate, and percent sand/silt/clay were not significantly different between the two regimes. Cultures of necrotic root tissue showed significantly higher levels of the beneficial fungus *Trichoderma* in OMVs in 1997 but not in 1998, and there were significantly higher levels of the pathogens *Fusarium oxysporum* and *Cylindrocarpus* spp. in CMVs in 1998 but not in 1997. Implications for further research and viticulture are discussed.

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Control of Clubroot on Chinese Mustard and Cauliflower using Meadowfoam (*Limnanthes alba*) Seedmeal or Screenings

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Seedmeal (MSM) and screenings (MS) of meadowfoam (*Limnanthes alba* H.) were evaluated for their influence on the development of clubroot caused by *Plasmodiophora brassicae* in potted seedlings. Treatments included MSM at 0%, 5%, 10%, and 20% (by vol.); MSM at 10% (by vol.) plus an 8 oz. application of 3% H₂O₂ per pot; and MS at 10% (by vol.) pre-sowing incorporation into potting media (Sunshine Mix #1) with a 10% (by vol.) clay-loam soil known to be infested with *P. brassicae* resting spores. One-hundred percent Sunshine mix #1 was used as a control medium. Following media preparation, seeds of Chinese mustard (*Brassica chinensis*) and cauliflower (*Brassica oleracea* var. *botrytis* 'Snowball Y Improved') were sown every 7 days for 4 weeks. Symptoms of *P. brassicae* infection (clubbing or rotting of roots) occurred in 70% to 90% of all plants grown in pots with media containing infested soil and no MSM or MS, with disease severity ranging from <25% to >50% of root systems clubbed or rotted. Chinese mustard seedlings had more clubbing compared to cauliflower seedlings. All plants grown in media containing MSM or MS showed no clubbing or rotting. Plants grown in 20% MSM or 10% MSM plus a 3% H₂O₂ had symptoms of phytotoxicity. Plants grown in 10% MSM or 10% MS were taller compared to controls. Although plants grown in MSM and MS showed no clubroot symptoms, asymptomatic presence of pathogen has not been excluded.

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Cover Crops Improve Soil Quality in Strawberry Production

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Improving soil quality and suppressing weeds are two challenges facing strawberry growers. Cover crops, such as perennial ryegrass (*Lolium perenne*) and sorghum-sudangrass (*Sorghum sudanense*), have been used in rotation with strawberry in the Midwest. The objective of the field study was to investigate the effects of various cover crops on soil quality and weed populations for strawberry production. The experiment was established in 1996 at the Iowa State Univ. Horticulture Station, Ames, in plots that previously were planted continuously in strawberry for 10 years. Nine treatments were arranged in a randomized complete-block design with three replications. Treatments included cover crops of Indian grass (*Sorghastrum avenaceum*), switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), black-eyed susan (*Rudbeckia hirta*), marigold (*Tagetes erecta* 'Crackerjack'), sorghum-sudangrass, perennial ryegrass, strawberry (*Fragaria xananassa* 'Honeoye'), and bare soil (control). Data from 1998 showed that both annual and perennial cover crops were established more readily (higher treatment-plant populations and less weed populations) than in 1997. Water infiltration rates were highest in bare soil plots and lowest in *P. virgatum* plots. Bare soil plots and *S. sudanense* plots had the lowest percent soil moisture.

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Strawberry Growth and Weed Control in Response to Using Corn Gluten Hydrolysate

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Alternative approaches to strawberry production that rely on cultural practices, biological controls, or natural products to reduce or replace off-farm chemical

inputs are needed. Driving this growing interest are environmental concerns and rising production costs. Corn gluten meal (CGM), a byproduct of corn wet-milling, has weed-control properties and is a N source. The weed control properties of CGM have been identified in previous studies. The hydrolysate is a water-soluble, concentrated extract of CGM that contains between 10% to 14% N. Our objective was to investigate corn gluten hydrolysate as a weed control product and N source in 'Jewel' strawberry production. The field experiment was a randomized complete block with a factorial arrangement of treatments and four replications. Treatments included application of granular CGM, CGM hydrolysate, urea, urea, and DCPA (Dacthal), and a control (no application). Granular CGM and urea were incorporated into the soil at a depth of 2.5 cm at rates of 0, 29, 59, and 88 g N/plot. Plot size was 1 x 3 m. The field experiment was conducted from 1995–1998. The source of nitrogen showed few effects for all variables measuring yield and weed control for all years. In general, the rate of nitrogen had little or no effect on total yield. However, the rate of nitrogen at 88 g N/plot showed an increase in average berry weight, leaf area, leaf dry weight, and weed control.

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Growth of First-year Grapevines in Desiccated Rye Residues With and Without Follow-up Weed Control

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In a previous study to determine the feasibility of using herbicide desiccated cover crops for weed suppression during vineyard establishment, we found that weed suppression is excellent for about 6 to 8 weeks after desiccation in fall-planted rye. By the end of the season, however, weed growth in rye plots was similar to weedy control plots. Vine growth was reduced in rye plots compared to weed-free bare ground plots. Because of the experimental design, no follow-up weed control was performed in the rye plots and weeds eventually became well-established. So, it was impossible to determine if reduced vine growth was due to weed competition or allelopathy from the rye residues. A second study was conducted to determine the effects of follow-up weed control (with glyphosate) in fall-planted rye plots and weedfree bare ground plots. Results indicate that vine shoot number, shoot length, leaf area, and top growth dry weight was greatest in weedfree bare ground, less, but not significantly so in rye with follow-up weed control, and significantly less in rye without follow-up weed control. Root dry weight was reduced in rye with and without follow-up weed control compared to weedfree bare ground. Root dry weight was reduced 37% in rye with follow-up weed control and 63% in rye without follow-up weed control compared to weedfree bare ground. These results suggest that weed competition is not the primary cause of vine growth reduction in herbicide desiccated rye cover crops, so there is likely allelopathic effects of the rye residues on grapevines, which would limit using rye as a desiccated cover crop during vineyard establishment. However, there may be some value in using rye in established vineyards to reduce vigor.

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Influence of Cover Crops on Weed Control and Plant Growth in Strawberry (*Fragaria x ananassa* Duch.)

Braja B. Datta* and Ray D. William: Department of Horticulture, Oregon State University, Corvallis, OR 97331

Fall-planted cover crops killed in spring is practiced in strawberry cultivation in different regions of the North America. These systems have shown significant weed suppression and conservation of soil without significant yield reduction in strawberry. During the establishment season, this study was initiated to assess weed suppression with cover crops ('Wheeler' rye and 'Micah' and 'Steptoe' barley) along with perlite, an artificial plant medium. Strawberry ('Selva' and 'Totem') plant growth and weed biomass were measured during 1995–96 season. Small-seeded summer annual weeds were suppressed in cover crop treatments compared to control treatment. 'Micah' barley in growth phase suppressed more than 81% of the total weed biomass compared to control plots with no cover crop in early spring. However, in early summer, cover crop residues failed to suppress different types of weeds 60 days after killing of cereal with herbicide (2% glyphosate). Distinct differences in strawberry plant growth were evident between the cover crop treatments and non-cover crop treatments including 'Micah' applied on surface. Strawberry growth was doubled during 10 July to 15 Aug. in both cultivars. 'Micah' barley applied on surface produced better growth in both strawberry varieties than the growth in other treatments. 'Micah' barley applied on soil surface produced 50% more strawberry shoot biomass may indicate the root competition between cover crops and strawberry.

47 POSTER SESSION 6 (Abstr. 184–106) Crop Production

Thursday, 29 July, 1:00–2:00 p.m.

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The Influence of Trellising System and Cane Density on 'Titan' Red Raspberries

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The effect of three trellising systems (Hedgerow, V-Trellis, and Single-Sided Shift-trellis) and four cane densities were studied on *Rubus ideaus* L. cv. Titan red raspberries. Yield, cane growth, canopy microclimate, disease load, canopy light penetration, and fruit quality were examined. The treatments significantly affected yield and yield components. The V-trellis had a higher yield (+19%) and a larger fruiting framework than the hedgerow, while the shift-trellis had a lower yield than the hedgerow (–36%) and the V-trellis (–50%) due to a small fruiting framework. Path analysis indicated that interrelationships among yield components were significantly affected by trellising system. The shift-trellis was found to have lower quality berries than the other systems. These differences were related to light penetration into the different canopies. An optimum cane density was not found for any system. Yield potential per cane decreased as cane density increased; however yield per square meter increased as cane number increased. Berry quality decreased as cane density increased. Differing cane density did not affect canopy microclimate or disease load.

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Managing Primocane Growth for Rotatable Cross-arm Trellis

Fumiomi Takeda* and Ann K. Hummel; USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430

A new trellis system called the "rotatable cross-arm" (RCA) trellis was developed to ease mechanical fruit harvesting of eastern thornless blackberries. The rotation of the cross-arm following bloom 1) positions all the fruit to one side of the trellis in a plane underneath the cross-arm and 2) permits primocanes to be trained to side without the fruit. To maintain productivity, the number of lateral shoots that arise from primocanes must be maximized. In this study, we examined the growth and development of individual primocanes within plants and the number of lateral canes that developed on them to decide which canes should be retained during the growing season. In 'Chester Thornless' blackberry, primocanes trained early in the season produced more laterals per cane, had higher percentage of buds forming laterals, and were much larger in diameter than primocanes trained later in the season. Field observations suggested high sink strength and less light competition probably contributed to the increased productivity of early canes. These results indicated that the canes that become trainable early in the season must be retained for the success of the RCA trellis. Conversely, the primocanes that become trainable later in the season do not develop sufficiently and should be removed.

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Effect of Primocane Topping Height and Lateral Length on Yield of 'Navaho' Blackberry

David G. Himelrick*, Robert C. Ebel, and Floyd M. Woods; Department of Horticulture, Auburn University, Auburn, AL 36849

'Navaho' erect thornless blackberry plants were subjected to a combination of three primocane summer topping heights and two winter lateral length pruning treatments. Plants were topped at 91, 122, 152 cm tall, and laterals were shortened to either 30 or 61 cm in length. Treatment effects on yield and plant structure were examined for four growing seasons. Lateral length had little effect on yield and any pruning height. Yield generally increased with increasing plant height. The 122-cm height appeared to optimize yield while still allowing for manageable florican architecture.

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Effect of Nutrient Source on Quality and Yield of Strawberry Grown in *Verticillium*-infested Soil

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Verticillium albo-atrum, a cosmopolitan pathogen that causes wilt of strawberry, can cause economic losses for growers and increased prices for consumers. This study was conducted in 1998 to assess the impact of organically and inorganically supplied N on fruit yield and quality. 'Allstar' (resistant) and 'Raritan' (susceptible) varieties of strawberry were planted in *V. albo-atrum*-infested soil that was amended with poultry compost (organic N) or ammonium nitrate (inorganic N). Fruit quality was assessed as titratable acidity (TA), soluble solids content (SSC) using a refractometer, and reducing sugars concentration using a gas chromatography. Disease incidence was below threshold level and did not affect the results of this study. Plants grown in compost amended plots produced an average of 41 fruit, weighing 354 g, compared to the 34.5 fruit weighing 487 g that were harvested from the inorganically amended plots. TA was not affected by the treatments. Overall, yield of 'Raritan' was 40% greater than that of 'Allstar'. The SSC of 'Allstar' was highest in fruit that were produced in compost-amended soil in contrast to that of 'Raritan', which was greatest for plants that were grown in the inorganically amended plots. Fruit grown in the inorganically amended plots generally had a higher concentration of glucose and fructose, but sucrose was found only in fruit from the control plots. Poultry compost may be an alternative source of N for producing strawberries but this needs to be further evaluated because of the slower release of nutrients over time.

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Influence of Planting Date on Strawberry Growth and Development in the Low Desert

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A field study was designed to determine the effect of planting date and cultivar on growth and yield of strawberries in the low desert. The study was conducted at the Univ. of Arizona, Citrus Agricultural Center, near Waddell. Treatments included two strawberry cultivars (Camarosa and Chandler) and three planting dates 20 Aug. and 8 and 22 Oct. 1997. There was no significant difference in fruit yield between cultivars. However, fruit number was significantly greater for 'Chandler', and, therefore, fruit size was smaller than 'Camarosa.' Yield was significantly higher for strawberries planted 20 Aug., with nearly four times the yield compared to the other planting dates. Results of this study suggest summer planting of strawberries in the low desert to produce economically viable yields.

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Vegetation Management of Lowbush Blueberries

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The influence of noninvasive, companion crops on lowbush blueberry production was examined at the Nova Scotia Wild Blueberry Inst. in 1998. A randomized complete-block experimental design was used with four replications and a plot size of 10 x 6 m. Treatments consisted of a control (no companion crop), sawdust, creeping red fescue, hard fescue, chewings fescue, sheeps fescue, birdsfoot trefoil (BFT), and redtop. Measurements of companion crop height, dry weight, and density, and lowbush blueberry vegetative and reproductive data were recorded. In addition, the effects of the companion crops on soil stability and weed pressures were measured at the conclusion of the growing season. Overall, the fescues and BFT established well within the blueberry canopy and in bare areas with plant densities ranging from 960 plants/m² to 3500 plants/m², plant dry weights of 7.2 to 11.7 mg/plant, and plant heights of 5.4 to 9.5 cm. The use of the companion crops increased yields with yields from the creeping red and hard fescue treatments being 9.0% and 13% greater, respectively, than the control. The creeping red and hard fescue treatments also significantly reduced weed pressures and increased soil stability. Therefore, using companion crops in lowbush blueberry production appears to be a viable management strategy with future research being required on herbicide use, fertility regimes, and harvestability.

Growing Highbush Blueberry in Coal Ash–Compost Mixtures

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Highbush blueberry is adapted to well-drained sandy soils containing some organic matter, but these are often unavailable in many areas where blueberry production is desired. I tested the concept of using freely available by-products to produce an artificial medium for growing blueberries. In June 1997, 1-year-old tissue-cultured plants of 'Bluecrop' and 'Sierra' blueberry were planted into 15-L plastic pots filled with soil or soilless medium in a total of 10 treatments. Soils used were Berryland sand (alone) and Manor clay loam (alone or amended with 25% or 50% compost mix 1); soilless media were composed of coal ash amended with 25% municipal biosolid compost (B), 25% leaf compost (L), 25% or 50% compost mix 1 (1 B : 1 L), or 25% or 50% compost mix 2 (1 compost mix 1 : 1 acid peatmoss). pH of all mixes containing compost was adjusted to ≈ 4.5 with sulfur. After the first year, plants of both cultivars in Berryland sand had significantly more shoot growth than in any other treatment except for Manor clay loam. The least growth was produced by plants growing in Manor clay loam amended with compost mix 1 and in coal ash amended with unblended compost (B or L). After the second year, plants in the best treatments were 90 to 100 cm tall. More shoot growth was produced by plants in Berryland sand and in coal ash amended with 25% or 50% of compost mix 1, followed by plants in coal ash amended with 50% compost mix 2 or 25% compost B; plants in Manor clay loam, whether or not amended with compost, had the least growth. In 1998, 95% of the plants flowered and most set fruit, but differences among treatments were not significant. 'Sierra' plants produced more growth than those of 'Bluecrop' in all treatments.

Structure and Development of Cultivated Grapevines in the Northeastern United States

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Northeastern U.S. grape growers have become more knowledgeable about many aspects of grape production, including pruning and training, canopy management, nutritional recommendations, pest and disease management strategies, vineyard floor management, etc. Important to all these aspects is a firm understanding of vine structure and development. Yet, there is no current publication on vine growth and development that growers and researchers can consult to gain an understanding of the organs, tissues, and developmental processes that contribute to growth and production of quality vines in the northeastern U.S. climate. A concerted effort is underway to secure enough information on how vines are constructed, grow, and develop in the northeast so that a publication useful to a wide audience can be produced. Our objective is to consolidate information already on hand that can help explain the internal and external structures of grapevines that are pertinent to the needs of northeast growers, to add information that is lacking by collecting and examining vine parts, and to work toward integrating vine structure with vine physiology and viticultural practices. Over the past decade, organs of various native American, French hybrid, and vinifera varieties have been collected from vineyards at Cornell's experiment stations and from growers' vineyards in the Finger Lakes and Lake Erie regions. Much quantitative data on vine development have been collected and interpreted. Lab work has included dissections of organs, histological and microscopic examination, microphotography, and the production of interpretive diagrams and charts. A list of the subject matter and examples of visual materials will be presented.

Controlling Early Growth of Marigold and Tomato Plugs

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Some transplanted crops, like tomato and marigolds, tend to stretch very early after germination, especially if grown in low light environments. By the time growers apply growth regulators (PGRs), the stretching of the hypocotyl has already occurred and sprays are ineffective. Seeds of marigold 'Bonanza Gold' and tomato 'Sun 6108' were soaked for 6, 16, and 24 h in paclobutrazol solutions of 0, 500, and 1000 ppm. After imbibition, seeds were dried for 24 h before sowing in plugs. Sixteen, 26, and 36 days after sowing, seedling height and percent emergence were measured. Increasing concentrations of PGR and time of imbibition pro-

duced shorter seedlings. Tomato seedling heights measured 36 days after sowing were 1.9, 1.5, and 1.7 cm when imbibed in water for 6, 16, and 24 h, respectively. When PGR was used at 500 ppm, seedling heights were: 1.4, 1.2, and 1.2 cm, respectively. Similar reductions were observed for marigolds. It was hypothesized that some seeds have coats that are impermeable to PGRs. These impermeable coats might serve as PGR carriers, delivering the chemical into the growing medium of the plug cell. When the root emerges from the seed, it absorbs the growth regulator. These preliminary results indicate that this method of PGR application may be feasible and could benefit plug growers of marigold and other ornamental plant species prone to early stretching (e.g., cosmos).

The Effect of Bedding Plant Plug Source on Postplug Production

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Plug production has increased the finished quality and uniformity of bedding plants, making them one of the most important greenhouse crops grown. The wide range of cultural practices used by different growers to produce plugs, may influence the efficacy of plant growth regulators applied to the same crop in post-plug production. Ten bedding plant species were grown from plugs obtained from two sources using different cultural practices. The plugs were transplanted to jumbo six packs and sprayed with either chlormequat/daminozide tank mix, ancymidol, or paclobutrazol at three concentrations at three times of year. The effect of each plant growth regulator varied by plant species and time of year applied. Source of plug material did have a significant effect on height and time of flowering of finished bedding plants and the use of plant growth regulators did not minimize the differences in height between sources in most cases.

Effects of Chemical Growth Retardants on Rooting and Stem Elongation in Propagation of *Stachytarpheta* spp.

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Plants, which move directly from the wild into commercial propagation, without the benefit of extensive breeding and selection, often pose production-oriented problems for growers. Vigorous plant growth, especially during the propagation phase of production is a common problem. The purpose of this work was to determine the degree of efficacy offered by chemical control of stem elongation in propagation of Porter Weed [*Stachytarpheta mutabilis*, *S. mutabilis* var. *violacea*, and *S. urticifolia*]. Tip cuttings of three *Stachytarpheta* species were given a 10-s dip in the following treatment solutions: daminozide (2500 and 5000 mg \cdot L⁻¹), daminozide and chlormequat chloride tank mix (2000 mg \cdot L⁻¹ ea.), paclobutrazol (2 and 4 mg \cdot L⁻¹), uniconazole (2 and 4 mg \cdot L⁻¹), distilled water, and undipped controls. Cuttings were then treated with a 0.1% IBA rooting powder and placed under intermittent mist on the propagation bench. After 2 weeks in propagation, cuttings were harvested and shoot elongation, root development, and dry weights were evaluated. The interaction of chemical and species was significant for stem elongation and dry weight; chemical effect on root development was also significant. Paclobutrazol and uniconazole offered greater control of stem elongation than daminozide, daminozide-chlormequat chloride, water, or control treatments.

Bird Pepper Growth and Fruiting Response to Pinching and Uniconazole Sprays

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Preliminary experiments with uniconazole (UNZ) at 5- and 10-ppm sprays on Bird Pepper indicated that UNZ could be used to enhance appearance and improve fruiting of Bird Pepper, but some refinement of UNZ rates had to be made. Another experiment was conducted to determine rates of UNZ needed to maintain a suitable plant size with manual pinching and improve yield and total number of red fruit produced. Best overall effects were on plants single-pinched 4 weeks after sowing and treated with a foliar spray of 4 to 6 ppm UNZ. Higher UNZ levels produced too compact plants in which individual branches had to be staked. More-attractive double-pinched plants may be produced if UNZ application is delayed after the second pinch. Bird pepper can therefore be produced as a dual purpose pot plant by pinching followed by foliar applications of UNZ preferably at 4 to 6 ppm.

Effects of Paclobutrazol on Growth and Postharvest Characteristics of Miniature Pot Roses

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Plants of *Rosa* L. 'RUIJef', 'RUIldodo', and 'RUIrosora' were grown using a short-cycle production schedule. Rooted cuttings were established in 11.4-cm pots followed by pinching to start a final forcing period. Paclobutrazol was sprayed at 0, 25, 50, 100, or 200 mg • L⁻¹ when shoots growing after the pinch were 2 to 3 cm long. Plants were harvested when at least two flowers were at stage 2 (showing color, calyx reflexing, no petals reflexed). At harvest, plants were moved to a simulated interior environment at 21 °C with 30 lower case $\mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ fluorescent light. Plants of 'RUIJef' had the most flowers per pot, whereas plants of 'RUIldodo' were the shortest and the latest to flower. Plants of 'RUIrosora' exhibited the longest shelf-life, but cultivars responded similarly to paclobutrazol treatments. Paclobutrazol treatment at 50 mg • L⁻¹ and above resulted in shorter plants than the control while 25 mg • L⁻¹ and above reduced peduncle length. Days to harvest was unaffected. Plant shelf-life was reduced 2.1 d by 100 or 200 mg • L⁻¹ paclobutrazol treatment in comparison to the control. Longevity of selected individual flowers was reduced 1.4 d after 50 mg • L⁻¹ treatment and by 2.2 d after 100 mg • L⁻¹ treatment. Leaf abscission during the interior evaluation period was significantly reduced by paclobutrazol treatment of 50 mg • L⁻¹ or higher, but leaf abscission overall was less than 10%. Considerations of height control, plant shelf-life and floral longevity should be balanced when using paclobutrazol in miniature pot rose production.

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Rate of Flower Formation in *Primula malacoides* Varied with Photoperiod and Temperature Conditions

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Primula malacoides ('Prima Red') was grown at 16 or 20 °C and 8- or 16-hr daylength. Irradiance was adjusted to 10 mol/m² per day. Germination took place at 16 °C and seedlings were transplanted 28 d from seeding into 10-cm (800 mL) containers. Growing conditions until treatment 58 d from seeding were 16 °C and long days. Flower buds first appeared 80 d from seeding at 16 °C and after 100 d at 20 °C independent of daylength. Less time was required for the development of flower buds at 16- compared to 8-h daylength. Fastest flowering (110 days) was observed at 16 °C and long days. Short days at 16 °C delayed flowering 5 to 6 days. At 20 °C, open flowers were recorded 120 d from seeding with long days and 138 days with short days. In addition, groups of 10 plants within each temperature were moved weekly from one day length to the other and allowed to flower. The rate of flowering gradually increased with increasing exposure to long days while increasing durations of short days delayed flowering.

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Daylength and Temperature Affect Rate of Flowering in *Primula obconica*

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Primula obconica ('Libre Light Salmon') was grown from transplant at 16 or 20 °C in combination with 8- or 16-h daylength. Irradiance was adjusted to 10 mol/m² per day. Germination took place at 20 °C and seedlings were transplanted into 10-cm (800-mL) containers. Growing conditions until treatment 58 days from seeding were 20 °C and 16-h daylength. Rate of flower bud formation was independent of photoperiod at 16 °C requiring 88–93 days from seeding. A similar rate was observed at 20 °C and 16-h daylength. However, short days (SD) delayed flower bud appearance with 10–15 d at 20 °C. Open flowers were first recorded 110 days from seeding at 20 °C and long days (LD). At 16 °C, 12 more days were required for flower development at LD and 22 days at SD. Open flowers did not develop by termination 145 days from seeding at SD and 20 °C. Treatments within each temperature were included where plants were moved weekly to the alternate photoperiod and allowed to flower. There was no significant difference in flower bud appearance among plants exposed to 16 °C or LD at 20 °C. Flower bud formation progressively slowed at increasing duration beyond 4 weeks of SD and 20 °C. Any duration of LD at 20 °C resulted in similar flowering time while more than 1 week at SD slowed or prevented flower appearance. At 16 °C, more than 6 weeks of exposure to SD delayed, while LD hastened flowering.

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Influence of Photoperiod, Temperature, and Growth Regulators on Growth and Flowering of *Helichrysum* and *Brachycome*

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Five taxa of *Helichrysum* Mill. and *Brachycome* Cass. were recently evaluated for greenhouse production and amenity use. Preliminary studies on the influence of photoperiod, temperature, and growth regulators were conducted for *H. bracteatum* Vent., (syn *Bracteantha bracteata*) 'Sunray' and 'Matilda Yellow', *H. apiculatum* D.C., (syn *Chrysocephalum apiculatum*) 'Golden Buttons' and *Brachycome iberidifolia* Benth. 'Jumbo Mauve' and 'Mauve Delight'. All taxa of *Helichrysum* were quantitative LD plants, flowering slightly more rapidly under night-break (2200–0200 HR) and extended day incandescent lighting, compared with 9-h short-day treatment. No influence of photoperiod occurred with cultivars of *Brachycome*. Constant temperature of 12, 20, or 28 °C were provided and all taxa demonstrated a linear decrease in flowering time as temperatures increased. The growth index (average of height and two measurements of width) was also influenced by temperature. Paclobutrazol and daminozide were applied at different concentrations and frequencies. Paclobutrazol was more effective than daminozide in both genera, and daminozide was ineffective in *Brachycome*.

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Photoperiod Influences Growth and Flowering of Seven Tropical Perennial Species

Richard K. Schoellhorn* and A.J. Compton; West Florida Research and Education Center, University of Florida, Milton, FL 32583

Floricultural crops without the benefits of extensive breeding or selection often pose problems for commercial cutting and finished plant producers. The objective of this work was to determine the effects, if any, of daylength control on the growth and flowering of the following genera: *Barleria cristata*, *Angelonia angustifolia* 'Pandiana', *Stachytarpheta mutabilis* var. *violacea*, *Streptosolen jamesonii*, *Mandevilla sanderi*, *Dichorisandra thyrsoiflora*, and *Pseuderanthemum laxiflorum*. Daylength of 8, 10, 12, or 14 h was imposed for 20 weeks, with cuttings harvested from plants every 4 weeks. At 20 weeks, plants were evaluated for degree of flowering and plant size. Photoperiod had a significant interaction with genera grown. Compared to plants grown under 14-h daylength; flowering and growth were reduced in *Stachytarpheta* and *Angelonia* at 8- and 10-h daylength. Flowering was increased, but overall growth reduced in *Pseuderanthemum*, *Mandevilla*, *Barleria*, and *Dichorisandra* as daylength decreased. Flowering of *Streptosolen* was not evident under any photoperiod. Vegetative growth was greatest with 14 h daylength for all genera tested, but only increased flower number of *Stachytarpheta*. Production temperatures of 20 °C night and 30 °C day were maintained throughout the study, the experiment was conducted in the summer production seasons of 1997 and 1998.

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Growth and Flowering of *Zephyra elegans* D. Don Grown in Greenhouse or Growth Chamber

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As a new product in the floricultural market, *Zephyra elegans* D. Don, shows great potential. It is a new product, so there is little known about its physiology. In this study, the growth cycles and the effects of day/night temperatures on flowering control of this new product were investigated. Stems elongated gradually during the growing season but more slowly after flowering. Original corm fresh weight decreased with increasing daughter corm fresh weight. During the growing season, the original corm dies after producing usually one daughter corm. The high ambient temperature of summer adversely effected shoot emergence. The optimum day/night temperature regimes for shoot emergence was 15/10 °C and for growth and flowering it was 20/15 °C. Under these conditions, it is possible to produce *Zephyra elegans* D. Don year-round.

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Production of Cut Flowers from Field-grown Hydrangeas

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Cut flowers from field-grown hydrangeas are a potential alternative source of

income for Kentucky growers. Early production is important to receive immediate returns of one's investment. In Spring 1998, a hydrangea cultivar trial was established at the Univ. of Kentucky Research and Education Center, Princeton. The planting consisted of 12 plants each of nine cultivars ('Annabelle', 'Boskoop', 'Pink Diamond', 'Unique', 'Kyushu', 'Tardiva', 'Pee Wee', 'Alice', and 'White Moth') allocated to 12 rows (blocks) in a randomized block design. Date of first bloom, number of inflorescence at first bloom, number of stems and their length were recorded. The cultivars 'Unique', 'Pink Diamond', and 'Tardiva' yielded significantly more flowers with commercially desirable stem lengths (>45 cm) than did 'Annabelle' and 'Boskoop'. 'Alice' and 'White Moth' did not bloom.

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Selection Strategies for Selecting Alternative Cut Flowers for Greenhouse Production

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The cut-flower industry is continually searching for unique products to introduce to the floral industry. Our objective was to select potential species for trial as new greenhouse-grown alternative cut flowers. Hardy perennials from the Rock/Alpine Garden at the Denver Botanical Garden served as the selection pool. Plants in this collection were fitting due to their durability in Colorado conditions and their rugged unique beauty. Several trial cuts of potential species were taken, and the flowers were evaluated for flower size, stem length, stem strength, foliage, vase life, usefulness, and general aesthetic quality. Next, an informal survey of growers, retailers, researchers, and consumers was taken to determine which flowers had already been seen on the market and which flowers would be potentially successful in the trade. After assimilating the information, the following six species were selected for trial future greenhouse production: *Anthyllis vulneraria*, *Dianthus giganteus*, *Diascia integerrima*, *Echium lusitanium*, *Heuchera sanguinea* 'Bressingham Hybrids', and *Trollius yunnanensis*.

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Evaluation of Six *Ficus* Species for Interior Conditions

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The most popular *Ficus* for interior conditions is *F. benjamina*, which has many clonal selections but still drops its foliage too readily. We compared 4- to 5-foot-tall, shade-grown plants of *F. nemoralis*, *F. celebensis*, *F. binnendykii* 'Alii', *F. oblongifolia* (?), and a selection of *F. benjamina* thought to be 'Gulfstream' with *F. benjamina* 'Exotica' that were transferred to the Hamilton Library of the Univ. Hawaii after 14 weeks under 50%, 65%, or 85% Saran shade. During a 9-week evaluation period, new growth, leaf drop, and photosynthesis were determined. Little new growth developed on any plants during the evaluation period in the library. Leaf loss was greatest for *F. benjamina* 'Exotica,' followed by *F. celebensis*, while the other four species suffered little leaf loss. Leaf loss was greater for plants grown under 50% shade than for 80% shade, while leaf loss from plants produced under 65% shade was either greater or less than 80% shade, depending on species. Leaf loss was greater in low light sites (13.6 $\mu\text{M}/\text{m}^2$ per s) than in medium conditions (20 $\mu\text{M}/\text{m}^2$ per s) or near windows (29 $\mu\text{M}/\text{m}^2$ per s). After the observation period, the plants were to be removed, but library staff asked to retain many plants as they liked the improved atmosphere the plants gave their office and library settings. Most popular for retention were *F. binnendykii* 'Alii', *F. benjamina* 'Gulfstream,' and *F. benjamina* 'Exotica,' which still looked good despite its high foliage loss initially. The weeping habits of *F. nemoralis* and *F. oblongifolia* (?) were not as desirable because of the space they required, although they are performing well after nearly 12 months in the library. *F. celebensis*, despite its attractive growth habit and foliage, was a disappointment as it lost many leaves and, over 12 months, developed chlorosis and exudation problems.

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Interactive Greenhouse Simulation (GHSIM) Translated from Quattro Pro to Microsoft Excel for Flexibility and Portability

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Improvements to computer software and advancing technology made it necessary to convert the computer greenhouse simulation model, GHSIM, to a new application for operation across a greater number of platforms. Originally, economics and internal organization compatibility led to use of spreadsheet Quattro Pro. Standard features were relative and absolute references, multiple pages for topic organization, random event generation, and graphing of calculated trends.

However, Quattro Pro contained many convenient features, yet proprietary, which were not readily converted: certain formats for graphing trends, recursive formulas, cross page referencing, buttons, macros for dynamic time execution, and floating toolbars that actually changed between old and newer versions (v.5.0 vs. v.7.0). Translation from Quattro Pro v.5.0 to Microsoft Excel 97 produced tedious page by page (worksheet) conversions, loss of buttons and macros, distorted/unreadable graphs, nonexistent toolbars, and, most troubling, obscure problems with recursive execution causing Excel to crash amid nondescript error messages and a core dump. All these were eventually resolved; current efforts seek to reach other platforms, including Macintosh and the Internet.

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Risk Analysis of Adopting Zero Runoff Subirrigation Systems in Greenhouses Using Monte Carlo Simulation

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Although zero runoff subirrigation (ZRS) technology has great promise to manage fertilizer inputs while improving production efficiency in greenhouse operations, high initial investment costs and inadequate technical background are major impediments for initiating the change. In a world of uncertainty, greenhouse operators face the challenge of making an optimal investment decision to satisfy environmental compliance expectations and meet the companies' financial goals. Using Monte Carlo simulation, cost risk was analyzed to compare the relative risks of investing in alternative ZRS systems for greenhouse crop production. An investment model was defined for greenhouse production with alternative ZRS systems. Each cost variable was allowed to vary based on a probability distribution. Random numbers were generated to determine parameters for the probability distributions for the uncertain variables. The simulation process was repeated 300 times for each production model. Simulation results showed that among the four ZRS systems studied (ebb-and-flow benches, Dutch movable trays, flood floors, and trough benches), the Dutch movable tray system returned the highest average profit for small potted plant production and the flood floor system returned the highest average profit for large potted plant and bedding crop flat production. Risk of the production models were compared by the variability of simulation results. The Dutch movable tray system is the least risky for small potted plant production, and the flood floor system is the least risky for large potted plant and bedding crop flat production. Despite its low initial costs of adoption, the trough bench system was least competitive as a ZRS technology for a greenhouse operation because of the relative low profitability and high risk of production due to volatile profitability.

93 POSTER SESSION 12 (Abstr. 207–237) Crop Production

Friday, 30 July, 1:00–2:00 p.m.

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Tillage Methods Affect the Growth of Sweetpotato

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Growth of the sweetpotato [*Ipomoea batatas* (L.) Lam.] is subject to environmental variation. High soil temperatures can restrict storage root initiation and development. Moreover, fluctuating soil moisture can have a pronounced effect on yield and quality. Cover crops, used in a conservation tillage system, could modify the soil environment. The objective of this research was to investigate the effects of conservation tillage on sweetpotato growth. A rye cover crop was broadcast seeded in Fall 1996, and sweetpotatoes were transplanted into the undisturbed residue the following spring. A fallow, unseeded plot represented the conventional method of sweetpotato culture. Plants were harvested at 14-day intervals commencing at 21 days after transplanting. Leaf area and dry weights of the storage roots and vines were recorded. Soil moisture was measured by taking soil cores at the depth of rooting (10 cm). The sweetpotatoes growing in the undisturbed rye residue had a significantly greater leaf area, vine weight, root set,

and yield (particularly large grade class) relative to conventional-tilled sweetpotatoes. The rye residue was very effective in reducing soil evaporation.

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Evaluation of Vegetable Soybean Cultivars from a Range of Maturity Groups for Edamame Production in California

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Coastal California vegetable growers produce a wide range of specialty crops for diverse domestic and export markets. Vegetable-type soybean (*Glycine max* L.) cultivars are grown and consumed fresh in many parts of the world, but particularly in Japan and Asia, where they are known as edamame. Traditional soybean maturity group classification may not be applicable for fresh-market edamame, particularly in mild coastal California growing conditions. We evaluated a total of 55 vegetable soybean cultivars during the 1998 growing season from maturity groups ranging from group 00 to group VI. Replicated field plots were planted on 30–31 May 1998 in San Luis Obispo, Calif. (lat. 35.12°N.). Cultivars from maturity Groups 00 and I began producing on 4 Sept., followed in 7 to 10 days by maturity Group II and III, and by harvest of maturity Group III and IV cultivars on 19 Sept. Harvest of Group IV cultivars continued until 24 Oct. Percent marketable (two- and three-seeded) pods ranged from 86% to 17% among the cultivars. Marketable yields ranged more than 15-fold, with cultivars such as 'Sapporo Midori', a group 00 cultivar popular in Japan, producing 348 g/plant, to cultivars such as 'Early Hakucho' and 'Envy' producing 20 and 5 g plant, respectively.

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Initiating a Statewide Evaluation System for Watermelons

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During the past several years, watermelon trials have been performed in the state, but not as a coordinated effort. Extensive planning in 1997 led to the establishment of a statewide watermelon trial during the 1998 growing season. The trial was performed in five major production areas of the state including: The Winter Garden (Carrizo Springs); South Plains (Lubbock); East Texas (Overton); Cross Timbers (Stephenville); and the Lower Rio Grande Valley (Weslaco). Twenty seedless and 25 seeded hybrids were evaluated at each location. Drip irrigation with black plastic mulch on free-standing soil beds was used to grow entries in each area trial and yield data was recorded in a similar manner for each site. Results were reported in a statewide extension newsletter. Future plans include a continuation of the trial in the hope that multiple-year data will provide a basis for valid variety recommendations for watermelon producers in all areas of the state.

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Water Uptake in Film-coated *shrunken-2* Sweet Corn (*Zea mays*)

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One possible influence film-coating may have on seeds is modifying water uptake and electrolyte leaking during imbibition. Film-coating is a seed treatment that can improve sweet corn germination, especially under cold soil conditions. Two *shrunken-2* sweet corn varieties ('Even Sweeter' and 'Sugar Bowl') were treated with a polymer film-coating and evaluated for water uptake patterns during imbibition. 'Even Sweeter' is a low-vigor sweet corn, while 'Sugar Bowl' is a high-vigor variety. Standard germination tests were performed according to AOSA rules and suggest film-coated seeds germinated at a slower rate than untreated seeds. After 4 days of imbibition, 'Sugar Bowl' film-coated seeds had 5% germination, while untreated seeds had ≈20% germination. However, after 7 days, film-coated seeds had 94% germination with untreated seeds at 80% germination. Results were similar for 'Even Sweeter'. Bulk electrical conductivity readings were taken over 24 h to determine the amount of electrolyte leakage during imbibition. Low-vigor 'Even Sweeter' had 92% higher overall leakage than high-vigor 'Sugar Bowl'. Additional conductivity readings were taken for both seed lots every 2 h for 12 h. Film-treated seeds leaked 15% less than untreated seeds for 'Sugar Bowl'. However, 'Even Sweeter' film-coated seeds actually leaked 17%

more than the untreated seeds. In both cases, 70% of electrolyte leakage occurred within the first 12 h of imbibition. An imbibition curve was established for the two seed lots comparing untreated and film-coated seeds. During the first 6 h of water uptake, film-treated seeds weighed ≈50% more than the untreated seeds for both 'Even Sweeter' and 'Sugar Bowl'. Pathways for water uptake as influenced by film-coating *shrunken-2* seeds will also be presented.

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Growth, Photosynthesis, Biomass Partitioning, Yield, and Their Relationships in Processing Snap Beans

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In Summer 1998, 17 standard cutting and 14 small-sieve wholepack varieties and advanced lines of processing snap beans were evaluated at the Greenhouse and Processing Crops Research Centre in Harrow, Ont. The varieties and advanced lines were arranged in randomized complete blocks with four replications. Of the standard cutting varieties and advanced lines, 'Saratoga' was the earliest variety, which was harvested 5 to 10 days earlier than rest of the cultivars. 'EX 371' had the highest yield, pod dry matter, and biomass and the second highest pod dry matter content, leaf area, and harvest index (total pod dry matter/biomass). 'Saratoga' had similar yield as 'EX 371', but its total pod dry matter production was much lower than 'EX 371' due to its lowest pod dry matter content. Of the small-sieve wholepack varieties and advanced lines, 'Marseilles' had the highest yield, pod dry matter, pod dry matter content, biomass, and harvest index and second largest leaf area. Leaf photosynthesis (measured at 1500 $\mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ photosynthetic photon flux density, 65% relative humidity, 28 °C, and ambient CO₂ with LI-6400 portable photosynthesis system in full bloom stage) ranged from 21.3 (EX 351) to 28.3 (Carlo) $\mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$. In both standard cutting and small sieve wholepack varieties and advanced lines, yield was significantly and positively related to total biomass, biomass allocation to pods and leaf area, and so was the total pod dry matter. Bean pod yield was significantly and negatively correlated with pod dry matter content in standard cutting varieties and advanced lines. Bean pod yield did not have significant relationships with leaf photosynthesis and chlorophyll. Therefore, the yield of processing snap beans might be mainly determined by total leaf area and biomass allocation to pods.

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Effects of Plant Density on Growth, Yield, and Quality of Fresh-market Sweet Corn

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In summer 1998, two *sh2*, fresh-market, sweet corn cultivars ('Candy Corner'—large plant size, and 'Swift'—small plant size) were grown at 5, 6.5, 8, and 9.5 plants/m² to investigate the effects of plant density on growth, photosynthesis, biomass, yield, and quality. Biomass and leaf area per plant were not affected by plant density. Therefore, biomass and leaf area per unit area were increased with increasing plant density. Plant height, leaf chlorophyll, leaf photosynthesis, and transpiration (measured with the LI-COR 6400 portable photosynthesis system) were not affected by plant density. Total cob weight (husk off) and number of ears harvested from plants were increased with increasing plant density. However, marketable yield (number of marketable ears) was not affected by plant density and marketable cob weight (husk off) decreased with increasing plant density due to the reduction in ear size with high plant density. There was a significant increase in percentage of unmarketable ears at plant density higher than 6.5 plant/m² with 'Candy Corner'. Kernel sugar content (°Brix) in both cultivars increased with plant density. According to the results of this experiment, the optimum plant density for fresh-market sweet corn was 5 to 6 plants/m².

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Effect of Plant Density on Plant and Stand Performance in Hydroponically Grown Dry Bean (*Phaseolus vulgaris*)

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Protein is an important and essential dietary component. Common bean, a major source of vegetable protein in the Americas, was chosen for study in controlled environments with a view to its potential for use in space colonies. Eighteen 0.58-m² stands of the cranberry type of bean, 'Etna', were grown in the green-

house at plant densities of 7, 15, and 28 plants/m² in a recirculating ebb-and-flow system. Duration of photoperiod and thermoperiod was 16 h. Day/night temperatures settings were 25/20 °C. Daily light integral was matched across greenhouse sections by means of supplemental lighting; it averaged 17 mol/m² per day. Crop cycle was 70 days from seed to harvest. At harvest, plants were dismembered so that dry weights of leaf, branch, stem, pod, and bean yields could be separately measured by node of origin. Internode lengths were recorded, and all loose trash recovered. The relationship between yield and plant density followed the form expected. Yield of edible biomass at 7 plants/m² (284 g/m²) was 88% of that at 28 plants/m² (324 g/m²), a significant difference. At 15 plants/m² it was 97%. The trend suggests that further gains (but only very small) in yield can be expected with increased density in this cultivar. Productivity and quantum yield at 28 plants/m² were 4.69 g/m² per day and 0.27 g/mol, respectively. The coefficient of variation for plants grown at 28 plants/m² was three times that of plants grown at 7 plants/m² (0.88 vs. 0.26). Yield component analysis, harvest index, and plant morphology at the different planting densities are discussed.

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Yield and Quality Response of Carrot (*Daucus carota* L.) to Simulated Storm Damage

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Parts of Colorado receive more hail than almost any other area in the nation. Severe storms can injure crop tissue and, thus, lower yield and predispose the crop to disease infection. Our study was conducted to determine the yield and quality response of carrot (*Daucus carota* L.) to simulated storm damage during different periods of plant development. We removed 33% and 67% of the carrot foliage at four dates, spaced 10 days apart, during the middle of the growing season. In 1997 and 1998, 67% defoliation significantly reduced total and marketable yields more than did 33% defoliation. Total yield components, length and diameter, were similarly affected. Defoliation, in general, decreased yield the greatest when it occurred at the later stages of development. Carrot foliage continued to develop and grow after all defoliation events. Nonetheless, moderate (33%) and severe (67%) foliage loss reduced marketable yield and yield components of carrots.

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Effect of Overhead Misting on Leaf Surface Microclimate of Greenhouse Cucumber

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Overhead fogging or misting is an essential technique applied in modern greenhouses for cooling and humidifying. This technique can be used to promote yield and quality of greenhouse crops either by providing favorable environment for the plant growth or by increasing the efficiency of greenhouse pest and disease control. In this study, the effect of high-pressure overhead misting on greenhouse climate and leaf surface microclimate conditions for cucumber crops in a glass greenhouse was investigated. It was found that the temperature of the greenhouse air was lowered by 5–6 °C and relative humidity was increased by 20% to 30% during misting. The temperature of sunlit leaves was slightly reduced in the morning (2–3 °C), and leaf wetness duration was significantly extended by misting. Leaf wetness duration under misting was predominately influenced by light intensity at the leaf level and was modelled as a function of misting period and average radiation intensity. Results of this study can be used to improve the predictions of pest and disease breakout and the efficiency of their control measures. The empirical model developed in this study can be integrated with leaf surface microclimate models to correctly predict surface moisture conditions and evaporative cooling from water films at the leaf surface.

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Squash Pollination by Honey Bees vs. Native Pollinators in Maine

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Managed and feral honey bee (*Apis mellifera*) colonies have declined dramatically in the past decade due largely to parasitic mites, pesticide contamination, and severe weather. Squash (*Cucurbita* spp.) is one of many agricultural crops whose production may be negatively effected by decline of these pollinators. A study was conducted on a set of nine farms in Maine to assess the rela-

tionship between bee abundance and fruit set of summer and winter squash. The organic and conventional farms targeted in the study included farms with and without the presence of honey bees. With winter squash, fields with more bees tended to exhibit higher fruit set. The average fruit set was slightly higher for farms with honey bees (42%) vs. those without (35%), but both types of farms were similar to that found in controlled hand pollinations (31% on average). In contrast, fruit set for summer squash averaged 95% to 96% for all farms, regardless of the relative abundance of censused bees. Bumble bees (*Bombus* spp.) were the most abundant wild bees found pollinating squash. Farms with honey bees on average had higher numbers of bees in squash flowers than farms without honey bees, although a difference in preference for floral sex type was detected for bee taxa. Honey bees were much more likely to be found in female flowers, while bumble bees were more abundant in male flowers. Significantly more native bees were found in squash flowers on farms without honey bee hives, although native bees were still present to some extent on farms that were dominated by *Apis mellifera*.

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Plant Height Control by Photosensitive Filters

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A research collaboration between Clemson Univ. and Mitsui Chemicals, Japan, has been established to develop and test photosensitive greenhouse covers that can filter out far-red (FR) light and control plant height with minimal use of chemicals. The effects of polymethyl methacrylate (PMMA) filters containing FR-intercepting dyes were evaluated on watermelon, pepper, chrysanthemum, and tomato to select an optimum dye concentration. As the dye concentration increased, FR interception increased, photosynthetic photon flux (PPF) decreased, and phytochrome photoequilibrium increased from 0.72 to 0.82. Light transmitted through photosensitive filters reduced plant height effectively in all species tested. However, watermelon was the most responsive (50% height reduction) and chrysanthemum was the least responsive (20% height reduction) to filtered light. Tomato and peppers had an intermediate response. In watermelons, total shoot dry weight was reduced over 25% compared to the control plants, with a progressive decrease in shoot weight as the dye concentration increased. The specific stem dry weight was gradually reduced as the dye concentration increased. Specific leaf dry weight was slightly reduced under filters, suggesting that smaller plants as opposed to a reduction in dry matter production primarily caused total dry weight reduction. Light transmitted through filters reduced percentage dry matter accumulation into stems from 27% to 18% and increased dry matter accumulation into leaves from 73% to 82%. Photosensitive filters are effective in controlling height similarly to chemical growth regulators. Considering the PAR reduction by increase in dye concentration, a dye concentration that gives a light reduction of 25% or 35% may be optimum for commercial development of photosensitive films.

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Effect of Promalin and GA_{4/7} on Marketable Asparagus Shoots Harvested

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Spraying 9-month-old UC157F1 asparagus plants (*Asparagus officinalis* L.) with aqueous solutions of GA_{4/7}, BA, and promalin ranging from 0 to 200 ppm in 200-ppm increments and using the mother-stalk method showed that BA continued to produce the most marketable shoots and obtained a higher level of effectiveness. GA_{4/7} showed significance on several days during the harvest period. On the final day, there was no significant difference found for either GA_{4/7} or promalin. BA produced marketable shoots earlier than promalin, but in the end, both these chemicals were equally effective. Early interaction with GA_{4/7} x BA resulted in delayed shoot emergence. Promalin is a mixture of GA_{4/7} and BA.

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Food-grade Greenhouses: Development and Implementation of a HACCP Plan for the Production of Controlled Environment Agriculture (CEA) Boston Lettuce

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With the primary objective of assuring food safety at the production level, a

HACCP (Hazard Analysis and Critical Control Point) plan was developed and implemented in an 8000-ft² greenhouse producing 1000 heads of lettuce per day in Ithaca, N.Y. The plan was developed following the HACCP principles and application guidelines published by the National Advisory Committee on Microbiological Criteria for Foods (1997). The CEA glass greenhouse uses both artificial high-pressure sodium lamps and a shade curtain for light control. Temperature is controlled via evaporative cooling and water heating. Lettuce plants are grown in a hydroponic pond system and are harvested on day 35 from day of seeding. Known and reasonable risks from chemical, physical, and microbiological hazards were defined during the hazard analysis phase. Critical control points were identified in the maintenance of the pond water, the operation of evaporative coolers, shade curtains, and during harvesting and storage. Appropriate prerequisite programs were implemented before the HACCP plan as a baseline for achieving minimum working conditions. Proper critical limits for some potential hazards were established and monitoring programs set up to control them. Postharvest handling was setup in an adjacent head house that was adapted as a food manufacturing facility according to New York State Dept. of Agriculture and Markets standards. Potential applications will be discussed.

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Gibberellic Acid Tank Mix and Adjuvant Effects on Peel and Juice Quality of 'Hamlin' Oranges

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An experiment was conducted to determine if gibberellic acid (GA; ProGibb, Abbott Labs) can be mixed with Aliette or Agri-Mek and oil to reduce application costs, without reducing GA efficacy, and if Silwet and Kinetic adjuvants enhance GA efficacy. Five tank mixes were tested along with a nonsprayed control. The tank mixes included: 1) GA, 2) GA + Silwet, 3) GA + Kinetic, 4) GA + Silwet + Aliette, and 5) GA + Silwet + Agri-Mek + oil. All compounds were applied at recommended concentrations. In September, ≈24 L of each tank mix was applied with a hand sprayer to mature 'Hamlin' orange trees [*Citrus sinensis* (L.) Osb.] on sour orange (*Citrus aurantium* L.) rootstock. Peel puncture resistance (PPR), peel color, and juice yield (percent juice weight) were evaluated monthly between Dec. 1997 and Mar. 1998. On most sampling dates the fruit of treated trees had higher PPR and were less yellow in color than fruit from control trees. However, in Jan., fruit treated with GA + Silwet and GA + Kinetic had greater PPR than other treatments. In Feb., fruit treated with GA + Silwet + Agri-Mek + oil had the lowest PPR. The effect of the different tank mixes on juice yield was usually similar to the effect of the tank mixes on PPR and peel color. On 8 Jan. 1998, fruit from trees treated with GA alone yielded significantly more juice than fruit from control trees. On 24 Feb. 1998, fruit from trees treated with GA alone yielded more juice than fruit from the other treatments. Thus, GA efficacy is generally not reduced by these tank mixes, nor improved by adjuvants.

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Gibberellic Acid Application Timing Effects on Juice Yield and Peel Quality of 'Hamlin' Oranges

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Gibberellic acid (GA) applied in late summer or fall delays subsequent loss of peel puncture resistance (PPR) and development of yellow peel color in many citrus cultivars. Our objective was to determine the optimal time to apply GA for increasing juice yield of 'Hamlin' sweet orange [*Citrus sinensis* (L.) Osb.]. Mature trees on sour orange (*Citrus aurantium* L.) rootstock were sprayed with ≈24 L of a solution of GA (45 g a.i./ha) and organo-silicone surfactant (Silwet, 0.05%). Trees were sprayed on 26 Aug., 9 Sept., 2 Oct. (colorbreak), or 13 Oct. 1997, or nonsprayed (control). Peel puncture resistance, peel color, and juice yield were evaluated monthly between Dec. 1997 and Mar. 1998. Fruit from trees sprayed with GA had peels with higher PPR and less yellow color than fruit of control trees for most of the harvest season. The effect of GA on PPR and peel color lasted about 5 months. Juice yield was usually numerically greater for GA-treated fruit than for nontreated fruit. Fruit treated with GA at color break had significantly greater juice yield when harvested in late February than fruit from control trees. Thus, GA applied at color break appears to be the most effective time for enhancing peel quality and juice yield of 'Hamlin' oranges.

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The Use of Polyacrylamide Polymer to Improve the Growth of Young Apple Trees

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Water-sorbing polymers have been used in greenhouses and in arid and semi-arid regions to improve soil water properties. Laboratory and field studies were conducted to investigate the effects of a cross-linked polyacrylamide polymer when incorporated into a silt loam. The soil treatments consisted of 0%, 0.06%, 0.12%, and 0.25% polymer by weight. The laboratory study consisted of four soil columns each containing a treatment. Water was added at a rate of 6.1 mm to the columns every 2 days. Soil moisture and volume was measured daily. The field experiment contained apple trees planted into soil amended with the different rates of polymer and covered with a polypropylene weed barrier. Tree growth and fruit yield were recorded from 1996–1998. The volume and bulk density of the soil–polymer matrix were dependent on the moisture content due to the swelling properties of the polymer. Bulk density was highest when no polymer was added and lowest for soil containing 0.25% polymer. Soil moisture measured by time delay reflectometry showed multiple wetting fronts in the soil columns after water was added. During the 1996 growing season, soil moisture was higher for field plots containing the weed barrier and amended with polymer; however, this trend was reversed in 1997. Tree growth was not effected in any of the years data was taken. Fruit yields did not differ between treatments in 1997. Fruit set and yield in 1998 was greater for trees planted without the weed barrier and polymer. The addition of polymer was not found to benefit apple tree growth or yields.

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Prohexadione-Ca: Effects against Apple Scab (*Venturia inaequalis*)

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Many trials have demonstrated that apple and pear trees treated with the plant growth regulator prohexadione-Ca (BAS 125 W) are less susceptible to infestation by the bacterial disease fire blight. In further investigations we have studied the effect of this compound against fungal diseases, concentrating on scab (*Venturia inaequalis*) in apple. Working with apple seedlings and artificial inoculation under greenhouse and field-like conditions, scab infestation could be reduced by applications of prohexadione-Ca. Whereas this effect was rather marginal if inoculations were made shortly after treatment, highly significant effects were found in the time span of ≈1 to 4 weeks after application. Preliminary results from trials conducted under orchard conditions support these findings. We assume that, similar to the situation with fire blight, changes in phenylpropanoid metabolism are mainly responsible for the reduced scab incidence. It should not be ruled out, however, that anatomical and morphological changes caused by prohexadione-Ca may also contribute to this effect.

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Effect of Accel and Ethephon on Fruit Set and Sugar Content of Three Apple Cultivars

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The influence of chemical thinners Accel and ethephon on three apple cultivars Royal Gala, Blushing Gold, and Ultra Gold was investigated. Two experiments were conducted in 1995 and 1996 to determine the effect of Accel at 0, 25, 50, and 75 ppm and ethephon at 0, 100, 200, and 300 ppm on fruit juice SSC, fruit juice sucrose, fruit juice glucose, fruit juice fructose, and fruit set. Accel and ethephon reduced fruit set of 'Royal Gala', 'Ultra Gold', and 'Blushing Golden'. In 1995, chemical fruit thinners Accel and ethephon increased SSC of 'Royal Gala' and 'Ultra Gold' and did not affect SSC of 'Blushing Golden'. In 1996, Accel and ethephon did not effect the SSC of 'Royal Gala' and 'Blushing Golden'. However, Accel increased SSC of 'Ultra Gold'. Accel and ethephon increased sucrose concentration of 'Royal Gala', 'Ultra Gold', and 'Blushing Golden'. Accel increased fruit juice glucose concentration of 'Royal Gala', 'Ultra Gold', and 'Blushing Golden'. Ethephon did not effect fruit juice glucose concentration of 'Royal Gala', 'Ultra Gold', and 'Blushing Golden'. Accel did not effect fruit juice fructose concentration of 'Royal Gala'. However, Accel increased fructose levels of 'Ultra Gold' and 'Blushing Golden' in 1995. Accel did not effect fruit juice fructose concentration of 'Blushing Golden' in 1996. Ethephon did not effect fruit juice fructose concen-

tration of 'Royal Gala'. Ethephon increased fruit juice fructose concentration of 'Ultra Gold'. Ethephon did not effect fruit juice fructose concentration of 'Blushing Golden'.

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Prohexadione-Ca: Reduction in Vegetative Growth and Pruning of Apple Trees

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Prohexadione-Ca (BAS 12511W or Apogee™ Plant Growth Regulator) acts within a plant by blocking the biosynthesis of growth-active gibberellin. The result is decreased cell and shoot elongation; thus, vegetative growth in apple trees can be reduced. Air blast applications of prohexadione calcium were made in the Spring 1998 in commercial orchards. Application rate was 125 ppm a.i. applied twice beginning at 5 to 12 cm of new shoot growth. Reduction of shoot growth averaged 45% across locations. As a result of reduced vegetative growth, dormant pruning was reduced. In total, significant benefits to the grower included reduced pruning costs in addition to other positive effects such as improved light penetration and enhanced resistance to some pathogens. Research will continue with the effect of prohexadione-Ca on pruning in multiple year studies.

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Prohexadione-Ca: Growth Regulation and Reduction of Fire Blight Incidence in Pears, cv. 'Abate Fetel'

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As in other countries, pear production in Italy requires an efficient control of excessive shoot growth. Chlormequat chloride, the only available plant growth regulator, does not necessarily represent the ideal solution because it requires high dosages, thus posing the risk of residues in fruit. Fire blight, which has invaded Italy in at the beginning of 1990, is of great concern because 'Abate Fetel', one of the predominant cultivars, is highly susceptible and no preparations for control are currently available. To evaluate solutions for both aspects, prohexadione-Ca (BAS 125 11 W) has been tested on pears under growth chamber and orchard conditions. In each case, reductions of shoot growth and, if present, lowered incidences of fire blight could be achieved. Six-year-old trees of 'Abate Fetel', located in an area with high fire-blight infestation pressure, were sprayed with prohexadione-Ca four times each at either 50 or 100 ppm of active ingredient at a new shoot length of 6, 12, 33, and 45 cm. The resulting final shoot length was 96% and 75%, respectively, of the control, whereas an average of 15 fire blight incidences could be found in the controls. This number was reduced to 8 and 4, respectively, in the treated trees. Fruit yield and quality was not affected.

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Response of Secondary Bloom of 'Bartlett' Pear to Gibberellins, Ethephon, and Pruning

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Secondary or "rat-tail" bloom, a major site for fireblight infection of 'Bartlett' pear, comprised 10% of the total bloom in 1997 and 20% in 1998. We are striving to find production practices that can be economically applied to reduce the number of "rat-tails." Of the five known types of secondary clusters in pear, four occur on 'Bartlett', the most numerous being types I and V. Type I rat-tails occur on the bourse at the base of normal clusters and bloom from 10 to 30 days after normal bloom. Type V rat-tails occur mostly at pruning sites and have one to three flowers per cluster, blooming 20 to 50 days after normal bloom. GA₃ or GA₄₊₇ + BA were applied at 100 mg • L⁻¹ in 1997 to reduce rat-tail bloom in 1998. In 1998, neither GA₃ nor GA₄₊₇ + BA had an effect on normal bloom or type I rat-tails. GA₃ reduced type V rat-tails when applied at either 2 June, 2 July, or 15 Aug. but had no effect on type V clusters when applied at full bloom, petal fall, 16 June, or 15 July. GA₄₊₇ + BA reduced the number of type V rat-tails when applied at either 2 June, 16 June, 2 July, and 15 July but had no effect when applied at full bloom, petal fall, or 15 Aug. Dormant pruning horizontal shoots resulted in as

many rat-tails as vertical shoots, and heading cuts a similar number as stubbing cuts. Dormant pruning 1-year wood resulted in fewer rat-tails than 2-year wood. Summer pruning 21 or 49 days after bloom resulted in fewer rat-tails than pruning 10 days after harvest, but was similar to pruning 89 days after bloom. These and other results from ongoing work will be presented toward development of an integrated fire blight reduction strategy.

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Effect of Ethylene Inhibitors on Postharvest Peach Quality

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A problem facing the peach industry is the ability to harvest field-ripened peaches and get them to market without significant softening or damage. However, getting mature peaches into marketing channels before significant softening occurs is a challenge. Our objectives were to evaluate two growth regulators to determine the effect on fruit quality and softening at harvest and after 1, 2, or 3 weeks in cold storage and to evaluate the effect on harvest date. The two products evaluated in this study were ReTain (aminoethoxyvinylglycine (AVG)—Abbott Labs) and EthylBloc (1-methylcyclopropene (MCP)—Biotechnologies for Horticulture). ReTain is a growth regulator that inhibits ethylene production and is used in commercial apple production to delay harvest. EthylBloc is applied as a gas and attaches to ethylene receptor sites which inhibits ethylene effects. A trial with preharvest foliar applications of ReTain and postharvest gassing with EthylBloc was initiated in July 1998 on 'Contender' peaches. ReTain applications were made at 3-day intervals beginning 19 days before first harvest at the rate of 50 g a.i./acre. Applications 3 days before harvest resulted in increased flesh firmness at harvest and decreased ethylene evolution, which continued for up to 3 weeks in cold storage. Fruit were also gassed with 1 µL • L⁻¹ (1ppm) EthylBloc in the laboratory the day following harvest for 24 h. Fruit treated with ReTain and EthylBloc had twice the flesh firmness of peaches that were not treated after 1 week in storage. ReTain applied 3 days before harvest delayed maturity. Further evaluation will be conducted in 1999.

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Solid Matrix Priming of Gourd Seeds for Fast and Uniform Germination

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Grafting is common in all cucurbits in Asia, and gourd (*Lagenaria siceraria*) is the most popular rootstock for watermelons. Since the grafting is practiced at very early stage (right after the cotyledon expansion), uniform germination of rootstocks as well as the scions is crucial for grafting efficiency. Seeds were divided into three groups; intact, dry-heat treated (75 °C for 72 h), and brushed (575 rpm for 5 min). In each group, various solid matrix priming (SMP) treatments were imposed. Microcel E was used for SMP treatment with water or chemical solutions (10 seed : 1 Microcel E : 3 water, by weight). SMP treatment promoted earlier seed germination in all tested cultivars, thus resulting in higher rate of graftable seedlings. Brushing before SMP further enhanced earlier and uniform seed germination. Dry heat treatment, which can eliminated the seed-borne *Fusarium* spp. and virus, significantly delayed the early germination although the final germination percentage was not influenced. The characteristics of seedlings will also be presented.

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Seed Priming of Triploid Watermelon Seed

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Triploid watermelon seed does not germinate in cold, wet soils as well as diploids; germination is slower due to reduced embryo size and thicker seed coat; fissures on the seed coat provide safe harbour for fungal spores; and triploid fruit set is later than most diploid cultivars. Because of these problems producers often transplant rather than direct-seed seedless watermelons. Seed priming has been shown to improve germination in other crops and would be an attractive method allowing for direct seeding of seedless watermelons. Seed from open-pollinated 4n x 2n crosses were primed in solutions of H₂O, polyethylene glycol 8000, KNO₃, or left untreated. Treatment times were 1, 3, or 6 days, and treated seed were subsequently dried for either 1 or 7 d. Seed were scored for germina-

tion in the laboratory and emergence under field conditions. Germination was better using H₂O than KNO₃ and PEG but not always better than the untreated control. Treatment time of 1 day was superior to 3 or 6 days, but length of drying time was insignificant. In the field trial, treatments did not differ in emergence.

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Effects of Stand Deficiencies and Timing of Replanting on Yields of 'Athena' Muskmelon

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Seedling losses shortly after emergence in muskmelon (*Cucumis melo* L.) can be potentially devastating to growers. Muskmelon growers often have problems with obtaining adequate stands and need to understand the affects of replanting seed into poor stands. Field studies were conducted over 2 years to determine if replanting (at 1, 2, 3, or 4 weeks after the initial seeding) into stand deficiencies of 10%, 30%, and 50% affected 'Athena' muskmelon size and yield. 'Athena' muskmelon stand deficiencies up to 30% does not appear to reduce total or marketable numbers, but stand deficiencies of 50% or more will decrease total and marketable melon yields. Replanting into 10%, 30%, and 50% stand deficiencies will increase early season melon numbers regardless of the replant times used. For main-season and total-season harvests, there was no advantage of replanting into 10% deficient stands, and in most cases, replanting reduced total and marketable melon numbers. In the 1997 experiment, replanting into 30% and 50% stand deficiencies improved yields but this did not occur in the 1998 experiment. 'Athena' muskmelon should be replanted only if a stand reduction of \approx 50% or more occurs. Melon numbers were generally higher if replanted by 1 or 2 weeks compared to 3 or 4 weeks, but the timing of replanting does not appear to have significant influence on total or marketable melon numbers.

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Determination of Cucurbitaceous Seedling Quality and Leaves Orientation for Robotic Grafting by Machine Vision

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Based on seedling properties and stage of growth for cucurbitaceous and solanaceous vegetables, separate robots are being marketed for each. Full automatic grafting robots are used for solanaceous vegetables like tomato and eggplant employing ordinary splice method by making a diagonal cut through the hypocotyl of both the scion and the rootstock. However, cutting one piece of cotyledon diagonally from the rootstock does grafting of cucurbitaceous vegetables like cucumber, melon, and pumpkin. This method had the advantage of easy recovery and high survival rate of seedlings. Only semi-automatic robots are marketed for this kind of plants because a fixed cotyledon orientation is required for grafting operation. Both the scion and the rootstock are loaded manually to their corresponding feeding devices. To replace the manual loading operation, this study proposed a neural network based automatic seedling loading system. The system automatically estimates the quality and determines the cotyledon orientation of seedling for guiding the loading device of the grafting robot. As a first step toward solution, we report the development of a model for seedling quality estimation and orientation detection using image processing and neural network techniques. The model has a learning ability and can judge seedlings according to the training patterns. A seedling leaves feature extraction model of 10 characteristics was proposed and a three-layer neural network was constructed. The experimental results indicate that the seedling leaves orientation was accurately detected with an average error of 3 degrees within 360 degrees of freedom and the machine vision system could properly classify seedlings into three classes (A-good, B-fair, and C-bad) according to the training pattern.

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Effects of Photoperiod during Transplant Production under Artificial Lighting Conditions on Floral Development and Bolting of *Spinacia oleracea* L.

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Spinach (*Spinacia oleracea* L.) was chosen to demonstrate that value-added

transplant can be relatively easily produced under artificial light in a closed system. Transplant production under artificial light was divided into three periods, and the photoperiod during each period was varied. It was found that the rate of floral development could be controlled by photoperiod treatments, although floral initiation itself could not be manipulated. Short photoperiod treatments retarded floral development and stem elongation. This occurred even when the transplants were transferred for transplanting to natural conditions with long days and high temperatures. In conclusion, by providing the short photoperiod during the transplant production process, marketable plants with negligible bolting can be produced under natural long-day conditions. Moreover, the production cost per transplant in summer could be reduced by using a combination of natural and artificial lighting during the transplant production process. These results open the possibility to produce value-added transplants of different species under artificial lighting conditions and control their floral development and/or stem elongation for a timely and profitable harvest.

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Holding Tomato Transplants beyond Planned Transplant Date

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In a wet spring, transplants must often be held beyond the planned transplant date. The plants become overgrown, making mechanical transplanting difficult. We compared several ways of holding 'Mountain Spring' tomato (*Lycopersicon esculentum* L.) transplants. Transplants were 1) planted outside on planned transplant date in late May (NH), 2) held outside for 2 weeks (HOF), 3) held outside for 2 weeks and not fertilized during that period (HONF), and 4) held in the greenhouse for 2 weeks (HGF). Throughout transplant production, half of the transplants in each holding treatment were fertilized with 100 ppm N and half with 25 ppm N from 20N-4.4P-17K or 15N-2.2P-12.3K. HONF reduced plant height 1.7 to 1.5 cm compared to HOF or HGF. Plants grown with 25 ppm N were 5 to 6.4 cm shorter than plants grown with 100 ppm N and showed symptoms of nutrient deficiency. On average, holding treatments reduced marketable yield 20% to 23% and early yield 31% to 37%, compared to NH. HOF and HGF produced similar marketable yield, early yield, and fruit size. HONF decreased early yield in 1997 and decreased marketable yield in 1998, compared to HOF. The differences between holding treatments were usually greater with 100 ppm N. Plants grown at 25 ppm N produced lower marketable and early yields and larger fruit than 100 ppm N. The best method for holding transplants among those tried here is to put them outdoors and continue fertilizing as during transplant production.

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Seed Treatments for Inactivation of CGMMV in Gourd and Its Detection

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Cucumber green mottle mosaic virus (CGMMV) is a noxious disease in cucurbits, especially in Asia where grafting is commonly practiced. CGMMV can be easily transmitted by seed, hands, soil, or grafting. Seed companies are rigorously looking for effective and efficient means of CGMMV inactivation in infected seeds. Among the various treatments applied to the seeds, dry heat treatment (35° C 1 day + 50° C 1 day + 75° C 3 days) was found to be most suitable for complete inactivation. Various identification methods including high-density latex agglutination test (HDLPAT), ELISA, RT-PCR, and bioassay (*Chenopodium amaranticolor*) were compared for accurate diagnosis of the presence of virus in seeds. The results from HDLPAT showed the highest correlation with the bioassay results, suggesting that HDLPAT can be safely used for accurate means of virus detection. Details of dry heat treatment, various seed treatment, and other detection methods will be presented.

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Breeding and Selection for Low-bearing Papaya in the Virgin Islands

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Demand for locally produced papaya fruit (*Carica papaya*) far outweighs the supply in the U.S. Virgin Islands. Due to the high incidence of papaya ringspot virus (PRSV), papayas are grown as an annual crop. The need exists in the Virgin

Islands for papayas with early production to ensure a marketable crop before being devastated by PRSV. Breeding and selection has been ongoing for 5 years to develop papayas with tolerance to PRSV and fruit production starting at or less than 60 cm from the ground. The height at first fruit set, of 15 papaya cultivars recommended for the Virgin Islands, ranges from 58 cm to 253 cm. Generally, female plants started setting fruit lower on the stem than hermaphroditic plants. Through breeding and selection, three papaya lines have been developed that set the first fruit between 40 and 60 cm from the ground and exhibit tolerance to PRSV. These low-bearing papaya lines produce fruit that are marketable 1 month earlier than other cultivars.

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Rootstock and Scion Trials for Lemon in Arizona

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Five rootstocks, 'Carrizo' citrange, *Citrus macrophylla*, Rough lemon, 'Swingle' citrumelo, and *Citrus volkameriana*, were selected for evaluation using 'Limoneira 8A Lisbon' as the scion. Four years of yield and fruit packout data indicate that trees on *C. volkameriana* and *C. macrophylla* are superior to those on other rootstocks in growth and yield. 'Swingle' and 'Carrizo' are performing poorly, and Rough lemon is intermediate. In a similar trial, four 'Lisbon' lemon selections, 'Frost Nucellar', 'Corona Foothills', 'Limoneira 8A', and 'Prior' selections of Lisbon lemon were selected for evaluation on *Citrus volkameriana* rootstock. Four years of yield and packout data indicate that the 'Limoneira 8A Lisbon' selection has generally outperformed the other selections in both growth and yield, although 'Corona Foothills' has been superior in the 1998–99 harvest season.

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Crop Production

Saturday, 31 July, 1:00–2:00 p.m.

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Isoperoxidase and Protein Patterns in Compatible and Incompatible Pear/Quince Graft Combinations

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The similarity or differences of peroxidase isozymes in rootstocks and scions may influence their graft compatibility. This study was conducted to identify peroxidase isozymes and/or other proteins that may be used as markers to predict compatibility between pear and various quince clones. 'Bartlett' (BT) and 'Beurre Hardy' (BH) pear cultivars were budded on 13 selected quince clones and quince A (QA) rootstocks; BT and BH cultivars are known to be incompatible and compatible, respectively, with quince root stocks. Bark and cambial tissues were taken from unbudded rootstocks, scions, and 4 cm above and below the graft union for isozyme analysis. Samples were collected 1, 2, 3, and 12 months after grafting. In addition, samples from the graft unions were also analyzed 12 months after grafting. Isozyme separation was performed by starch gel electrophoresis. Many isozyme bands were commonly observed in the two scions; however, one anodal peroxidase was detected in BH but not in BT samples. This isozyme was also detected in QA and in all but four quince clones. Protein profiles of bark tissues from QA and three pear scions (BT, 'Bosc', and *P. crassane*) were determined using SDS-PAGE. In general, protein profiles of the three pear cultivars appeared remarkably similar; however, *P. crassane* (a compatible pear cultivar on QA) had a 63 kDa protein, which was absent in BT and faintly observed in 'Bosc' (intermediate compatibility). Our results suggest that these isoperoxidase and polypeptide could be associated with pear/quince graft compatibility.

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Evaluation of Spur-type Apple Cultivars on Dwarfing Rootstocks

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The performance of spur-type apple cultivars was evaluated on MM.111, MM.106, M.7A, M.26, and Mark rootstocks. Shoot growth, leaf area, and total nonstructural carbohydrate (TNC) were affected by scion cultivar and rootstock. Empire on Mark stock had less shoot growth. Ultra Mac on M.7A produced smaller leaf area. 'Braeburn' on Mark stock exhibited higher TNC content. Scion cultivar and stock influenced fruit weight and yield, L : D ratio, SSC, pH, and the content of N, P, K in leaves and fruit. 'Braeburn' on M.7A, M.26, and MM.111 produced greater yield per tree. L : D ratio was higher in 'Ultra Gold' on MM.106. 'Ultra Gold' and 'Jon-A-Red' had higher SSC on Mark. 'Empire' and 'Ultra Gold' on M.7A resulted in higher juice pH. 'Empire' on MM.106 produced heavier fruit and higher N content in leaves and fruit. 'Ultra Mac' on M.7A showed higher P and K content in the fruit.

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Fruit Removal Effects on Growth and Carbon Allocation in Young Citrus Trees

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Fruit were removed 8, 16, and 24 weeks after peak bloom from 3- and 4-year-old, 'Hamlin' orange [*Citrus sinensis* (L.) Osbeck] trees on 'Carrizo' citrange rootstock [*C. sinensis* (L.) Osbeck x *Poncirus trifoliata* (L.) Raf.], planted as bare root or containerized trees, to determine if fruit removal enhanced vegetative growth. Bare-root trees had a greater stem diameter and tree height than containerized trees at planting and after years 3 and 4. Fruit of bare-root trees had lower fresh and dry weights, refixed less of their respiratory CO₂ during development, and lost water less rapidly after harvest. In addition, fruit removal treatments did not increase growth of either bare-root or containerized trees relative to trees from which no fruit had been removed. In fact, tree diameters were slightly higher when fruit were not harvested. Carbon cost of fruit production may have been countered by other factors under field conditions, such as known enhancement of photosynthetic rates by fruit load and/or diurnal contributions by fruit to leaf water demands.

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Estimating Optimal Sample Size for Sweet Orange Fruit Quality Experiments

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Variability in fruit quality of citrus occurs among and within trees due to an interaction of several factors, e.g., fruit position, leaf : fruit ratio, and fruit size. By determining variability in fruit quality among i) fruit, ii) trees, iii) orchards, and iv) geographic locations where citrus is produced in Florida, optimal sample size for fruit quality experiments can be estimated. To estimate within-tree variability, five trees were randomly selected from each of three 'Valencia' orange orchards in four geographic locations in Florida. Six fruit were harvested from each of two tree canopy positions, southwest top and northeast bottom; fruit were not selected or graded according to fruit size. °Brix and titratable acidity of juice samples were determined, and the °Brix : acid ratio was calculated. Statistical analysis of fruit quality variables was done using a crossed-nested design. The number of trees to sample and the number of fruit per sample were calculated. To estimate between-tree variability, 10 trees were randomly selected from each of three 'Valencia' orange orchards from four geographic locations in Florida. Fifty-fruit composite samples were picked from around the tree canopy (0.9 to 1.8 m). Juice content, SSC, acid content, and ratio were determined. Using a nested design, the number of orchards and number of trees to sample were determined. There was greater variability in fruit quality among trees than within trees for a given canopy position; the optimal sample size when taking individual fruit samples from a given location and canopy position is four fruit from 20 trees. There was

less variability in fruit quality when 50-fruit composite samples were used, resulting in an optimal sample size of five samples from three orchards within each location.

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Developing a Chemical Delivery System in Tree Fruit Production

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In China, one of the most serious problems to fruit growers is too much vegetative growth and too many pests and diseases during the growing season. Therefore, a large number of growth regulators, pesticides, and fungicides are used each year, which increases production costs and causes environmental pollution. To reduce the usage of agrochemicals, a device was invented to confine the treated area. Instead of applying chemicals directly to leaves, which may have reduced the efficiency by washing or UV degradation, the chemicals were injected directly to the trunk of trees and transported through the xylem to the target organ, the leaf. Results showed that, to reach the same level of control, using plant regulators such as paclobutrazol, gibberellins, and ascorbic acid, the amount used could be reduced by 50% to 80%. The use of fungicides such as captan and diazinon could be reduced by 35% to 60%, and the use of pesticides such as vendex could be reduced by as much as 50%. Compared with the conventional method, the injection method showed three advantages: 1) It is economical in that production costs were reduced by about 40%, 2) It is efficient in that the same level of control was achieved using less chemicals (Due to the small acreage cultivated by family growers in China, the device could be installed within days and chemicals could be applied within hours.), 3) It is environmentally friendly because chemicals were not released throughout the orchard.

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Vegetative Growth of *Malus domestica* sp. Enhanced with the Use of the Mycorrhizal Fungus *Glomus intraradices*

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Two experiments with *Malus domestica* sp. were planted in 1997 at the Laval Univ. experimental farm located south of the St. Lawrence river near Quebec City. These experiments examined the association of the mycorrhizal fungus *Glomus intraradices* with *Malus domestica* sp. The first experiment compared the vegetative growth of 'McIntosh' apple trees on M.106 rootstock in presence or absence of a commercial inoculum of *G. intraradices* (Premier Tech, Riviere-du-Loup, Quebec) under three levels of phosphorus fertilization (P) to the soil (0%, 50%, and 100% of the usual recommendation for this crop). After two seasons, all the treatments had better growth than the control (0% P without *G. intraradices*). The best treatment was achieved with 100% of the P associated with mycorrhizal inoculation. The second experiment compared the vegetative growth of three apple rootstocks Bud.9, M.26, and M.106, inoculated with *G. intraradices* under the same three P levels as the preceding experiment. Uninoculated rootstocks receiving the usual phosphorus fertilization served as control. Two rootstocks, M.26 and M.106, increased growth with *G. intraradices*, while the third one, Bud.9, did not respond to the presence of mycorrhizal fungus.

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Effects of Fall Urea and Copper Chelate (CuEDTA) Application on Defoliation, Reserve Nitrogen, and Spring Regrowth of 'Fuji' Apple Nursery Trees

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Bench-grafted 'Fuji'/M.26 trees were sprayed with 1% CuEDTA on 31 Oct., defoliated manually on 12 Nov., or allowed to defoliate naturally. Foliar urea at 3% was applied at 14 days and 9 days before CuEDTA treatment. Plants were harvested after natural leaf fall and stored at 2 °C. One set of the plants were destructively sampled for reserve N (expressed as total Kjeldahl N or soluble protein concentration) analysis, and the remaining plants were transplanted into a N-free medium in the spring without any N supply for 40 days after budbreak. CuEDTA resulted in >80% defoliation within 5 days of application. Trees defoliated with CuEDTA had lower reserve N content than naturally defoliated controls,

but had higher N than hand-defoliated controls. Foliar urea application before the CuEDTA treatment significantly increased reserve N level in all tree parts, without affecting the efficacy of CuEDTA on defoliation. The extent of spring regrowth was proportional to the reserve N level of the tree. Urea-treated plants, whether hand- or CuEDTA defoliated, had more growth in the spring than hand- or naturally defoliated controls. It is concluded that CuEDTA, as combined with foliar urea, can be used to effectively defoliate apple nursery trees, and increase reserve N level and improve regrowth performance during establishment.

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Growth of Papaya Seedlings under Wind Load and Drought Stress

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Two studies were conducted with 'Known You 1' and 'Sunrise' papaya seedlings to determine the combined influence of wind and drought stress on growth. For each study, 4-week-old nursery plants were transplanted into 2.6-L containers and placed in a protected site with rain exclusion provided by polypropylene cover. Industrial fans were used to provide unidirectional wind of ≈2 m/s for 12 hours per day to half of the plants; the remaining half of the plants received no wind. One half of the plants for each cultivar and wind combination were designated as well-watered and received daily irrigation. The remaining half of the plants were designated as drought-stressed and received 25% to 50% of the water applied to the well-watered plants. Plants were grown for 3 weeks under these experimental conditions. There were no interactions between the drought and wind main effects. The reduction in height, trunk cross-sectional area, total plant dry weight, and relative growth rate below that for control plants was similar for drought stress or wind stress. Wind stress reduced growth of 'Sunrise' plants more than 'Known You 1' plants in both studies. Although the main effects did not interact, the combination of drought and wind stress reduced growth of papaya seedlings more than did either main effect alone. The greatest wind load from trade winds occurs on Guam during the annual dry season. These data indicate that chronic wind stress during the dry season may be more detrimental to growth of papaya seedlings than during the rainy season or under sufficient irrigation practices.

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Arbuscular Mycorrhizal Fungal (AMF) Colonization of *Carica papaya* 'Waimanalo' Grown in Composted Landscape Yard Trimmings

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Seedlings of *Carica papaya* L. 'Waimanalo' (papaya) were transplanted into 27-L containers filled with nonsterile composted landscape yard trimmings passed through a 1.3-cm screen. At transplanting, papaya plants were inoculated with either one of three different AMF communities or were not inoculated as control plants. Two of the AMF communities were from Arizona citrus orchards, and one AMF community was from an undisturbed western Chihuahuan Desert soil. After transplanting, papaya plants were grown for 4 months under well-watered conditions in a temperature-controlled (32 °C day/24 °C night) glasshouse (45% light exclusion). Control plants remained non-mycorrhizal. Total colonization of papaya roots by AMF communities ranged from 56% to 94%. Depending on mycorrhizal treatment, AMF arbuscules and internal hyphae were present in 30% to 60% and 20% to 24% of roots, respectively. Noticeably absent in papaya roots were AMF vesicles. Papaya height, trunk diameter, and leaf phosphorus concentration were similar for inoculated and control plants. Compared with control plants, papayas inoculated with AMF communities had about 20% less shoot dry weight and about 50% less root dry weight. Under nonlimiting conditions in an organic substrate, AMF communities did not stimulate papaya growth but rather appeared to function as a carbon sink.

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Sunlight Penetration Before and After Pecan Orchard Thinning: Its Influence on Shoot Growth, Nut Production and Quality

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This study was performed during 1995, 1996, and 1997 seasons in a mature pecan orchard thinned 25% in 1993, 1994, or 1995. In the orchard section thinned

in 1994, more trees were removed in 1995 to reach 50% thinning. Shoot length in eight sides of the canopy periphery was measured in each growing season. Shoot growth was increased in thinned orchard sections compared with the unthinned orchard areas. Shoot growth during 1995 and 1996 was higher for trees sections thinned 25% in 1993 and 1994. Regardless of thinning years, shoot length was lower in the north side than in other canopy sides. A trend for nut yield increment was observed in thinned orchard blocks, especially where 50% tree removal was performed. Nut quality expressed in kernel percent was more related with crop load than to thinning percent or thinning year.

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Sunlight Penetration within the Tree Canopy after Tree Removal in Crowded Pecan Orchards

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This study was conducted during 1996 and 1997 in a mature pecan orchard gradually thinned over 3 years. Twenty-five percent of the trees were first removed in 1993, 1994, or 1995. The orchard thinned in 1994 was further thinned to 50% in 1995. Diffuse photon flux density of photosynthetic active radiation (PAR) was measured within the tree canopy before and after tree thinning. Sunlight penetration measurements were taken on eight tree sides as follows (N, S, E, W, NE, SE, NW, NE), 24 readings were taken on each tree side three times a day. As expected, penetration of PAR inside the tree canopy increased as thinning reduced tree density. PAR levels recorded at 9, 12 or 15 daytime hours within the tree canopy increased as the solar time increased. Lower light values were found in the north side of the tree canopy compared to other tree sections.

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Shading Effects on Vegetative Growth and Fruiting of Coffee

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A shade experiment for pruned coffee trees was conducted on Maui, Hawaii, in 1996. Nine-year-old 'Guadalupe' trees were stumped at 70 cm above the ground, and three main verticals were allowed to remain on the main trunk. Each stumped tree was randomly selected and covered with shade cloth. The shade cloths were 30%, 50%, and 70% shade, and each shade structure had a length x width x height of 1.5 x 1.5 x 2.5 m. Data were collected in 1997. In general, the basal diameters of the verticals were similar in all treatments, as were the lengths of the verticals. The total number of laterals in the full-light treatment was slightly more than that of the other treatments. The numbers of flowering laterals were similar in all treatments. The numbers of fruit per tree in the full light, 30%, 50%, and 70% shade treatments were 1876, 3434, 2399, and 403, respectively. Fruit per flowering node was the best index relating to yield. Fruit per node was highest under 30% shade, followed by full light and 70% shade. At the beginning, fruit ripened faster in the full light treatment than in the other treatments, but at the end of September, fruit in 70% shade ripened slower than the other treatments. Therefore, after stumping, coffee trees grew best under 30% shade. For coffee, pruning under the field condition, stumping every other row of trees may be a satisfactory way to obtain the best yield in the future.

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Using Leaf Area Devices (LADS) to Estimate Total Leaf Area of Coffee Plants

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It is difficult to estimate the total leaf area of coffee plants with accuracy due to the large number of leaves and the high leaf density of the plant canopy. In 1996, on Maui, Hawaii, 98 leaves of various sizes were randomly collected for each of five cultivars of *Coffea arabica* L. The cultivars used were 'Guadalupe', 'Guatemalan', 'Mokka', 'Red Catuai', and 'Yellow Caturra'. Leaf length, width, and area were measured. Seventy-five leaves were used to develop leaf area models, and the remaining leaves were used to test the accuracy of the models using a 1:1 line. We then developed leaf area devices (LADS), which were made of sheet plastic and shaped to resemble coffee leaves. There were three groups of areas in the leaf area devices, based on leaf sizes. Total leaf area (TLA) contained three components. Each component related to the mean leaf area (k) and the number of leaves (n) in that group. The model for the total leaf area was: $TLA = k_1n_1 + k_2n_2 + k_3n_3$, where k is a constant in each group. The estimation errors for the different culti-

vars ranged from 5.6% to 12.3% for 1-year-old plants (four cultivars) and from 1.9% to 7.8% for mature plants (five cultivars). By using the LADs and counting the number of leaves, we can obtain the total leaf area for coffee plants in the field.

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The Effect of Simulated Stress on the Yield and Size of 'Gala' and 'Empire' Apple

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Pest damage to apple fruit is intolerable by our current standards. However, the effects of foliar damage on the plant's physiological status and fruit quality are not thoroughly understood. The objective of this work was to determine the time during the growing season when apple trees are most susceptible to foliar damage. Terbacil (50 ppm), an inhibitor of photosynthesis, was applied to 8-year-old 'Gala'/Mark planted at 6 x 18-foot spacing or 14-year-old 'Empire'/M106 planted at 18 x 20-foot spacing at 20- to 30-day intervals from petal fall until harvest to simulate environmental or biological stress. The work was conducted from 1995 through 1998. Photosynthesis was inhibited by 50% to 80% within 24 h of application of Terbacil but recovered to control levels 10 to 14 days after. The fruit were evaluated at harvest for total yield, size of fruit, and fruit number. Terbacil induced fruit abscission when applied at petal fall but not at later dates. The earlier the application, the greater the effect on current seasons yield and fruit size depending on crop load. For 'Gala', there was a reduction in yield at petal fall of 30% to 70% over the control trees. Further detailed results will be presented.

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Oil Emulsions Enhance Transcuticular Movement of Captan into Apple Leaves

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Oil sprays increase the phytotoxicity of captan to apple foliage. The purpose of this study was to determine if oils increase the penetration of captan through leaf cuticles. Enzymatically isolated apple leaf cuticles were used as a model system to study captan penetration. A bioassay was developed using the inhibition of growth of *Penicillium cyclopium* on potato-dextrose agar as a measure of captan penetration through the cuticle. Captan penetrated through both surfaces, but significantly more penetrated through the abaxial cuticles than the adaxial cuticles. Increasing the captan concentration increased the captan penetration through the abaxial cuticle in a linear relationship. Captan penetration through the cuticle was increased by 63% when cuticles were treated with captan plus 1% emulsified soybean oil. Abaxial cuticles treated with captan plus emulsified soybean oil or with captan plus SunSpray Ultra-Fine oil had >125% greater captan penetration than cuticles treated with only captan. Cuticles treated with captan plus dormant oil (petroleum oil) had 220% more captan penetration than the captan only treatment.

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The Use of Particle Film Technology in Tree Fruit Production

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Particle film technology uses inert mineral particles to envelope a plant in a protective and porous "particle film." The film appears to protect against insect damage by creating a hostile and unfamiliar environment, causing nonrecognition of the host, acting as an irritant, and giving poor adhesion or gripping of eggs and insects to the plant surface. Being porous, the particle film allows free exchange of water and carbon dioxide from the leaf during photosynthesis. The mineral particles are reflective of infrared radiation and reduce the heat load on the plant. Laboratory, greenhouse, and field trials demonstrate that particle film technology is a viable pest control practice for a wide range of insect and disease problems with additional horticultural benefits due to reduced heat stress. In field studies, reducing heat stress improved red apple color development, increased leaf photosynthetic rates, and increased yield. Particle film technology appears to be a viable alternative to conventional pesticide use in apple and pear production. Particle films have the added benefits of reducing plant heat stress and improving safety to farm workers, consumers, and the environment.

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Study of Regular and High Applications of Water with Drip Irrigation in Small 'Manzanillo' Olives

Adán Fimbres Fontes*, Raúl Leonel Grijalva Contreras, and Manuel de Jesús Valenzuela Ruiz; Apdo. Postal No. 125, Caborca, Sonora, Mexico 83600

The area of olives in the region of Caborca has been increasing in the last years to 4500 ha. Olives in other regions do not need the application of water, at Caborca evaporation is greater than rainfall. Because of that situation, an experiment was conducted in 1998 to determine the optimum water requirements and the crop coefficient for 'Manzanillo' olives (2 years of planted) under drip irrigation and microsprinkler in a sandy loam soil. The results indicated no difference between treatments (50%, 75%, and 100% of ET estimated in a pan evaporation). The water applied to each treatment was 13.32, 19.98, and 26.64 cm.

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Evaluation of the Available Moisture in 'Mission' Olives

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The area of olives in the region of Caborca has been increasing in the last 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 1998 to determine the optimum water requirements for olives (table olives) in a sandy loam soil (flooded irrigation). The results indicated that the greatest yield (16.27 kg/tree) was with 90% and 80% depletion (15.8 kg/tree) of the available moisture (AM) in the soil (1-m depth) and the lowest yield (8.46 kg/tree) was with 100% depletion and 60% depletion of the available moisture in the soil. The total water applied with the 90% depletion of the AM was of 146.77 cm (1.467 m).

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Evaluation of Phosphate Desorption Characteristics of Clay Minerals for Soilless Root Media

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Soilless root media retain very little phosphate. This characteristic necessitates continual application of phosphate, which leads to excessive application and leaching. The phosphate desorption characteristics of synthetic hematite ($\alpha\text{-Fe}_2\text{O}_3$), goethite ($\alpha\text{-FeOOH}$), allophane ($\text{Si}_3\text{Al}_4\text{O}_{12}\cdot n\text{H}_2\text{O}$), and a commercial alumina (Al_2O_3), previously determined for their maximum adsorption capacities, were evaluated to determine their potential for providing a low, constant soil solution phosphate supply with low phosphate leaching from soilless root media. The desorption isotherms of the clay minerals were obtained by introducing 10 mM KCl solution at 0.2 ml/min flow rate into a stirred flow reaction chamber loaded with clay adsorbed with phosphate at maximum adsorption capacity. The suspension in the reaction chamber was held at pH 6.4 during desorption. Effluent solutions were collected for phosphorus analysis until the equilibrium concentration of phosphorus in solution reached 0.05 mg \cdot L⁻¹. Adsorbed phosphorus at 0.05 mg \cdot L⁻¹ equilibrium concentration in solution was in the order allophane (19 mg \cdot g⁻¹) > aluminaTM goethite (8 mg \cdot g⁻¹) > hematite (1.3 mg \cdot g⁻¹). The equilibrium concentration of phosphorus in solution over time showed that allophane releases phosphate for a longer time than the other clay minerals at a desirable soil solution concentration for plants, less than 5 mg \cdot L⁻¹. Among the clay minerals tested, allophane showed the most favorable potential to supply phosphate to plants in soilless root media.

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Evaluation of in situ N Mineralization of Composted Organic Wastes Applied to Sandy Soil

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In 1997, 24.7 million t of solid waste were produced in Florida (about 4.3 kg per person per day). If all biodegradable material was composted, 12.4 million t of compost would be produced annually. If this compost was used as a soil amendment in fruit and vegetable production, knowledge of its N mineralization rate would be important to determine the application rate. We measured the field N mineralization of four commercial Florida composts mixed with sandy soil (dry

weight rate): Jacksonville (yard trimming compost, 127 t \cdot ha⁻¹), Sumter (municipal solid waste compost, 67 t \cdot ha⁻¹), and Nocatee and Palm Beach (yard trimming and biosolids composts, 63 and 56 t \cdot ha⁻¹). The control treatment was unamended soil. Open-top, 20-cm long PVC columns were filled with soil/compost mixtures and fitted at the bottom with a trap containing cation and anion exchange resin to capture leaching NO₃ and NH₄-N. The columns were buried in the soil at ground level and incubated in situ for 45 and 90 days in the spring. The resin was extracted with 1 N KCl and the mass of NO₃-N and NH₄-N adsorbed was determined. A similar procedure measured the NO₃-N and NH₄-N left in the soil/compost mixture. After 90 days in the field, net N immobilization was observed with Nocatee (-4.3%), Sumter (-3.0%), and Jacksonville (-1.3%) composts, while N mineralized (6.4%) from Palm Beach compost. Where N immobilization occurred, composts had initial C : N greater than 20 : 1 and N concentration <1.6%. Mineralization occurred where compost had C : N ratio lower than 20 : 1 and N concentration greater than 1.6%.

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Pampas Grass (*Cortaderia argentea*) Response to Ancymidol, Paclobutrazol, and Uniconazole Substrate Drenches

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Plant growth retardant (PGR) substrate drenches (in milligrams active ingredient) of ancymidol at 0.25, 0.5, 1, 2, or 4; paclobutrazol at 1, 2, 4, 8, or 16; and uniconazole at 0.25, 0.5, 1, 2, or 4 were applied to pampas grass (*Cortaderia argentea* Nees) to compare their effectiveness at chemical height control during greenhouse forcing and evaluate the residual effect on plant growth in the landscape. *Cortaderia argentea* plant height exhibited a quadratic dose response to paclobutrazol and uniconazole, while ancymidol-treated plants showed a linear dose effect. During greenhouse production, all rates of uniconazole reduced plant height by 56% to 71% compared to the untreated control, whereas paclobutrazol and ancymidol treatments reduced plant height by 14% to 61% and 0% to 34%, respectively. Severe height retardation was evident at 2 mg of uniconazole. By week 5 in the field all plants treated with uniconazole, paclobutrazol doses of 4, 8, or 16 mg, and with 4 mg of ancymidol were shorter than the untreated control. By week 24 in the field, all plants exhibited similar heights except plants treated with uniconazole at 1, 2, or 4 mg remained shorter than the untreated control. In conclusion, each PGR was effective in controlling plant height of *Cortaderia argentea* during greenhouse forcing. Furthermore, plants treated with low to moderate rates of ancymidol or paclobutrazol grew out of the regulating effect by week 5 in the landscape. These results demonstrate that PGR can be effectively and economically employed in the production of *Cortaderia argentea*.

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Comparison of On-site and Electronic Meteorological Service Weather Data for Use with a Disease Forecast System

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Weather information has many applications in crop production practices, including disease forecasting. A variety of weather instruments are available for on-farm use, but associated costs and need for regular calibration and maintenance can limit actual use, especially by smaller growers. Subscription to an electronic meteorological service may be a viable alternative to on-site weather stations. In 1997 and 1998, hourly temperature, relative humidity and leaf wetness were monitored at six sites in a 400-m² area of New Jersey with Field MonitorTM data loggers (Sensor Instruments, Inc.) and by subscription to SkyBit, Inc., an electronic meteorological service. There was close correspondence in temperature data from the two sources at all sites, the average seasonal difference ranging from 0 to 2 °F. Relative humidity data was variable between the two sources, the greatest

variation occurring at low and high humidity, the ranges at which relative humidity sensors had been shown to be least accurate. Leaf wetness estimates from the two sources agreed at least two-thirds of the time. Data differences related to source were attributed to both systematic and random error. The usefulness of electronic weather data in crop production depends on how sensitive the particular weather-dependent applications (e.g., predictive disease and insect models) are to variation in the input data. The TOM-CAST early blight forecaster for tomatoes was not particularly sensitive to differences between SkyBit and Field Monitor leaf wetness estimates.

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Micropropagation of *Baptisia bracteata* Mnhl. via Direct Regeneration

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Native plants are often ignored in horticulture because they may lack major ornamental traits and many of them are difficult to propagate. Creamy indigo (*Baptisia bracteata* Mnhl.) is a North American legume with considerable potential as a container-grown or ornamental plant for managed landscapes. Nodal explants from aseptically germinated seedlings were evaluated for axillary shoot and leaf development. The explants were cultured on Murashige and Skoog medium (MS) containing adenine sulfate at 80 mg • L⁻¹, 30% sucrose, and different levels of N-6-benzyladenine (BA) (0.5, 1.0, 2.0 mg • L⁻¹) supplemented with indole-3-acetic acid (IAA) (0.05, 0.1 or 0.5 mg • L⁻¹) or with IAA omitted. Shoot regeneration occurred within 2 to 3 weeks. The best medium for shoot regeneration was MS supplemented with BA at 1.0 mg and IAA at 0.1 mg • L⁻¹. Shoots were transferred onto rooting medium consisting of ½ MS supplemented with 1.0 mg alpha-naphthaleneacetic acid (NAA) and 1.0 mg indole-3-butyric acid (IBA)/L and 20% sucrose. Rooting took place within 3 to 5 weeks. Plantlets were then planted in soil mix, placed under a polyethylene tent for 2 weeks, and transferred into the greenhouse for further growth.

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Effect of SMP and Brushing on Gourd Seed Germination at Different Temperatures

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The effectiveness of solid matrix priming (SMP) and seed brushing was further evaluated by using an thermo-gradient table (Seed Processing, Holland) set at 10 different temperatures from 12 to 30 °C. Intact or brushed seeds of gourd (*Lagenaria siceraria*) were primed with Micorocel E (Celite Corp.) at 25 °C for 3 days in the mixture of 10 seed : 1 Micorocel E : 3 water, by weight, and the primed seeds were dried again for long-term storage. SMP treatment significantly increased earlier seed germination at all temperatures. However, the difference in seed germination rate between intact and SMP-treated seeds was most pronounced at somewhat lower temperatures of 18–22 °C. SMP-treated seed showed about 20% final germination rate at 12 °C, whereas intact seeds did not germinate at all. Seed brushing treatment itself did not influence the germination rate. However, brushing treatment before SMP treatment significantly increased the SMP effect. Combined use of chemicals in solution further increased the early germination. Details of various seed treatment methods will be presented.

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Nursery Irrigation Effects on Postplanting Root Development of Two Mediterranean Species in Semi-arid Conditions

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A study was conducted with *Lotus creticus* and *Limonium cossonianum* to analyze the influence of irrigation regime in nursery on the dynamics of root development after being transplanted with minimum management conditions. Plants were pot-grown in a greenhouse located at the southeastern Mediterranean coast of Spain (37°47'N, 0°54'W). Each plant was potted into 625-mL plastic pot filled with a 1 silica sand medium : 1 peat (v/v) mixture amended with osmocote plus (3.7 g • kg⁻¹ substrate). Drip irrigation was used, with a 2-L • h⁻¹ emitter per plant. Three irrigation treatments were utilized: T6, plants watered 6 days a week at the water-holding capacity (leaching ≈20% of the applied water); T3, plants watered 3 days a week; and T2, plants watered twice a week. T3 and T2 plants received

amounts of water at ≈50% and ≈30%, respectively, of T6 plants throughout the nursery period (3 months for *Lotus* and 45 days for *Limonium*). After nursery period, plants were transplanted into transparent containers (round acrylic tubes 8 cm in diameter and 100 cm tall) filled with silt loam texture soil, and just one establishment irrigation was applied (30 mm). Containers were covered with a black plastic sheet and isolating material to prevent light influencing and becoming heated. There were three replications. Plant root and top growth were measured every 3 days for 1 month. Results indicate that those plants that were less watered in nursery showed a greater and faster root development especially where depth was concerned. Lotus plants root growth, for the top 20 cm of soil, were not significantly affected by irrigation treatments; between 20 and 40 cm deep, T2 plants at 12 days after transplanting (DAT) had 2.8- and 9.1-times greater root length (RL) than T3 and T6 plants, respectively. At 30 DAT, T2 plants had 1.7- and 6.2-times higher RL than T3 and T6, respectively. Under 40-cm deep (where infiltration of the establishment irrigation water was very limited), only T2 plants developed roots. There was no plant top growth throughout this period. *Limonium* plants exhibited notably lower root development (≈1/5) than *Lotus* plants. In the top 15 cm of soil, *Limonium* plants RL were not significantly affected by irrigation treatment; between 15 and 30 cm deep, T2 and T3 plants, at 10 DAT, had 2.2-times longer RL than T6 plants, and at 30 DAT, T2 plants had 1.4- and 2.1-times greater RL than T3 and T6 plants, respectively. Below 30 cm, only T2 plants developed roots and, even so, very few ones. For this period, a slight plant top growth was observed, there being no significant differences among irrigation treatments. Research supported by CICYT grant AGF-96-1136-C02-02.

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Selected Seed Treatments to Enhance Germination of Oil-bearing *Oenothera* Species

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The oil extracted from seed of selected accessions of *Oenothera*, also known as the wildflower evening primrose, has documented medical applications. Evening primrose oil contains from 0.0 to 12.0% gamma-linolenic acid (GLA) (C 18:3, delta 6, 9, 12). This unique fatty acid, which occurs in only a few plant species, can correct deficiencies in the delta 6 desaturase enzyme. Low levels of this enzyme prevent formation of the long chain fatty acids responsible for the production of prostaglandins and thromboxanes. Supplementation of the diet with evening primrose oil rich in GLA ensures adequate levels of these essential products. Inconsistent seed germination, poor emergence, and small seed size of accessions containing higher levels of GLA have limited commercial production of this crop. Currently, most producers establish their field through transplants. In this project, methods of improving seed germination have been explored. Seed coatings using diatomaceous earth were shown to facilitate handling and improve germination in the laboratory. Osmotic priming and red light exposure were also evaluated as means of improving germination.

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Identification and Characterization of Overwintering Methods for Container-grown Herbaceous Perennials

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A survey was conducted to identify and characterize the effectiveness of overwintering methods used to protect container-grown herbaceous perennials in USDA hardiness zones 3 through 8. Survey questionnaires were sent by first-class mail on 20 Aug. 1996 to 634 firms involved in growing and/or selling container-grown herbaceous perennials identified from the *Perennial Plant Association Membership Directory*. Completed questionnaires were received from 293 individuals (46.2% response rate) in 38 states, the District of Columbia, and six Canadian provinces. Survey participants reported using several overwintering methods: structureless systems (71.0%), polyhouses (52.9%), polyhouses with inflated double polyethylene covers (30.7%), and low-profile polytubs (12.3%). Over three-fourths of the respondents (78.8%) said their winter protection methods resulted in minimal to no plant loss (0–10%). Only 53 respondents (18.1%) reported losses >10%. The most frequently cited reason for plant loss across all hardiness zones was excessive moisture inside the overwintering environment (50.2%). Equal percentages (33.4%) indicated low temperatures and damage from animals as the next most likely factors responsible for plant loss. Respondents identified, in descending order, *Iris*, *Delphinium*, *Lavandula*, *Papaver*, and *Lupinus* as the five genera most difficult to overwinter.

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Root Architecture in *Quercus falcata* after Physical Removal of the Radicle Tip or Copper Treatment

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Quercus falcata acorns were cold-stratified for 120 days and then sown in vermiculite under greenhouse conditions. When radicles were 7 cm long, the root tip was either removed (physically pruned) or dipped in a copper hydroxide solution (copper-treated). Intact root systems were used as control. Seedlings were then moved to a root box to observe root system architectures. The box was built of clear plexiglass 2.5 mm thick, and each face was 25.7 x 35.7 cm. Styrofoam spacers were used to separate faces, and nuts and bolts were placed along edges to hold the root box together. To permit observation of the entire root system, plants were grown in a plane between the plexiglass surface and a nylon sheet that separated roots from the medium (MetroMix 510). At 7, 9, and 11 days after treatment, the entire root system was traced on an acetate sheet, and number of internal and external links and number of secondary and tertiary roots were recorded. Total length, internal and external root links length, were obtained using digital analysis (MacRhizo). Dry weight of roots and shoots was collected at the end of this experiment (day 11). Treatment effects were evident 11 days after treatment. Copper-treated plants had statistically more secondary roots and larger internal link length than control or physically pruned plants. Also, copper-treated plants had smaller mean external link length, showing a more branched root system. Root biomass was similar for all treatments; however, copper-treated plants had smaller root : shoot ratio. This suggests that copper was acting as more than a pruning agent because copper-treated plants showed a different root system architecture compared to physically pruned plants.

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Retractable Shading Reduces Summer Substrate Temperatures in Container-grown Nursery Crops

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The influence of no shading; 30%, 47%, or 63% black polypropylene stationary shading; and white poly retractable shading (50% shade operated to provide morning "cold trapping") on substrate temperature was studied for *Coreopsis verticillata* 'Zagreb' and *Forsythia* 'Lynwood' growing in 2.75-L black polycontainers filled with an unamended Douglas-fir bark substrate. The southwest region of the rootball had the highest daily substrate temperatures under all the shading systems. Substrate temperatures were highest under no shading or 30% shading (often >45 °C) and lowest under retractable shading (never >38 °C). Root death occurred on the southwest portion of the rootball on plants growing under all shading systems except under retractable shading. *Coreopsis* and *Forsythia* were taller when grown under 63% stationary shading compared to other shading systems but had more shoot dry weight when grown under retractable shading. Cooler substrate temperatures that prevent damage to the root system may help explain increased growth of some nursery crops when produced under retractable shading.

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Phytotoxic Effect of Pine Bark Mulch in Landscape Beds

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The use of shredded bark, wood chips, and other organic mulches to conserve water and moderate soil temperatures is a common practice in landscape maintenance. Four mulch materials (cottonseed hulls, cypress pulp, pine bark, and pine straw) were examined to determine effects on plant growth and soil conditions in annual flower beds during a 1-year rotation of warm season to cool season annuals. Inhibited plant growth was observed in pine bark treatments at the conclusion of the growing season for both plantings. Effects on soil conditions were insignificant over the year-long study in pine bark treatments. To further investigate potential phytotoxic effects of pine bark and other mulch used in the initial study, a seed bioassay was performed to determine the influence of mulch extracts in solution on germination and primary root elongation.

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Nursery Irrigation Effects on Postplanting Root Dynamics of *Limonium cossonianum* O. Kuntze in Semi-arid Conditions

J.A. Franco*, M.J. Garcla, and V. Cros. Dept. Ingenieria Aplicada, Area Produccion Vegetal, Universidad de Murcia, Alfonso XIII, 34, 30203 Cartagena, Spain

A study was conducted with *Limonium cossonianum* O. Kuntze to analyze the influence of irrigation regime in nursery on the dynamics of root development after being transplanted with minimum management conditions. Plants were pot-grown in a greenhouse. Each plant was potted into 625-mL plastic pot filled with a 1 silica sand medium : 1 peat mixture (v/v) amended with osmocote plus (3.7 g • kg⁻¹ substrate). Drip irrigation was used with a 2-L • h⁻¹ emitter per plant. Two irrigation treatments were used: T3, plants watered 6 days a week at the water-holding capacity (leaching 20% of the applied water) and T1, plants watered twice a week, receiving an amount of water at 30% of T3 plants throughout the nursery period (45 days). After nursery period, plants were transplanted in the open air at the southeast Mediterranean coast of Spain (37°47'N, 0°54'W), and just one establishment irrigation was applied (50 mm). There were three replications. Plant root and top growth were measured weekly for 13 months. For the root dynamics study, minirhizotrons were used. Acrylic tubes, 2 m long and 80 mm in outside diameter, were placed at an inclination of 24°, reaching a total depth of 160 cm. The evolution of the root length density (RLD) was measured by seven 23-cm-deep soil layers. Results indicate that those plants that were less watered in nursery showed a greater RLD for the whole soil profile. Plants root growth for the top 46 cm of soil were not significantly affected by irrigation treatments; between 46 and 115 cm deep, T1 plants showed greater RLD than T3 (average values of 0.6 vs. 0.3 cm • cm⁻³); and under 115-cm deep (where root growth was more limited), there were not significant differences. For the first 6 months, a important plant top growth was observed, there being no significant differences among irrigation treatments. Research supported by CICYT grant AGF-96-1136-C02-02.

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Effect of ReTain on Peach Harvest Delay and Fruit Quality

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This experiment was conducted to determine peach harvest delay, quality, and storage life by ReTain. ReTain was applied to 'Loring' at 50 ppm at 17, 14, 12, 10, or 7 days before harvest (n = 4). Fruit were harvested based on conversion of ground color to yellow over five dates at 3- to 4-day intervals in July. Fruit were segregated into five size classes, counted, and weighed. Ten fruit were randomly selected from the 2.5-in. size class, and fruit quality was measured at harvest and after 5 days at 20 °C. Some fruit were stored for 5 days at 4 °C, removed from storage, and fruit quality measured 4 h after removal. Harvest date was not affected by ReTain. Firmness was higher for fruit held at 5 days in cold storage with earlier treatment application but not at harvest or after 5 days at room temperature, although the trend at harvest was similar to the 5-day storage data. Soluble solids were not affected at harvest, after storage or after 5 days at room temperature. Red blush was slightly less at harvest and after 5 days in cold storage with earlier application rates, but differences disappeared after 5 days at room temperature. Yellow color was higher with earlier application date after 5 days of cold storage but not at harvest or after 5 days at room temperature. These results indicate that ReTain may have some utility for improving peach firmness at harvest, but there was no benefit of harvest delay at the rates applied in this study.

48 POSTER SESSION 7 (Abstr. 270–293)

Crop Physiology

Thursday, 29 July, 1:00–2:00 p.m.

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Root, Stem, and Fruit Growth of 'Tainung 1' Papaya Plants following Defoliation

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The influence of plant size on recovery following defoliation of 'Tainung 1'

papaya was used to study the role of respiratory sink size relative to photosynthetic surface area and the carbohydrate pool size available for remobilization. Defoliated (D) plants at three different ages: oldest, 24 weeks posttransplant (PT), supporting ≈ 8 weeks of fruit set; intermediate, 10 weeks PT, ≈ 2 weeks from initial flowering; and youngest, 4 weeks PT, were compared to an equal number of control plants. The oldest plants abscised all fruit < 5.5 cm in diameter as a result of defoliation. Increase in stem height and basal circumference ceased on all plants and increase in fruit circumference ceased on the oldest plants following defoliation. Increase in stem height of D plants began again 3 weeks postdefoliation (PD) and returned to that of control plants by 6 weeks PD. Increase in basal circumference of D plants began again 6 weeks PD. Root density was observed on observation windows, and fine roots completely disappeared within 1 week PD. Root density returned to that of control plants by 6 weeks for the youngest and intermediate plants and by 8 weeks for the oldest plants. Increase in fruit circumference of pre-existing fruit for the oldest D plants never returned to that for control plants. These plants began setting fruit again ≈ 8 weeks PD. Defoliation delayed initial flowering of the intermediate plants 6.5 weeks and of the youngest plants ≈ 2 weeks. Thus, the greatest impact of defoliation on reproductive growth occurred with the two oldest age groups.

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Unidirectional Wind Load Influences Growth, Morphology, and Physiology of Papaya

Hiphiil S. Clemente and Thomas E. Marler*, College of Agriculture & Life Sciences, Univ. of Guam, Mangilao, GU 96923

Trade winds are a widespread horticultural consideration throughout the tropics. Growth and productivity of most horticultural crops are not optimal on sites that are exposed to these chronic, unidirectional winds. We conducted four container studies on an exposed site, using clear plastic or screening material to provide three levels of wind exposure: 0%, 36%, or 100%. Two studies were conducted with direct-seeding, such that seedling emergence and early growth were determined for 7 weeks. Two studies were conducted using 8-week-old nursery plants that had been grown in a protected nursery. These plants were transplanted to the experimental site and grown for 6 weeks. Cultivars were 'Known You 1', 'Sunrise', and 'Tainung 2'. Full exposure to wind reduced height up to 32%, increased root : canopy ratio up to 36% and exhibited no influence or slightly reduced stem cross-sectional area when compared with full protection from wind. Net carbon dioxide assimilation (Pn) was measured on intervals of about 2 h throughout several 24-h periods. Although the daily pattern depended on cultivar and date, the general trend was for Pn to be unaffected by wind from early to mid-morning, and for Pn of the unprotected plants to decline below that of the protected plants throughout the rest of the day. The Pn of plants receiving intermediate protection was highly variable among the cultivars and dates in relation to the protected and unprotected plants. Moreover, dark respiration of the unprotected plants was greater than the protected plants throughout the entire nocturnal period. The primary influence of wind on growth of young papaya seedlings was a shift in biomass allocation in favor of the stem base and roots.

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Development of Apple Cuticular Matrix Sub-structure

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The cuticle is a complex organ. As the first line of defense for apple fruit, its main function is to protect cells from desiccation. It begins developing within several weeks of anthesis and continues responding to environmental conditions until the underlying tissue becomes necrotic. The physicochemical properties of the cuticle differ with cultivar and stage of development but are thought to be composed of carbohydrate fibers extending from the cell wall or the aqueous apoplast. If the latter is true, these fibers could allow contact or exchange with the environment through the lipoidal cuticle matrix. This visual report is the result of an examination of the substructure of the apple cuticle using scanning electron microscopy. These high-resolution micrographs suggest a transcuticular continuum exist in the form of tubular fibers.

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Reduction of Fruit Cracking by Automatic Application of Calcium Chloride

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We have developed a system of automated intermittent salt application above the tree during a rain event that has shown very encouraging results (*Washington State Hort Soc. Proc. 1995, Good Fruit Grower*, vol. 47; pp. 23–24; *Acta Hort.* vol. 468 pp. 649 & 683) in Michigan and the Pacific Northwest. In 1998, we significantly reduced rain cracking with the system used in previous years. At the Southwest Michigan Research and Extension Center (SWMREC), on 'Ulster', the control averaged 18% while the 0.5% calcium chloride had 6.7% cracks. Similar results were found for 'Ulster', 'Somerset', and 'Rainer' at the Northwest Station. Cracking was greater in the upper part of the tree than the lower part for the control. The calcium chloride had less cracking on the upper part than the lower part indicating that calcium chloride applied from above the tree was not uniformly distributed to the lower part of the canopy in high enough concentrations. Multiple emitters per tree decreased this problem. We determined that there was an interaction with temperature. More fruit cracked at high temperature than low temperature. In the field more fruit cracked during the day than at night. We attribute this to the difference in day and night temperature. Using a bioassay system we were able to determine the critical concentration of salt that must be on the fruit to inhibit water uptake and rain splitting up to a 4-h period. It ranged between 0.05% to 0.10 % depending on the variety and stage of development.

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Effects of Supplemental Calcium on Plant Growth, Ion Accumulation in Roots and Transports to Shoots of *Brassica rapa* L.

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The effects of supplemental Ca on salinity tolerance were tested using a *Brassica rapa* L. landrace, 'Sani', which is salt-sensitive. Plants were grown in a continuous aerated hydroponic system with 0.25-strength Hoagland solutions containing 125 mM NaCl plus 0, 2.5, 5.0 or 10 mM CaCl₂. The effects of Ca treatment were significant in reducing Na accumulation in roots, Na⁺ transport from roots to shoots and in enhancing K and Ca accumulation and transport. The Ca addition also enhanced the selectivities of both K and Ca over Na of accumulation at roots and of transport to shoots. However, supplemental Ca did not alleviate the growth reduction caused by the NaCl salinity. These results suggest that the growth inhibition of salt-treated *B. rapa* 'Sani' is mainly caused by factors other than Na, K, and Ca contents in plants.

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Water Relations of Fruit Cracking in Single-truss Tomato Plants

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This study was undertaken to investigate the water relations of tomato (*Lycopersicon esculentum* Mill.) fruit cracking for single-truss tomato plants. The tomato plants were cultured on a closed hydroponic system in greenhouse. Water status of culture solution and plant tissues was measured with psychrometers. Water potential of the culture solution for the stressed plant was changed from -0.06 MPa (control plants) to -0.36 MPa at 24 days after anthesis. Hardness of the fruit skin was not different significantly between the stressed plants and the control plants. Fruit cracking occurred frequently in the control plants, but not in the stressed plants. Water potential gradient between the tissue of fruit flesh and water source for the control plants was bigger than that of the stressed plants. Turgors were increased at the tissues of fruit flesh and fruit skin at the control plants between predawn and morning but not at the stressed plants. These results indicated that the water potential gradient and the increased turgor in these tissues might be a trigger for the occurrence of fruit cracking on single-truss tomato plants.

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Effects of Water Stress on Super Oxide Dismutase (SOD) and Water Content of Tomato Cultivars at Different Plant Ages

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Effects of water stress at different plant ages on SOD activities were studied in two tomato cultivars. Water stress treatment decreased the leaf water potential in all stages, but reduction of leaf water potential was more rapid and pronounced in KF than TM at all DSLs (days of seedlings). After withdrawal of water stress treatment, stressed plants of TM increased leaf water potential to the values of control level in all DSLs, but in KF, leaf water potential of stressed plants were much lower than that of control plants. Effects of water stress on relative water content (RWC) of leaves at 20 DSL showed a similar tendency to that on leaf water potential. The SOD activities in both cultivars showed significant increase by water stress treatment at all DSLs, but the increase of SOD by water stress was larger in TM than in KF. This tendency was observed at all DSLs. The results may indicate that SOD activities play an important role in drought tolerance of tomato at various plant ages and suggest a possible use of SOD activities as a criterion for tomato drought tolerance.

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Transpiration and Membrane Competence in *Fragaria* Exhibit Genotype-specific Responses to ABA

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Divergent physiological responses to drought between and among accessions within *Fragaria chiloensis* (FC) and *F. virginiana* (FV) may result from differing responses to ABA produced during the drought. Excised leaves from an accession of each species as well as *F. xananassa* (FXA) 'Tribute' and their inter-specific hybrids were fed ABA at 0, 1, 10, 100, and 1000 nM via the cut petiole for 24 h before measuring transpiration rate. Transpiration rates of the FV accession and FV by FXA hybrid were relatively less responsive to ABA than any of the others tested. Foliar membrane competence of the FC and FV accessions, measured by the g_{T1} method using excised disks, was reduced by ABA treatment in both species with a relatively greater effect on FV. A drought episode before sampling affected g_{T1} values of FV but not FC. ABA treatment had no additional effect on g_{T1} values of a previously droughted FC accession, while g_{T1} values of a previously droughted FV accession were increased with ABA treatment. Thus, transpiration of the FV accession was less responsive to increasing ABA concentration than the FC accession, while membrane competence of the FV accession was affected more by both drought and ABA treatment applied separately or in combination than the FC accession.

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Gas Exchange and Water Relations of Diverse Tall Fescue Cultivars in Response to Drought Stress

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To investigate shoot physiological responses to drought stress of six tall fescue (*Festuca arundinacea*) cultivars representing several generations of turfgrass improvement, forage-type 'Kentucky-31', turf-type 'Phoenix', 'Phoenix', and 'Houndog V', and dwarf-type 'Rebel Jr' and 'Bonsai' were grown in well-watered or drying soil for 35 days in a greenhouse. Net photosynthetic rate (Pn), stomatal conductance (g_s), transpiration rate (T_r), relative water content (RWC), and photochemical efficiency (F_v/F_m) declined during drought progression in all cultivars, but the time and the severity of reductions varied with cultivars and physiological factors. Pn, RWC, g_s , and T_r decreased significantly for 'Rebel Jr', 'Bonsai', and 'Phoenix' when soil water content declined to 20% after 9 days of treatment (DOT) and for 'Falcon II', 'Houndog V', and 'Kentucky-31' when soil water content dropped to 10% at 15 DOT. A significant decrease in F_v/F_m was not observed in drought-stressed plants until 21 DOT for 'Rebel Jr', 'Bonsai', and 'Phoenix' and 28 DOT for 'Houndog V', 'Kentucky-31', and 'Falcon II'. The decline in Pn was due mostly to internal water deficit and stomatal closure under short-term or mild drought-stress conditions. After a prolonged period of drought (35 DOT), higher Pn in 'Falcon II', 'Houndog V', and 'Kentucky-31' could be attributed to their higher F_v/F_m .

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Influence of NaCl on Seed Germination of Selected Cool-season Turfgrass Species

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The influence of increasing levels (0.0%, 0.05%, 0.1%, 0.2%, 0.4%, 0.6%, 0.8%, 1.2%, 1.6%, and 2.0%) of NaCl on the germination of Kentucky bluegrass (*Poa pratensis*), annual ryegrass (*Lolium multiflorum*), perennial ryegrass (*Lolium perenne*), creeping bentgrass (*Agrostis palustris*), tall fescue (*Festuca arundinacea*), and crested wheatgrass (*Agropyron cristatum*) was investigated. Kentucky bluegrass, creeping bentgrass, and crested wheatgrass had a 50% reduction in germination at 0.2%, 0.6%, and 0.6% NaCl, respectively, compared to the control and completely lost germination at 0.6%, 1.2%, and 1.6% NaCl, respectively. Seed germination in both annual ryegrass and perennial ryegrass was only 50% of the control at 1.2% NaCl and completely inhibited at 2.0% NaCl. Tall fescue, red fescue, and creeping red fescue showed a 50% reduction in germination at NaCl concentrations of 1.2%, 1.2%, and 0.8%, respectively, while showing a complete inhibition of germination at 2.0%, 2.0%, and 1.6% NaCl, respectively.

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Botryosphaeria dothidea Causes Premature Breaking of Endodormancy and Reduces Cold Hardiness in *Cercis canadensis*

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Near-lethal abiotic stresses, e.g., low or high temperatures, chemicals, etc., can break endodormancy prematurely and reduce cold hardiness in woody plants. It is not well-documented whether biotic stresses can cause the same effect. *Botryosphaeria dothidea* causes canker in redbud (*Cercis canadensis*) and many other woody plants and is one of the most limiting factors growing redbud in the landscape. Two-year-old seedlings were planted in a nursery in May 1998 at The Morton Arboretum. Trees were inoculated (n = 10/treatment) with the fungus in Sept. 1998 using the stem slit method (a slit was cut about 5 cm above the base of the trunk and the wound was covered with parafilm after treatment). The treatments were T1 = control (PDA, Potato Dextrose Agar), T2 = 1-mm mycelium plug, T3 = low spore suspension (25 μ L), T4 = high spore suspension (25 μ L). Stem cold hardiness was evaluated by artificial freezing tests in Nov. 1998. The mean LT₅₀ (the temperature at which 50% of the tissues is killed) from ion leakage were T1 (Control) = -29.3 °C, T2 (mycelium) = -24.05 °C, T3 (low spore) = -18.75 °C, and T4 (high) = -16.4 °C. T3 and T4, the low- and high-spore inoculation, significantly reduced cold hardiness in redbud stem tissues. The LST (lowest survival temperature) based on visual observation of the samples after 7 days indicated all *Botryosphaeria dothidea*-treated plants had lower cold hardiness compared to control. Endodormancy was broken in *B. dothidea*-treated plants after placing plants under 16 h of light and 23 /18 °C day/night temperature for 1 month after the treatment. The highest percent budbreak was for T4 (high spore), followed by T3 (Low Spore) and T2 (Mycelium).

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Water Use in Herbaceous Landscape Plants

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Water conservation in a landscape is an important issue because periodic water shortages are common in many regions of the world. This increases the importance of specifying landscape plants that require less water and matching the plant to site microclimates. Our objectives were to establish water-use rates for three herbaceous landscape plants and to determine the level of water reduction these plants can tolerate while maintaining both visual and landscape quality. Water use rates were determined for *Schizachyrium scoparium* (Little bluestem), *Hosta* spp. (*Hosta*) and *Festuca cinerea* 'Dwarf' (Dwarf blue fescue) in studies using pot lysimeters at the Univ. of Nebraska Horticulture Research Greenhouse facility. Each lysimeter was watered to saturation, allowed to drain to field capacity, and weighed. The lysimeters were weighed again 24 h later, and the process was repeated to determine daily evapotranspiration. Results indicated that *Hosta* used less water than dwarf blue fescue and little bluestem. In a subsequent study to compare the relative effects of withholding irrigation among these species,

seven groups of five replicates of each species were grown in 1 peat : 0.33 vermiculite : 0.66 soil : 1 sand (by volume) in 7.6-L containers. Each container was watered to saturation, allowed to drain for 24 h to reach field capacity, and allowed to dry down in 10-day increments. Results of the dry-down study indicated that little bluestem maintained the best visual quality for the longest duration of drought, followed by dwarf blue fescue and hosta in decreasing order of visual quality.

282 Shoot and Root Characteristics of *Rudbeckia hirta* L. at Different Clipping Heights in a Model Wildflower Sod Production System

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Field-grown wildflower sod has been in production for several years, but as with any crop management system, the reasoning behind the methods is not always known. One characteristic of wildflower sod production that has been debated is the height at which the plant is maintained. The above-ground shoot growth is managed to reduce the damage to plants when undercut and to allow for ease of shipping. Growers typically use a height of 7.6 cm because this is the highest height allowed by many mowers. Also, root production is the key to forming a sod that will hold together well and withstand the rigors of undercutting, lifting, storage, and transplanting. The purpose of this study was to determine the influence of cutting height on the plant's ability to produce a sod. *Rudbeckia hirta* L. was used as a model wildflower species and was seeded into polyvinyl chloride (PVC) tubes 10.2 cm in diameter with a depth of 60 cm to simulate a field situation. To characterize shoot and root growth, during a period of 12 weeks plants either received no clipping or continuous clipping at heights of 5.1, 7.6, and 10.2 cm. Root dry weights were measured at depths of 0–2.54, 2.54–21.7, 21.7–40.8, and 40.8–60.0 cm. Leaf area measurements of the clippings were recorded to determine productivity. Results indicated that clipping the shoots of *Rudbeckia hirta* caused a decrease in root biomass.

283 Response of Forbs to Grass Herbicides, Fire, and Mowing in Mid-successional Tallgrass Prairies of Central Missouri

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Because of thousands of years of adaptation to the native climate, prairie forbs ("wildflowers") present a large potential for their use in beautification projects along roadsides, in large backyards, and in nature centers. Vegetation in abandoned, naturally revegetated, grass-dominated areas can be managed to encourage a forb-dominated stage. Two grass herbicides [sethoxydim (Poast™) and fluzafop (Ornamec-170™)], three burning treatments (winter, early spring, and late spring), and two mowing treatments (fall and late spring) were tested to determine their effect on forb cover and species diversity in a mid-successional tallgrass prairie. One application of either of the herbicides, at the time of recommended growth stage of target grasses, changed species composition significantly (80% forbs vs. 46% forbs in control plots; $P < 0.05$) in favor of showy forbs. Species diversity of sprayed plots was relatively low, however. Burning was the next best alternative (averaging 63% forbs) that also resulted in highest species diversity. Fall and late spring mowing reduced cover of forbs (32%) and species diversity to levels lower than those found in control plots. Cover of *Solidago canadensis* (tall goldenrod) in sethoxydim-treated plots increased to 22.8% compared to 2.5% in control plots. *Cirsium discolor* (pasture thistle) and *Rudbeckia hirta* (black-eyed susan) also increased significantly in response to herbicide treatments.

284 Towards Efficient Nutrient Management in Recirculating Hydroponic Culture

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There is an increasing need to recirculate and reuse nutrient solutions to reduce environmental and economic costs. However, one of the weakest points in hydroponics is the lack of information on managing the nutrient solution. Many growers and research scientists dump out nutrient solutions and refill at weekly intervals. Some authors have recommended measuring the concentrations of individual nutrients in solution as a key to nutrient control and maintenance. Dumping

and replacing solution is unnecessary. Monitoring ions in solution is unnecessary; in fact the rapid depletion of some nutrients often causes people to add toxic amounts of nutrients to the solution. Monitoring ions in solution is interesting, but it is not the key to effective maintenance. During the past 18 years, we have managed nutrients in closed hydroponic systems according to the principle of "mass balance," which means that the mass of nutrients is either in solution or in the plants. We add nutrients to the solution depending on what we want the plant to take up. Plants quickly remove their daily ration of some nutrients while other nutrients accumulate in the solution. This means that the concentrations of nitrogen, phosphorous, and potassium can be at low levels in the solution (<0.1 mM) because these nutrients are in the plant where we want them. Maintaining a high concentrations of some nutrients in the solution (especially P, K, and Mn) can result in excessive uptake that can lead to nutrient imbalances.

285 Interaction between Cold Duration, GA₃, and Photoperiod on *Raphanus sativus* L. Flowering

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Previous research indicated that *Raphanus sativus* L. 'Chinese Radish Jumbo Scarlet' (CJRS) has an obligate vernalization requirement for flowering and can be vernalized as an imbibed seed in less than 10 days at 6 °C. For these reasons, it serves as an excellent model system for vernalization studies. This study was initiated to gain an understanding of the interaction between cold duration, exogenously applied GA₃, and photoperiod on *R. sativus* CJRS flowering. *R. sativus* CJRS seeds were sown in 90-mm petri plates on Whatman no. 1 filter paper saturated with plain water or a solution containing 10-5 M or 10-3 M GA₃. After germination (i.e., when the radicle was visible), seedlings were either directly transplanted into 10-cm pots and placed in a greenhouse, or transferred to another petri plate onto filter paper saturated with water only and placed in a growth chamber at 6 °C (75 μmol • m⁻² • s⁻¹ for 8 h) for 2, 4, 6, 8, or 10 days. Greenhouse conditions were: 20 °C, ambient light (December to January, St. Paul, Minn.) plus 70 μmol • m⁻² • s⁻¹ supplemental light (high-pressure sodium lamps, 0830–1630 HR), under either an 8-h photoperiod (covered with opaque cloth from 1630–0830 HR), or ambient photoperiod plus night-interruption lighting (2 μmol • m⁻² • s⁻¹, using incandescent lamps, 2200–0200 HR). Results will be presented.

286 Plant Life Form Frequency, Diversity, and Irrigation Application in Urban Residential Landscapes

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Heightened awareness of ecological concerns have prompted many municipalities to promote water conservation through landscape design. In central Arizona, urban residential landscapes containing desert-adapted plant species are termed xeriscapes, while those containing temperate or tropical species and turf are termed mesoscapes. Research was conducted to ascertain landscape plant species diversity, tree, shrub, and ground cover frequency; landscape canopy area coverage; and monthly irrigation application volumes for xeric and mesic urban residential landscapes. The residential urban landscapes were located in Tempe and Phoenix, Ariz., and all were installed initially between 1985 and 1995. Although species composition of xeric and mesic landscapes was generally dissimilar, both landscape types had comparable species diversity. Mesoscapes had significantly more trees and shrubs and about 2.3 times more canopy area coverage per landscaped area than xeriscapes. Monthly irrigation application volumes per landscaped surface area were higher for xeriscapes. Even though human preference for xeric landscape plants may be ecological in principle, use of desert-adapted species in central Arizona urban residential landscape settings might not result in less landscape water use compared with mesic landscapes.

287 Total Biomass and Ion Accumulation of *Eucalyptus camaldulensis*, Hybrid *Populus*, and *Robinia pseudoacacia* Irrigated with Saline Municipal Wastewater

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A field study was conducted in 1997 and 1998 in Ojinaga, Chihuahua, Mexico,

to compare biomass production potential and ion uptake capacity of seven tree species and clones, *Eucalyptus camaldulensis* (4016, 4019, and 505), hybrid *Populus* (029, 197, and 367), and seedlings of *Robinia pseudoacacia* irrigated with saline municipal wastewater. Total dry biomass production was greatest with poplar clone 367 (657 g) and eucalypt clone 4019 (643 g). Both clones also provided the most aboveground biomass (463 and 528 g, respectively), essentially because of their greater stem biomass (274 and 234 g, respectively). Poplar clone 367 had the highest lateral branch biomass (84 g), followed by eucalypt clone 4019 (75 g). The clones with the greatest leaf biomass were eucalypt clone 4019 (179 g), followed by eucalypt clone 505 (148 g) and poplar clone 367 (145 g). In all tree selections, Cl concentration was highest in the leaves with poplar clone 197 having the highest concentration (>2%), but the lowest subsequent winter survival at just 55%. The tree with the second lowest survival rate, poplar clone 029 (76%), also had the second highest Cl concentration in its leaves, almost 1.5% Cl. Eucalypt clones 4019 and 4016 accumulated the most total Cl in its tissues (327 and 236 g per tree, respectively) followed by poplar clone 029 (216 g per tree). Eucalypt clone 4019 accumulated the most Na in its tissues (109 g per tree) followed by poplar clone 367 (74 g per tree). In conclusion, poplar clone 367 and eucalypt clone 4019 seem to be sufficiently salt-tolerant for these saline conditions, having high survival, growth, and biomass capacity and perform well under high biomass-generating, short rotation conditions. Eucalypt clone 4019 is also an effective accumulator of Cl and Na ions and may be the most suitable tree for the remediation of salt-affected land in these experimental conditions.

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Effects of Foliar Urea on Reserve Nitrogen and Carbohydrates in Young Apple Trees with Different Nitrogen Background

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Bench-grafted Fuji/M26 plants were fertigated with seven nitrogen concentrations (0, 2.5, 5.0, 7.5, 10, 15, and 20 mM) by using a modified Hoagland solution from 30 June to 1 Sept. In mid-October, half of the fertigated trees were sprayed with 3% urea twice at weekly intervals, while the other half were left as controls. The plants were harvested after natural leaf fall, stored at 2 °C, and then destructively sampled in January for reserve N and carbohydrate analysis. As N concentration used in fertigation increased, whole-plant reserve N content increased progressively with a corresponding decrease in reserve carbohydrate concentration. Foliar urea application increased whole-plant N content and decreased reserve carbohydrate concentration. The effect of foliar urea on whole-plant reserve N content and carbohydrate concentration was dependent on the N status of the plant, with low-N plants being more responsive than high-N plants. There was a linear relationship between the increase in N content and decrease in carbohydrate concentration caused by foliar urea, suggesting that part of the reserve carbohydrates was used to assimilate N from foliar urea. Regardless of the difference in tree size caused by N fertigation, the increase in the total amount of reserve N by foliar urea application was the same on a whole-tree basis, indicating that plants with low-N background were more effective in using N from urea spray than plants with high-N background.

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Ammonium Ion Uptake by Feeder and Extension Roots of MM106 Apple Rootstock

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New roots of *Malus domestica* Borkh MM106 apple rootstock were divided into two categories, 1) feeder roots and 2) extension roots based on morphology and their ability to take up NH_4^+ , were studied. The roots were harvested in August from 1-year-old potted plants growing under natural conditions in Corvallis, Ore. Extension roots were thicker and longer than feeder roots. Average diameter and length were 0.89 and 45.29 mm for extension roots and 0.27 and 5.36 mm for feeder roots. Root special length (cm/g FW) and surface area (cm²/g FW) were 11.94 and 33.17 for extension roots and 108.97 and 93.38 for feeder roots. Maximum uptake rate, I_{max} , K_m , and α root absorption power, α ($\alpha = I_{\text{max}} \cdot 1/K_m$), for NH_4^+ absorption were 6.875, 0.721, and 9.48 for extension roots and 4.32, 0.276, and 15.63 for feeder roots. Feeder roots had stronger affinity to NH_4^+ (low K_m) and higher NH_4^+ absorption power (high α value) than extension roots. The feeder roots were better able to uptake NH_4^+ at lower external solution concentrations than extension roots according to the nutrient depletion curve, which indicates

feeder roots being more efficient than extension roots in nutrient absorption when NH_4^+ availability was low.

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Nutrient Uptake by New Roots of Six Clonal Apple Rootstocks

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The nutrient uptake kinetics by new roots of 1-year-old potted clonal apple rootstocks (M7, M9, M26, M27, MM106, and MM111) were determined by the ion depletion technique at the stable development stage of trees in August. The total roots of five of the rootstocks (except MM111) consisted of more than 60% feeder roots and less than 12% extension roots. MM111, the most vigorous rootstocks tested, had 60.7% feeder roots and 24.5% extension roots. Root : top ratio was negatively related to the growth inhibiting character of the rootstock. Nutrient uptake by excised new roots was found to fit into Michaelis–Menton kinetic model for all rootstocks tested. The kinetic characteristics (maximum uptake rate, I_{max} , apparent Michaelis-Menton constant, K_m , and root absorption power, ($\alpha = I_{\text{max}} \cdot 1/K_m$)) between rootstocks differed significantly. MM111 had the highest I_{max} for NH_4^+ absorption and M9 for NO_3^- . Root affinity to ions was highest with MM106 for NH_4^+ and with M26 for NO_3^- . Root absorption power ($\alpha = I_{\text{max}} \cdot 1/K_m$) was greatest in MM106 for NH_4^+ and M9 for NO_3^- . At this developmental stage the data suggest no relationship between nutrient uptake and dwarfing character of the rootstocks.

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Effect of Nitrogen Fertilization Time on Nitrogen Storage and Return Bloom of Pecan

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A study was conducted to compare a single nitrogen application in March (125 kg N/ha) vs. a split application in March (75 kg N/ha) and October (50 kg N/ha) on 15-year-old 'Mareme'. After one season, N application time did not affect return bloom. A split N application increased trunk wood Kjeldahl-N but decreased Kjeldahl-N in the current season's reproductive shoots and 1-year-old branches compared to a single application in March. Kjeldahl-N concentration was not affected by treatment in current season's vegetative shoots, trunk bark or roots. Nitrate-N concentration was not affected by treatment in any tissue sampled. Between the first week of October and the first killing frost in November, Kjeldahl-N increased 29% in current season's shoots, 21% in trunk bark, 32% in roots >1 cm in diameter, and 15% in roots <1 cm in diameter but decreased 42% in trunk wood and 5% in 1-year-old branches. Roots <1 cm in diameter accumulated more nitrate-N than other tissues during November.

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Nitrate Uptake and Root Morphology of Kentucky Bluegrass

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Intraspecific variation in nitrate absorption by turfgrasses has been studied, but differences in turfgrass root morphology, which may contribute to observed variation, have not been ascertained. This information may benefit breeding programs aimed at improving the ability of turfgrasses to absorb nitrate from low fertility soils. This study quantified root morphological traits of Kentucky bluegrass (*Poa pratensis* L.) cultivars and their nitrate uptake rates (NUR). Tiller-generated plants were grown in silica sand, mowed weekly, and watered daily with half-strength modified Hoagland's nutrient solution containing 1 mM nitrate. When 5 months old, plants were excavated, and roots washed to remove sand. The plants were then transferred to 120-mL black bottles. After nitrate depletion of the nutrient solution was monitored for 8 consecutive days, the underground portion of each plant was separated into three parts: 1) adventitious roots, 2) fibrous roots, and 3) rhizomes. Measurements of total root length, total surface area, and average diameter were made by a scanning and image analysis system. NURs were calculated from nitrate depletion data and expressed as micromoles per plant per hour. Correlation analyses were performed on these morphological traits and NUR by the Minitab program. NUR was significantly and positively correlated with the total biomass, length, and area of the three underground parts. This was attributable mainly to fibrous roots as indicated by significant and positive correlations between NUR and the total biomass, length, area, and average

diameter of fibrous roots. NUR was also positively correlated with the total biomass, length, and area of adventitious roots but negatively correlated with total biomass, area, and average diameter of rhizomes.

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Genotypic and Temporal Variation in Nitrate Uptake Rate by Kentucky Bluegrass

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Turfgrass cultivars that have superior nitrate uptake ability are needed for the protection of ground water from pollution by excess nitrate. Information on temporal variation of nitrate absorption is also needed to enhance the environmental safety of turfgrass N fertilization programs. Our objectives were to evaluate Kentucky bluegrass (*Poa pratensis* L.) cultivars for their differences in nitrate uptake rate (NUR) and temporal variation in NUR. Six cultivars (Barzan, Blacksburg, Connie, Dawn, Eclipse, and Gnome) were propagated from individual tillers and six plants of each cultivar were generated from one mother plant. Plants were grown in silica sand, mowed weekly, and watered daily with half-strength modified Hoagland's nutrient solution containing 1 mM nitrate. When 5 months old, the plants were excavated, the roots were washed to remove sand, and the plants were transferred to 120-mL black bottles. After 24 hours in tap water, the plants were supplied with half-strength nutrient solution containing 0.5 mM nitrate, and the solutions were replaced daily for 8 days. NURs expressed as micromoles per plant per hour were calculated from solution nitrate depletion data. Significant genotypic differences in NUR were found: 'Blacksburg' > 'Connie' > 'Dawn' > 'Barzan' = 'Eclipse' > 'Gnome'. Significant temporal variation in NUR was also found, with NUR on the second day more than the first day after tap water. A significant interaction was noted between genotype and time. Temporal variation was greatest in 'Blacksburg', while none noted in 'Connie' and 'Eclipse'. In 'Barzan' and 'Gnome', NUR on the last day was higher than the first day.

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Crop Physiology

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Quantifying the Effect of Application Date of Paclobutrazol Drenches on Poinsettia Stem Elongation and Bract Size

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Paclobutrazol drenches (1 ppm, 118.4 mL per pot) were applied to *Poinsettia* 'Freedom' Red' on 1, 11, 21, and 31 Oct. in 1997 and 1998. Plant heights were recorded twice weekly throughout the experiment, and internode length and bract area were measured at harvest. The total bract area of the three true bracts and the top three transitional bracts was reduced by 5.8%, 13.6%, 4.2%, and 2.3% for the 1, 11, 21, and 31 Oct. application dates, respectively; however, all plants were highly marketable. At the time of each drench application, the most newly unfolded leaf was marked. The internode lengths for the three internodes below this leaf and the internodes that developed after the drench application were typically between 5 and 10 mm in length, while the internode lengths of the control plants were typically 10 to 25 mm, depending on node number. Plant height increased 62, 51, 47 and 19 mm following application on the 1, 11, 21, and 31 Oct. application dates, respectively. The 1, 11, 21, and 31 Oct. drench applications reduced total stem elongation from 1 Oct. to anthesis by 64%, 49%, 28%, and 15%, respectively. Paclobutrazol drenches did not affect time to anthesis.

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The Effect of Cultivar, GA₄₊₇, and Number of Fruit per Spur on Flower Initiation in Apple

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Experiments were initiated to document the effect of cultivar, GA₄₊₇, and number

of fruit/spur on appendage number and flower bud initiation in apple. 'Pacific Rose' is strongly biennial, 'Braeburn' and 'Fuji' are moderately biennial, and 'Royal Gala' is not biennial. In the cultivar study, buds were sampled every 18 days starting at 50 days after full bloom and continuing through until leaf fall to determine the rate of appendage formation and appendage number in relation to doming. Because of the tendency for 'Pacific Rose' to exhibit biennial bearing, the rate of appendage formation and the timing of doming were compared on nonfruiting trees, trees carrying a commercial crop, and trees sprayed with 300 PPM GA₄₊₇ applied 14 days after full bloom. Number of appendages for the treatments were similar up to 100 days after full bloom. Presence of fruit on a spur has been demonstrated to inhibit flowering of apple. Spurs of 'Pacific Rose', 'Splendor', and 'Royal Gala' were labeled with zero, one, two, and three fruit per spur and sampled three times during the season. As buds were harvested to count appendage number, the number of fruit per spur and the number of total seeds per spur were recorded. Correlation between number of seeds per spur and rate of appendage formation were done.

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Chemical Thinning of 'Fuji' Apple with Ethephon, NAA, MCPB-ethyl, and Carbaryl

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We propose that return flowering of 'Fuji' apple can be improved if sufficient flower clusters are removed during or shortly after bloom. In this study conducted at Corvallis, Ore., we evaluated two synthetic auxins, MCPB-ethyl and the Na salt of NAA, each at 0, 4, 8 and 16 ppm, as blossom cluster thinners. Each auxin treatment was applied alone or with 100 ppm ethephon as a tank mix. Six-year-old 'Fuji/M.26 trees were sprayed at full bloom of the king flowers (~85% of whole-tree full bloom). A follow-up treatment of Sevin XLR (800 ppm carbaryl) was made at 11-mm fruit diameter to determine if carbaryl's known effectiveness as a fruitlet thinner was influenced by the bloom-time auxin or auxin + ethephon treatments. MCPB-ethyl proved ineffective as a bloom-time thinner, whereas the NAA effect on cluster removal was linear with concentration, 16 ppm NAA completely defruiting 33% of initial flower clusters. On control trees fewer than 12% of flowering clusters failed to set fruit. Ethephon alone defruited 25% of the clusters and NAA+ethephon defruited 51% of clusters. It is notable that the NAA and ethephon + NAA treatments did not reduce fruit set on the remaining clusters, resulting in considerable need for hand-thinning. Carbaryl effectively reduced total crop load by increasing the number of defruited clusters and reducing the incidence of doubles and triples. There was evidence to suggest that its effectiveness was compromised by the bloom-time NAA and/or ethephon sprays.

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Effect of Gibberellic Acid on One-year Apple Rootstock Plant Growth in the Greenhouse

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Aiming to improve plant growth of the apple rootstock cultivar Marubakaido (*Malus prunifolia*) in greenhouse, 1-year-old plants were sprayed once, twice, and three times in a 7-day interval with gibberellic acid (GA₃) in the following concentrations: 0, 50, 100, 200, 400, 800 and 1600 mg•L⁻¹. The plant growth was evaluated every 2 weeks during 2 months. The internode length, bud number, and the dry weight of the aerial part were also evaluated at the end of the experiment. It was verified that GA₃ sprayed at 800 mg•L⁻¹ by three times consecutively was the best treatment presenting the largest rate of plants growth (91.2% against 114% of nontreated plants) in relation to their initial height, besides providing larger internode length and dry matter weight of the aerial parts. However, using this regulator did not affect the plant bud number. Plants sprayed once did not present significant response to GA₃ for any of the studied variables. These results suggest that the use of GA₃ in 1-year-old apple plants reactivates growth, although, the increase in the number of applications associated with higher doses is necessary to improve the efficiency of this product.

Root Restriction and Fertilizer Effects on Young Peach Trees

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Shoot growth of peach trees can be managed by manipulating edaphic conditions such as root volume and soil fertility. In this experiment, 2-year-old peach trees (*Prunus persica* L. cv. Sentry on 'Lovell' rootstock) were planted in pots with a split root design, so that half the roots were not treated and the other half received one of four treatments: root volume restricted with polypropylene non-woven fabric (FAB), fertilizer alone (FER), FAB + FER, and untreated control (UTC). Total shoot growth and root growth were measured, and root growth in the split halves was compared. FER increased leaf number and weight by 48% and 60%, respectively, but not stem growth. Leaf nitrogen concentration and photosynthesis were greatest in FER treatment. FAB did not affect shoot weight or reduce total root weight or length, although roots did not grow past the fabric barrier. FER increased root weight and length (116% and 57%, respectively, compared to UTC) on the treated half but did not affect root growth on the untreated half. Greatest root growth occurred in the root half that received FAB + FER, particularly in the 5-cm soil segment proximal to the fabric (4.6 cm • cm⁻³ compared to 0.8 cm • cm⁻³ in UTC). Shoot length was greater in FAB + FER than FAB. Thus, fertilizer applied near fabric increased root growth and the combination of fertilizer and fabric may be used to regulate shoot growth. Specific root length (root length per gram dry weight) was highest in trees with no treatment, suggesting root acclimation to low nutrient soil conditions. Lower specific root length resulted in soils that were fertilized. The results indicate that nonwoven fabric restricts root growth in peach trees and reduces shoot elongation. The combined effect of fabric plus selected application of fertilizer may be used to regulate growth of peach trees.

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Response of Mature Peach Trees to Grass Competition

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Peach tree size has been restricted when trees were grown continuously with grass after tree planting. However, control of excess vegetative growth of fruit trees was inconsistent when grass was planted beneath mature trees. This research determined the effect of seven grasses on growth, leaf nitrogen concentration, and yield of 8-year-old peach trees and on weed abundance. Two cultivars ('Loring' and 'Redhaven') of peach [*Prunus persica* (L.) Batsch] trees were planted in separate orchards in 1987 in a split-plot design with grass as a main effect and time as the subplot. Nine treatments were installed as ground covers beneath peach trees in 1995: *Festuca arundinacea*, *Lolium perenne* var Manhattan II; *L. perenne* var. Linn; *Agrostis gigantea*, *Dactylis glomerata*, *Phleum pratense*, *Bromus carinatus*, weedy control, and herbicide control (simazine, glyphosate). In general, grasses reduced vegetative growth and yield in 'Loring' and 'Redhaven'. For example, compared to herbicide treatments, orchardgrass reduced sprout length by 27% in 'Loring' and by 15% in 'Redhaven'. Fruit-bearing branch length was reduced with orchardgrass by 30% in 'Loring' and 19% in 'Redhaven'. Orchardgrass affected fruit yield more than vegetative growth, reducing yield by 37% and 24% in 'Loring' (predominantly in the >2- to 2.5-inch size class) and 'Redhaven' (predominantly in the >2.5-inch size class), respectively. All grasses were not equally competitive, 'Linn' perennial ryegrass never significantly affected growth or yield. Weedy treatments also did not differ from herbicide treatments in peach tree growth and yield. Grasses and weeds consistently reduced peach tree leaf nitrogen by 17% compared to herbicide treatment, but weed density was not correlated with reductions in yield and vegetative growth. The results indicate that peach cultivars respond differently to grass competition but the relative competitiveness of grass species was similar for both cultivars. Grass competition can reduce growth of mature peach trees but this reduction did not translate to reduced pruning time per tree.

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Bioregulators Can Affect Apple Mineral Nutrition

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Experiments were performed in 1995 and 1996 at the Mississippi State Univ. Agricultural Experiment Station, Pototoc Ridge, to investigate the effect of Accel and carbaryl sprayed 2 weeks postbloom on fruit set, yield, and plant nutrition of

three apple cultivars (Empire, Jon-A-Red, and Braeburn). The treatments consisted of Accel 25 ppm, Accel 50 ppm, Accel 75 ppm, Carbaryl 0.05%, Carbaryl 0.1%, Carbaryl 0.2%, and an unsprayed control. Thinning trials using the two bioregulators conducted over 2 years indicated that Accel and Carbaryl consistently thinned the apple cultivars and increased the yields. Leaf mineral concentrations were affected by the treatments. In 1995, the treatments affected leaf concentrations of N, Ca, and Mg, while in 1996 the treatments affected the leaf contents of N, P, K, Ca, Mg, Fe, Mn, and Zn, but no copper. The treatments also affected the fruit flesh mineral concentration by increasing the contents of K, P, and Mg in 1996. It can therefore be concluded that, depending on apple cultivar, N content was reduced by the treatments while Ca and Mg were generally increased. Similarly, the fruit flesh contents of Fe, K, P, and Mg were also increased. The two bioregulators therefore thin apples, increase yields, and affect the fruit quality.

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Bioregulators Affect Apple Yield and Quality Attributes

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Experiments were conducted in 1995 and 1996 to investigate the effect of Accel and Carbaryl sprayed 2 weeks postbloom on apple fruit yield and quality and to relate the degree of fruit set reduction to the yield of three apple cultivars (Empire, Jon-A-Red, and Braeburn). The treatments consisted of Accel 25 ppm, Accel 50 ppm, Accel 75 ppm, Carbaryl 0.05%, Carbaryl 0.1%, Carbaryl 0.2%, and an unsprayed control. Trials conducted over the 2 years indicated that Accel and Carbaryl reduced the fruit set of three apple cultivars as shown by the lower number of fruit per limb cross-sectional area on the sprayed trees compared to the unsprayed trees. Most effective concentrations in reducing the fruit set on apples were Accel 50 ppm, Accel 75 ppm, Carbaryl 0.01%, and Carbaryl 0.2%, with high yields and high fruit rates. Therefore, it was concluded that these are the best concentrations for thinning of apples. Other quality attributes, such as pH, sugar content, and percent fruit red were also increased by the treatments. The treatments did not influence the number of seeds in the fruit, fruit length, fruit diameter, and fruit length : diameter ratio.

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Accel and Carbaryl Affect Apple Thinning

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Experiments were conducted in 1995 and 1996 to investigate the effect of Accel and Carbaryl on apple fruit on three apple cultivars (Empire, Jon-A-Red, and Braeburn) at the Mississippi State Univ. Agricultural Experiment Station, Pontotoc. The treatments consisted of Accel 25 ppm, Accel 50 ppm, Accel 75 ppm, Carbaryl 0.05%, Carbaryl 0.2%, and an unsprayed control. Trials conducted over 2 years showed that Accel and Carbaryl consistently reduced the fruit set of three apple cultivars. There were interactions between the bioregulators and cultivars only in 1996. In all the bioregulators, treatments reduced fruit set, while in 1996, Carbaryl and Accel at all concentrations except Accel 25 ppm reduced the fruit set of 'Empire', 'Jon-A-Red', and 'Braeburn'. Carbaryl 0.2% and Accel 75 ppm were the most-effective concentrations in 'Empire', 'Jon-A-Red', and 'Braeburn', respectively, in 1996. The treatments generally increased yield and sugar content, while pH was either not affected, increased or decreased, depending on the apple cultivar.

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Effect of Growth Regulators on the Growth and Performance of *Celosia plumosus*

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Seedlings of *Celosia plumosus* 'New Look', a new variety, were evaluated for their response to the recommended rates of three different plant growth regulators commonly used by growers. The plant growth regulators were B-nine, paclobutrazol, and uniconazole. These plant growth regulators were applied at the rate recommended by the manufacturer for this species. Group I, the control, was not treated with a plant growth regulator, but was sprayed with water at the same

time the other treatments were applied. Plants were grown in 5-inch plastic pots in the greenhouse. Plant height was recorded before treatment and once weekly thereafter for the duration of the experiment. Upon termination of the experiment, plant top fresh weight and top dry weight were measured. Results showed that at the recommended rate for all three plant growth regulators, there were no significant difference in height or weight between the plant growth regulator-treated groups of plants or the control group. The only observable difference noted was in leaf coloration of the plants treated with plant growth regulators.

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Influence of Late Thinning with NAA and Carbaryl in the Apple Cultivar Braeburn

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NAA (1-naphthaleneacetic acid) is widely used for thinning apples; however, its mechanism of action is not well understood. Postbloom application of NAA is cultivar-specific and may, in addition to causing fruit abscission, show unwanted side effects. The response of 5-year-old 'Braeburn'/MM 111 apple (*Malus domestica* Borkh.) trees trained to palmette leader to NAA used alone or in combination with carbaryl (1-naphthyl-N-methylcarbamate) was evaluated in late thinning trials. The experiment was conducted at the Comahue National Univ. (lat. 38°56'S long 67°59'W), during the 1997–98 growing season. Treatments were 1) control, 2) NAA (13 ppm), and 3) NAA (6.5 ppm) + Carbaryl (600 ppm). Whole sprays were applied 17 Oct. at 22 days after full bloom (DAFB) to five trees per treatment. Fruit diameter (FD) was recorded twice weekly ($n = 20$ per date and treatment). At 169 DAFB, cropload and fruit fresh weight (FW) were determined. Fruit were then graded into size categories. Analysis of variance was used and mean separations were computed with Student's *t* test. Good thinning resulted from NAA applications; however, this did not reflect in increased mean FW. The number of fruit ≥ 70 mm was increased by 6.67%. Cropload was overthinned by NAA + carbaryl. Mean FW was slightly greater than control (185.15 and 172.45 g, respectively) and this treatment resulted in 90 % of the fruit ≥ 70 mm compared to 75 % from control. The following potential model best fitted the fruit growth pattern on non-thinned trees: $FD = 2.9077 \text{ DAFB}^{0.6307}$ ($R^2 = 0.98$, $P \leq 0.001$). More work needs to be done to establish the most effective timing and concentration of spray for 'Braeburn' to give the maximum crop of large fruit on a regular cropping basis.

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Omega-3 Fatty Acid Concentration of Purslane (*Portulaca oleraceae* L.) Is Influenced by the Stage of Harvest and the Variety

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Omega-3 fatty acids (O3FA) are essential for normal human growth, development, and disease prevention. Purslane (*Portulaca oleraceae* L.) is an excellent source of alpha-linolenic acid (LNA, an O3FA) and the anti-oxidant alpha-tocopherol. Twenty-one-day-old seedlings of cultivated purslane seedlings were transplanted into greenhouse ($\approx 18\text{--}20^\circ\text{C}$) and arranged in a randomized complete-blocks design with six replications. Plants were fertilized with nitrogen at $25 \text{ mg} \cdot \text{mL}^{-1}$ for the first week, $50 \text{ mg} \cdot \text{mL}^{-1}$ for the next week, and $100 \text{ mg} \cdot \text{mL}^{-1}$ until harvest using a 20N–4.4P–16.6K water-soluble fertilizer in the irrigation water. The terminal three nodes of shoots were harvested at 6, 10, and 14 true-leaf stage. At each harvest the dry mass (DM), fresh mass (FM), and leaf area were determined. The leaf and stem LNA concentration were determined using gas chromatography. The leaf fatty acid concentrations were 30% to 52% higher at the 6- and 14-leaf stages than at 10-leaf stage. The fatty acid concentrations at the 6- and 14-leaf stages did not differ significantly from each other. FM, DM, and leaf area were the highest at the 14-leaf stage. These data indicate that fatty acid levels do vary with the stage of development in purslane. A more detailed study is necessary to follow the change in LNA concentration in purslane throughout its ontogeny beyond 14 leaves. In another study to determine if the LNA concentration of the upright cultivated type of purslane differed from that of the prostrate wild type, we observed that at 14 to 16 true-leaf stage, the leaves from the cultivated type had 52.5% and 35.2% greater linoleic acid and LNA, respectively, than the wild purslane. In both varieties, leaves were richer in LNA than were the stems. Though the varieties did not differ significantly in the DM yield, the FM and leaf area were higher in the cultivated type than the wild type.

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Implications for Biogenic Hydrocarbon Inventory Development from Leafmass Measurements of Urban Trees

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More than 70 biogenic hydrocarbon (BHC) compounds are known to be emitted by plants, but only a few are emitted in relatively large quantities. The magnitude of BHC emissions from individual trees is affected by ambient light and temperature, species-specific emissions rates, and leafmass. Like other volatile organic compounds (VOC), BHC emissions react with oxides of nitrogen (NOx) to form ozone and, thus, can contribute to urban air pollution. On average, BHC emissions are as reactive or more reactive than the VOC emissions from automobiles and can have higher ozone-forming potential. An accurate estimate of the overall magnitude of BHC contributions is important in formulating strategies to reduce peak ozone concentrations because an effective strategy will take into account the relative strengths of NOx and VOC emissions. The choice between NOx and VOC controls is crucial since an incorrect emphasis may result in non-attainment of ozone-reduction goals and control measures for either NOx or VOC involve enormous costs. As part of a program to develop a reliable BHC emission inventory for the Central Valley of California, a quantitative investigation of the leafmass of urban trees was conducted. Twenty-one trees in Bakersfield, Calif., were harvested and leaves removed, dried, and weighed. Leaf masses per tree ranged from 1.5 to 89.6 kg. Leaf mass densities (dry leaf mass per area of crown projection) ranged from 150 to $3200 \text{ g} \cdot \text{m}^{-2}$, as much as eight times greater than leaf mass densities for deciduous forests and more than twice those for coniferous forests. These data suggest the BHC contributions of urban trees may be underestimated if their foliar masses are calculated using forest-based leaf mass density data.

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Characterization of Amylolytic Activities of Tulip Bulb Scales

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Amylolytic activities extracted from scales of tulip (*Tulipa gesneriana* L. cv. Apeldoorn) bulbs stored at 4°C for 6 weeks under moist conditions were characterized. Anion exchange chromatography of enzyme extract on DEAE-Sephacel revealed three peaks of amylolytic activity. Three enzymes showed different electrophoretic mobilities on non-denaturing polyacrylamide gels. The most abundant amylase activity was purified extensively with phenyl-agarose chromatography, gel filtration on Sephacryl S-200, and chromatofocusing on polybuffer exchanger PBE 94. The purified amylase was determined to be an endoamylase based on substrate specificity and end product analysis. The enzyme had a pH optimum of 6.0 and a temperature optimum of 55°C when soluble starch was used as the substrate. The apparent K_m value for soluble starch was 1.28 mg/ml . The inclusion of 2 mM CaCl_2 in the reaction mixture resulted in a 1.4-fold increase in the enzyme activity. The presence of calcium ions also enhanced the thermo-stability of the enzyme at higher temperatures. The enzyme was able to hydrolyze soluble starch, amylose, amylopectin, and beta-limit dextrin, but it had no activity against pullulan, inulin, maltose, or p-nitrophenyl alpha-glucopyranoside. Only maltooligosaccharides, having a degree of polymerization of 7 or more, were hydrolyzed to a significant extent by the enzyme. Exhaustive hydrolysis of soluble starch with the enzyme yielded a mixture of maltose and maltooligosaccharides. This amylase activity was not inhibited by alpha- or beta-cyclodextrin upto a concentration of 10 mM . Maltose at a 50 mM concentration partially inhibited the enzyme activity, whereas glucose had no effect at that concentration.

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Antioxidant Activity in Leaves and Fruit of Blackberry, Raspberry, and Strawberry

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Fruit and leaves from different cultivars of thornless blackberry (*Rubus* sp.), red raspberry (*Rubus idaeus* L.), black raspberry (*Rubus occidentalis* L.), and strawberry (*Fragaria xananassa* D.) plants were analyzed for total antioxidant capacity (oxygen radical absorbance capacity, ORAC) and total phenolic content. In

addition, fruit were analyzed for total anthocyanin content. Compared to fruit, leaves were found to have higher ORAC values. In fruit, ORAC values ranged from 7.8 to 33.7 μmol Trolox equivalents (TE)/g of fresh berries, while in leaves, ORAC values ranged from 20.8 to 45.6 μmol TE/g of fresh leaves. Fruit harvested at different stages of maturity were analyzed in blackberries, raspberries, and strawberries. Blackberries and strawberries had their highest ORAC values during the green stages, while raspberries generally had the highest ORAC activity at the ripe stage (with exception of cv. Jewel, a black raspberry). Total anthocyanin content increased with maturity for all three fruit. There was a linear correlation existed between total phenolic content and ORAC activity for fruit and leaves. For ripe berries, there was also a linear relationship between ORAC values and anthocyanin content. Of the ripe fruit and leaves tested, raspberry plants appeared to be the richest source for antioxidants.

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Fertilizer Applications on the Growth of Three Groundcover Species in Sun and Shade

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Use of groundcovers in the landscape is often limited due to their slow establishment rate compared to that of turf. *Hedera helix* L., (English ivy), *Euonymus fortunei* 'Coloratus' (Turcz.) Hand.-Mazz. (purpleleaf wintercreeper euonymus), and *Liriope spicata* Lour. (creeping lily-turf) were evaluated in a full sun and 50% shade environment to determine the effects of fertilizer applications on their establishment and growth. Fertilizer treatments, of 13N–13P–13K at a rate of 45 kg/93 m², used were: 1) at planting only; 2) at planting and once during the summer; 3) at planting, in summer, and once in the fall; or 4) at planting, in summer, in fall, and once the following spring. Data collected included fresh and dry weight comparisons of pruned material, percentage canopy cover, plant quality and vigor by visual assessment and photographs, and time required for maintenance of each plot. Results show limited fertilizer effects and interaction according to species during the first several months of growth. Establishment and survivability of *Hedera* was influenced mainly by light exposure rather than fertilizer applications. There was no difference in establishment rates between *Liriope* and *Euonymus*, however, under shade, *Euonymus* did not develop its characteristic fall color. *Hedera* was established in one season under 50% shade and can be considered very competitive with turf under the same conditions.

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Lowbush Blueberry Response to Soil- or Foliar-applied Zinc Fertilizers

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Lowbush blueberries (*Vaccinium angustifolium* Ait.) in two commercial fields were treated with a preemergent soil application of ZnSO₄ at 0.34 g Zn/m² or a prune-year or crop-year foliar application of Zintrac (1.76 g Zn/L) in a RCB design with five treatments and nine blocks, using 1.5 x 15-m treatment plots. Prune-year foliar Zintrac treatments were applied 20 June and 30 June at 53.8 mL • m⁻² or 20 June at 107.6 mL • m⁻². A crop-year application of Zintrac at 53.8 mL • m⁻² was made on 26 June at only one location. Composite leaf tissue samples taken 14 July of the prune year indicated that two applications of Zintrac at 53.8 mL • m⁻² raised Zn concentrations at both locations more than a single application at twice the rate. Soil application of ZnSO₄ did not raise leaf Zn concentrations compared to the control at either location. Crop-year leaf samples taken 6 July at the site that received the crop-year foliar treatment indicated no carryover effect of prune-year Zn treatments on leaf Zn concentration, but crop-year foliar application of Zn from Zintrac did raise leaf Zn concentrations compared to the controls. The characteristics of stems sampled in the fall of the prune year at each location (stem density, stem length, flower bud formation) were not meaningfully affected by any of the prune-year treatments. Blueberry yield was not affected by any of the treatments at either location. These data suggest that control plot leaf Zn concentrations of about 15 ppm in both fields were adequate. Raising the leaf Zn concentrations to about 80 ppm with two applications of Zintrac at 53.8 mL • m⁻² had no effect on growth or yield.

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Growth and Mineral Nutrition of Tomato Seedlings under Diurnal Temperature Variation of the Root and Shoot

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Does heating roots only in the day improve growth and nutrient status of seedlings grown under a day-to-night difference (DIF) in air temperature? To answer this question, tomato seedlings (*Lycopersicon esculentum* Mill) were grown in early March or April in greenhouses heated to give either a 14 °C DIF or a 5 °C DIF with a 18 °C mean. The roots were in peat-vermiculite medium that was unheated or heated to 21 °C, constantly or only in the day, or only in the night. Growth was faster and there were higher concentrations of elements in leaves under 5 °C compared to 14 °C air DIF. Any root-zone heating increased growth and nutrition compared to no heating. Under both air conditions, the trend in root temperature treatments was constant > day > night. In general, there was no benefit of heating the roots only in the day, compared to constant heating of the root zone, even with a large diurnal variation in temperature of the shoot. The only nutrient to respond differently to root heating under 5 °C compared to 14 °C air DIF was nitrate in leaves. Under a 14 °C air DIF, heating roots in the day resulted in the highest nitrate concentration, whereas constant root heating was optimal under a 5 °C DIF. Research supported in part by grant 93-37100-9101 from NRI Competitive grants program/USDA.

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

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Nutrient availability may depend on method of fertilization particularly when the root medium is cool. The salad greens, arugula, lettuce, and spinach, were grown in spring, fall, and winter using organic or conventional fertilization to test this hypothesis. Field plots were mineral soil fertilized with 10N–10P–10K, or soil was amended with leaf compost and cotton-seed meal. Unheated high-tunnel plantings plots contained either perlite fertilized with a complete soluble fertilizer or a 1 leaf compost : 1 perlite mixture fertilized with cotton-seed meal. There was no consistent difference in growth due to the method of fertilization, either in the field or in high tunnels. Over all plantings in field and high-tunnel plots, concentrations of nitrogen and phosphorus were higher in leaves of plants grown with leaf compost. The time of year did not affect the difference in composition between plants grown in compost and perlite in a manner that could be related to the environment or rate of growth. Although relative growth rates were only 5% per day in high tunnels in winter compared to 10% to 18% per day in other seasons, the difference in reduced nitrogen among plants grown in compost and perlite was similar in winter and summer. The changes in composition due to method of fertilization were similar in all three plant species under study.

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Iron-chelate Photodegradation in Lab-prepared Nutrient Solutions Alters Root Physiology and Causes Mn Toxicity in Marigold

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Our objective was to determine the effects on plant growth and physiology that a photodegraded Fe-chelate containing lab-prepared nutrient solution would have when used in plant culture. Plants grown hydroponically in the irradiated Fe-DTPA containing nutrient solution had ferric reductase activity 2.2 times greater, foliar Fe level 0.77 times less, and foliar Mn level 1.9 times greater than in plants grown in an identical but non-irradiated solution, indicating that plants growing in the irradiated solution were responding to Fe deficiency stress with physiological reactions associated with Fe efficiency. The youngest leaves of plants that were grown in the irradiated solution had symptoms of Mn toxicity. Restoration of the irradiated solution by removing the precipitated Fe by centrifugation and adding fresh Fe-chelate resulted in plants that were, in general, not different from those grown in the non-irradiated solution (control).

Effects of Mycorrhiza Fungi and Phosphorous on Growth and Nutrient Uptake of Micropropagated Prickly Pear Cactus Plantlets (*Opuntia amyoclaea* Tenore cv. Reyna)

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Micropropagated cactus pear plantlets (*Opuntia amyoclaea* Tenore) cv. Reyna were colonized with a Mexican endomycorrhiza isolate, ZAC-19 (containing *Glomus etunicatum* and two unknown *Glomus* spp.) and fertilized with two phosphorous levels (0 and 11 µg P/ml) to study their effect on plant growth and nutrient uptake. After 7 months of greenhouse culture, there was 100% survival of the micropropagated cactus pear plants. Evidence of mycorrhizal colonization was observed 5 days after inoculation, with the development of internal hyphae in root cortices. At the end of the study, high colonization occurred (48% to 54%) with no differences in P treatments. Plantlets transferred to soil began to actively grow with no lag phase. However, plant growth rate was significantly affected by treatments. Absence of P supply and lack of colonization resulted in lower dry mass and surface area of prickly pear cactus plants. In contrast, the combination of supplementary P and mycorrhizal colonization significantly increased plant growth.

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Effect of Mycorrhizal Inoculation with Two *Glomus* spp. on Growth and Development of American Ginseng Plantlets in Greenhouse

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American ginseng (*Panax quinquefolius*) is a native plant of the deciduous forests of eastern North America. This highly valuable medicinal plant has been grown commercially for nearly a century in the field, under artificial shade sources, or in forests under mature trees. Wood-grown ginseng roots are highly similar to the wild ones, which increases their value. However, the time required to produce a marketable root is two to three times longer in the forest than in the field. In an attempt to reduce this time, a new technique has been developed to produce ginseng transplants destined for forest culture. Ginseng seedlings pre-treated with gibberellic acid were sown in forest plots in a peat base culture medium amended with an inoculum of the arbuscular fungi *Glomus intraradices* or *G. etunicatum*. The plantlets were grown for 18 weeks in greenhouse under shade cloth. The two *Glomus* spp. succeeded in colonizing the ginseng rootlets, developing the 'Paris' mycorrhizal type, as previously reported for this plant. In addition, plantlets inoculated with *G. etunicatum* weighed 15% more than the control and were significantly more branched. The amount of P, K, and Mg in the roots was significantly higher in mycorrhizal ginseng plantlets.

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Effects of Planting Density and Short-term Changes in Photoperiod on the Growth and Photosynthesis of Two Cultivars of Bean (*Phaseolus vulgaris* L.)

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The effects of planting density and short-term changes in photoperiod on the growth and photosynthesis of bean (*Phaseolus vulgaris* L.) was investigated. Two cultivars of bean (cv. Etna, a dry bean variety; cv. Hystyle, a snap bean variety) were grown using nutrient film technique hydroponics in a walk-in growth chamber with a 12 h/12 h (light/dark) photoperiod and a corresponding thermoperiod of 28/24 °C (light/dark) and constant 65% relative humidity. Lighting for the chamber consisted of VHO fluorescent lamps and irradiance at canopy level was 400 µmol • m⁻² • s⁻¹ PPF. For each cultivar, plants were grown at densities of 16 or 32 plants/m². Short-term photoperiod changes were imposed during vegetative growth (21–29 DAP) and pod-fill (42–57 DAP). From the base 12 h/12h (light/dark) photoperiod, lighting in the chamber was cycled to provide 18 h/06 h (light/dark) or 24 h/0 h (continuous light) for 48 h. Diurnal single leaf net photosynthetic rates (Pn) and net assimilation vs. internal CO₂ (Aci) measurements were taken during the short-term photoperiod adjustments. Results showed that there was no difference between cultivars or planting density with regard to total

biomass or single leaf photosynthetic rates, but cv. Etna produced 35% more edible biomass than cv. Hystyle. Additionally, there was no effect of short-term photoperiod adjustment on single leaf Pn or Aci.

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Photosynthetic Characteristics of Two *Cycas micronesica* Leaf Cohorts

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Cycas micronesica is an arborescent cycad with sclerophyllous, long-lived compound leaves that are produced in synchronized pulses. The photosynthetic characteristics of leaves in two sequential cohorts of ≈2 and ≈11 months after leaf expansion were determined in this study. Fluorescence yield following 30-min of light exclusion or from leaves engaged in photosynthesis under ambient light was measured throughout several 24-h periods to determine maximum quantum efficiency of PSII photochemistry and quantum efficiency under ambient light. Maximum quantum efficiency was similar for the two cohorts throughout the nocturnal period. Maximum quantum efficiency and quantum efficiency under ambient light declined following exposure to daily direct sun but recovered quickly each afternoon. This daily decline was greater for the older cohort than the younger cohort. Net carbon dioxide assimilation (Pn) was also determined using gas exchange, and light saturated Pn of the older cohort was 75% to 85% of that for the younger cohort during the daily maximum at late morning. Pn of the older cohort increased more slowly in the morning and declined more rapidly in the afternoon than did Pn of the younger cohort. Apparent quantum yield determined by gas exchange was similar for the two cohorts in the absence of extended sun exposure. However, this characteristic declined during midday, and the decline was greater for the older cohort. These results indicate that photosynthetic capacity of older *C. micronesica* leaf cohorts remains high, and these older leaves may substantially contribute to the plant's overall carbon economy. However, the number of hours during the day in which these older leaves reach their photosynthetic capacity is less than for the younger leaves.

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Interrelationships among Cumulative Yield, Scion Weight, and Trunk Cross-sectional Area of Apple Trees

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Productivity of perennial fruit plants depends to a sizeable degree on partitioning of assimilates between vegetative and reproductive structures. Cultivars and rootstocks modify the partitioning pattern, but there are very few data published on these relationships. The termination of a long-term evaluation of standard-growing and spur-type strains of 'Delicious' and 'Golden Delicious' on several dwarf and semi-dwarf rootstocks and interstocks provided an excellent opportunity to assess the relationships among cumulative yield, scion weight, and trunk cross-sectional area (TCA). Cultivars were 'Goldspur' and 'Smoother' strains of 'Golden Delicious' and 'Redchief' and 'Red Prince' strains of 'Delicious'. Rootstocks and interstocks included Malling 9 (M.9), M.26, M.9/Malling Merton 106 (MM.106), M.9/MM.111, M.7, MM.106, and MM.111. Row spacing was standard at 6.1 m. Tree spacing varied with anticipated vigor and ranged from 1.8 to 5.5 m. Pruning times and weight of prunings were recorded in two years. After 18 years, trees were cut off just above the soil line and weighed. TCA and scion weight were highly correlated despite of considerable differences in degree of containment pruning required, and cumulative yields were well correlated with both TCA and scion weight. The ratio of cumulative crop weight to final scion weight decreased quadratically with increasing TCA. Pruning times and weight of prunings were somewhat better correlated with TCA in 'Delicious' than in 'Golden Delicious'.

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Flowering Phenology of Mamey Sapote [*Calocarpum sapota* (Jacq.) Merr.] in Florida

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Flowering and fruit set characteristics were examined in the popular commercial cultivar Magaoa in an effort to elucidate the reproductive phenology of mamey sapote, *Calocarpum sapota* (Jacq.) Merr. [syn. *Pouteria sapota* (Jacq.) H.E. Moore and Stearn]. Flowers opened during the night with anthesis beginning around

sunset. The length of floral opening varied according to season, ranging from 6 days in winter to a single day in summer. Bursts of new flowers generally appeared in cycles of about 7 days in declining numbers of flowers per burst until all the floral buds of a particular floral bud flush had flowered. Floral buds flowered randomly along a branch with only a few flowers open at any one time. Flower position around the branch was a factor in fruit set. Flowers and small fruitlets encircled horizontal branches in great numbers, but immature fruit most often developed from flowers located on the upper branch quadrant. The lower quadrant contained the fewest immature fruit. As fruit matured, however, more upper quadrant fruit abscised until by harvest, most mature fruit were found on the lower quadrant. The observations provide new insights into the reproductive phenology of mamey sapote.

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Does Water Availability Influence Photosynthesis and Yield Components of the Lowbush Blueberry (*Vaccinium angustifolium* Ait.)?

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Drought is the most limiting factor of crops worldwide. Sound management of any crop is based on a knowledge of its physiology as well as response to drought. Therefore, water use management has become an agricultural priority, with increased research focusing on plant growth and yield under limited water conditions. The lowbush blueberry (*Vaccinium angustifolium* Ait.) is the most important horticultural crop in Nova Scotia in acreage, export sales, and value to the economy. A study initiated at the Nova Scotia Wild Blueberry Inst., Debert (45°26'N, 63°27'W), N.S., during the 1998 growing season investigated the effects of water availability on the growth and development of the lowbush blueberry. Treatments consisting of supplemental irrigation (i), drought stress (d), and a control (c) were applied to plants in their cropping phase of production. Net photosynthetic rates (P_n) were highest during bloom (i: 11.9, d: 9.7, c: 9.8 $\mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$) and then declined throughout the season. No significant ($P = 0.05$) treatment effect on P_n was observed. Stem sample analysis before harvest showed no significant differences ($P = 0.05$) between stem length, node number, flowering node number, flowering zone length, or number of fruit per stem. Samples from 1-m² quadrats indicated the drought-stressed plots produced the lowest yield (378 g $\cdot \text{m}^{-2}$) compared with the supplemental irrigation (449 g $\cdot \text{m}^{-2}$) or control (512 g $\cdot \text{m}^{-2}$) plots. Results from this study suggest drought stress on the lowbush blueberry does not produce significant differences in the number of fruit set; it does result in smaller fruit.

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Morphological Shoot Apex Changes During Inflorescence Development in *Heliconia rostrata* Ruiz & Pavon

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The colorful and pendulous inflorescence of *Heliconia rostrata* Ruiz & Pavon terminates an erect and herbaceous-musoid axis of a sympodial rhizome system. Each hapoxanthic axis bears a variable number of leaves (5 to 10) subtending the inflorescence. The number depends on the time between shoot emergence and flowering stimulus. Inflorescence initiation and development occurs without external evidence of this process until the inflorescence emerges from the pseudostem. The morphological changes occurring at the terminal shoot apex of the *H. rostrata* as it changes from vegetative to the flowering stage are described and illustrated by photomicrographs in this paper. The anatomical sections reveal that the apex on vegetative phase is domed, and a maximum of four furled leaves including one leaf primordium can be observed surrounding it. The growth of the leaf primordium is highly synchronized with growth of the most recently formed leaves. With the transition to inflorescence development, more primordia are observed on the apex, which ultimately give rise to the bracts. Except for the first sterile bract, a cincinnus primordium (flower cluster) is detectable in the axil when the next bract begins to develop. Flower differentiation on the cincinnus begins when many bracts are well-developed. The increase of longitudinal height on the internodes is among the first detectable morphological changes in the apex. Under inductive conditions, the transition to the reproductive stage is achieved early in plants with three or more unfurled leaves. The reproductive plant status is easier to detect under the microscope when the inflorescence has at least three bracts.

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Saturday, 31 July, 1:00–2:00 p.m.

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Influence of Mycorrhiza and an Isoflavonoid on Plant Growth and Gas Exchange of Potatoes Started from Minitubers

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The influence of the mycorrhizal fungus *Glomus intraradices* and reduced levels of *G. intraradices* treated with the isoflavonoid formononetin was tested on growth and gas exchange of container-grown potato plants. Tissue culture-produced minitubers of *Solanum tuberosum* cv. Russet Norkotah and Russet Norkotah selection TX112 were subjected to four treatments: 1) *G. intraradices* at 750 propagules per container, 2) *G. intraradices* at 376 propagules per container, 3) *G. intraradices* at 376 propagules per container treated with the isoflavonoid formononetin, and 4) noncolonized plants. Plants were grown under glasshouse conditions in 1500-mL containers containing a sterilized sand : sandy loam soil, and fertilized with Long Ashton nutrient solution modified to supply phosphorus at 11 $\mu\text{g P/mL}$. The experiment was initiated on 4 May 1998 and terminated on 27 Aug. 1998, during which the plants were exposed to adverse high temperatures (mean high: 30.7 °C). Both cultivars responded similarly to mycorrhizal treatments. Formononetin enhanced growth of mycorrhizal plants and increased total colonization, arbuscule, and hyphae development. Only formononetin-treated mycorrhizal plants had increased shoot growth. Net photosynthesis and stomatal conductance were generally greatest with reduced levels of mycorrhiza and formononetin treated mycorrhizal plants.

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Identification of *Aglaonema* Cultivars for Resistance to Chilling Temperatures

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Aglaonema is among the most popular tropical ornamental foliage plants used indoors because of its bright foliar variegation, low light and humidity tolerance, and few pests. *Aglaonema*, however, has been labeled as one of the most chilling-sensitive foliage plants. The dark, greasy-appearing patches on leaves injured by chilling can result in completely unsalable plants. With recent breeding activity, more and more *Aglaonema* cultivars have been developed and released. How new cultivars respond to chilling temperatures is, however, mostly unclear. This study was undertaken to evaluate cultivar chilling responses to identify chilling-resistant cultivars. Twenty cultivars were chilled at 1.7, 4.4, 7.2, 10, and 12.7 °C for 24 h using a detached single-leaf method and also whole-plant assay. Results indicate that great genetic variation exists among the cultivars, ranging from no injury at 1.7 °C to severe injury at 12.7 °C. A popular cultivar, Silver Queen, is the most sensitive, while the cultivar Stars is the most resistant. There was also a chilling response difference based on leaf maturity. Young leaves showed less injury than did either mature or old leaves. In addition, there was a significant correlation between the single-leaf and whole-plant assay for chilling resistance in *Aglaonema*: the single leaf assay could be particularly useful for a quick test.

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Heat Tolerance Varies with Species, Provenance, and Accession in *Fragaria*

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Several components of whole-plant growth were compared among accessions of *Fragaria chiloensis* (FC) and *F. virginiana* (FV) grown at 23 and 31 °C daytime temperatures. The accessions loosely represented North American (NA) and South American (SA) provenances of FC and Kentucky (KY) and eastern Canadian (CN) provenances of FV. Differences in component values between

species and by provenance and accession within species were observed at each temperature. Using the ratio of the component value at 31 °C to that at 23 °C as a basis for comparisons, whole-plant relative growth rate (RGR), leaf net assimilation rate (NAR), root RGR, and root : shoot ratio were reduced relatively more by high temperature in FC than FV, while crown RGR, leaf RGR, and leaves produced per day were not consistently affected by temperature or and did not differ significantly between species. While the SA FC exhibited higher values for nearly all components than the NA FC at both temperatures, both were affected similarly by high temperature. The CN FV exhibited somewhat greater sensitivity to high temperature than the KY FV, with significantly lower leaf NAR, crown RGR, and leaves produced per day in the former group.

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Evaluation of 'Meeker' Red Raspberry Freeze Tolerance using Whole-plant Growth and Root Electrolyte Leakage Viability Tests

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In Spring 1996, 'Meeker' red raspberry root cuttings were planted into a sandy loam soil in 30 cm tall x 27 cm diameter black plastic containers. During Mar. 1997, a second bottomless container was placed over the overwintering canes of half of the plants. The second container was filled with the same sandy loam soil to simulate ridging of the plants. All plants were grown using standard cultural practices on an outdoor, gravel nursery bed. Freeze tolerance of potted whole plants and excised root sections was measured at 5 °C intervals between -5 and -20 °C in a series of laboratory freeze tests conducted during Jan. 1998. Electrolyte leakage data were used to calculate the index of injury for excised roots while whole-plant response to freezing was determined by measuring the subsequent growth of floricanes lateral shoots and of primocanes. After 1 month in the greenhouse, results indicated the dry weight of primocanes harvested from plants that were exposed to -20 °C was 56% of the nonfrozen control primocane dry weight. Primocane dry weight from plants exposed to -5, -10 and -15 °C was not different from the controls. Similar results were obtained for the percent of floricanes that were alive and for the dry weight of laterals produced by these floricanes after 3 months in the greenhouse. The whole-plant freeze test results indicated plants at the lowest temperature, -20 °C, were injured but not killed. Root index of injury of single potted plants averaged 5%, 15%, 29%, and 58% at -5, -10, -15, and -20 °C, respectively.

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High Root-zone Temperature Inhibits Strawberry Reproductive and Vegetative Growth and Development

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High temperatures are reported to promote day-neutral strawberry (*Fragaria xananassa*) vegetative growth and development and inhibit floral and fruit development, thereby imposing geographic and temporal limitations on fruit production. Day-neutral strawberry response to air temperature has been researched, but specific responses to temperature in the root zone have not. In a 1998 greenhouse experiment, 60 'Tristar' plants were grown hydroponically in a system of individual, temperature-controlled pots. A randomized complete-block design with constant root-zone treatments of 11, 17, 23, 29, and 35 °C and 12 replications were used. Stomatal conductance and transpiration rate were significantly lower for plants at 35 °C, compared with plants at all other temperatures. Leaf area and leaf dry mass of plants at 35 °C were five and four times smaller, respectively, than the combined mean for plants in all other treatments. Leaf area of runner tips was 450 and 44.5 cm² at 11 and 35 °C, respectively, compared with that of plants at all other temperatures, 1552.1 cm². Fruit dry mass was 14.5, 21.6, 25.5, 29.0, and 3.96 g per plant at 11, 17, 23, 29, and 35 °C, respectively. Root dry mass was highest at 11 and 17 °C and lowest for plants at 35 °C. The number of flowers, fruit, and inflorescences per plant was reduced at 35 °C, as were individual berry fresh mass and diameter. Overall, 'Tristar' growth and development were near optimal at 17, 23, and 29 °C.

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High Root-zone Temperature Effects on Floral Initiation in 'Allstar' June-bearing Strawberry

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Temperature, as a potential environmental stressor, interacts with photoper-

iod in floral initiation of June-bearing strawberries (*Fragaria xananassa*), such that high-temperature exposure can result in poor floral initiation. Our objectives were to examine the effects of various durations of high root-zone temperature on floral initiation and development and on vegetative growth and development. In a 1998 greenhouse experiment, hydroponically grown 'Allstar' June-bearing strawberry plants were subjected day/night temperatures of 31/21 °C in the root zone for one, two, or three continuous periods (of ≈7 days), followed by exposure to 17 °C for the duration of the experiment. Control plants were raised at 17 °C in the root zone throughout the experiment. An additional temperature treatment was exposure to 31/21 °C in the root zone for two periods, each followed by a period at 17 °C. Plants were arranged in a randomized complete-block design with factorial treatments of duration of high root-zone temperature and harvest time. At the end of each period, plants were harvested and the apical meristems dissected for microscopic evaluation of vegetative and floral meristems and the stage of development of the primary flower. We observed floral initiation in all treatments after photoperiodic induction. However, exposure to 31/21 °C in the root zone during key periods of floral initiation in June-bearing strawberry may alter floral development.

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Long-term Impact of Cold Damage on Physiological Performance and Yield Efficiency in Red Raspberry

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Two test sites pairing perennially cold-damaged portions of fields vs. controls for a 3rd year were assessed. Winter 1997-1998 was very mild and produced less winter injury than the previous winters. We evaluated continued recovery of the raspberry canopy and cane productivity. In contrast to the last 2 years, the previously cold-damaged plots did not show higher levels of cane dieback, percentage of cane dieback, number of dead or dormant buds per cane, and percentage of dead buds at either site. Very few secondary laterals were produced at either site, which supports previous observations that raspberry compensates for winter injury with increased production of secondary laterals. For the first time, the damaged plots actually produced higher yields mainly through a significantly increased berry number per cane at both sites. Floricane leaves in the damaged plots showed higher photosynthetic rates at the green fruit stage and after harvest at site 2. Cane size was similar across sites, although the previously cold-damaged plants had higher berry numbers per lateral. It seems the newly recovered plants in the previously damaged plots had a renewed vigor, working harder to achieve a higher yield. No differences between treatments was detected in leaf nitrogen for a third year, suggesting this may not be a factor in winter injury here. A high population of weevils was observed at one injured site, suggesting a possible interaction with cold damage.

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Rubus Plant Growth and Development as Influenced by Two High Summer Heat Environments

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Seven *Rubus* cultivars were evaluated at two locations in Arkansas, northwest (Fayetteville) and southwest (Hope), to evaluate plant growth differences under high and very high summer temperature conditions. Temperatures during the hottest month (July) averaged 34 °C and 38 °C for Fayetteville and Hope, respectively. Growth: leaf area and number; and fresh and dry weights of leaves, stems, and roots were measured on the containerized raspberry cultivars Autumn Bliss, Dormanred, Heritage, Nova, Reveille, and Southland and the blackberry cultivar Arapaho. Growth measurements included number of canes per plant, number of laterals per cane, cane length, node number, and internode length. Measurements were taken monthly from June through September. Leaf areas were done after all growth measurements were taken at both locations in September. Variation occurred among cultivars and locations for leaf area, fresh and dry weights, growth, and leaf number. Plant death occurred at the Hope location, with 'Heritage', 'Reveille', and 'Southland' all having plant mortality, while 'Dormanred' and 'Arapaho', both southern-adapted cultivars, had the greatest fresh and dry weights. The Fayetteville location had no plant loss after initial emergence in spring, and this more moderate environment probably contributed to higher plant survival. Our data indicated that only 'Dormanred' and 'Arapaho' achieved adequate survival and growth in the very high temperatures of the Hope location, whereas

other cultivars (Reveille and Southland) with some southern U.S.-adapted germplasm, showed poor adaptation to the environments of our study. Our findings reflect the impact of high heat on non-adapted germplasm and reveal information on adaptation levels needed for parental consideration in breeding for southern conditions.

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Effects of Calcium Salts on Chilling Tolerance in Cucumber Seedling Roots

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The effects of calcium salts and concentrations from 25 to 200 mM on the induction of chilling tolerance in cucumber roots were studied using total root growth, electrolyte leakage, lipid peroxidation, and activities of antioxidant enzymes as indices of chilling injury. Cucumber seeds 'Poinsett 76' germinated at 25 °C for 36 h were treated with calcium sulfate, calcium nitrate, and calcium chloride for 2 h at 25 °C. After incubation, treated seedlings were rinsed with distilled H₂O and chilled at 2 °C for 72 or 96 h with or without re-warming at 25 °C. Roots of CaSO₄-treated cucumber seedlings exhibited less chilling injury at all concentrations, when exposed to 72- or 96-h chilling periods with a 72-h re-warming period as shown by greater root growth compared to the chilled control. Concentrations of CaCl₂ and Ca(NO₃)₂ above 100 mM resulted in significant root growth inhibition. Electrolyte leakage (EL) was significantly reduced by CaSO₄ up to 150 mM under chilling conditions and all calcium salt treatments reduced malondialdehyde (MDA) levels in seedling roots up to 150 mM. However, at 150 mM CaSO₄ both EL and MDA values of 72 h chilled and re-warmed roots were at their lowest levels compared to the control and other treatments. Both superoxide dismutase and catalase activities of seedling roots decreased under chilling conditions compared to the nonchilled control, although the reduction was less in the presence of CaSO₄. Peroxidase and glutathione reductase activities increased under chilling conditions and were generally reduced in the presence of calcium salts compared to the chilled control.

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Late Planting Reduces Annual Artichoke Productivity

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Artichoke, a cool-season, frost-tolerant, but freeze-sensitive, crop, was investigated for annual production in Utah. The objectives were to assess the effects of alternative cropping methods on growth and productivity. Artichoke ('Imperial Star') was seeded in January or February and grown for 3 months before transplanting to the field. Plants were planted in bare soil, through plastic mulch or through plastic with floating rowcovers in April or May. Plant growth (leaf area), environmental conditions, and yield (number, weight, and quality) were monitored throughout the year. Planting date and mulching treatments had a significant effect on plant growth and productivity. Leaf area was greatest at all measurement dates as temperature adjacent to the plant increased (plastic with cover > plastic > bare soil). Early planting had greater yield than late planting regardless of mulching treatment. There was no difference in final yield between the plastic mulch and plastic plus cover at early plantings, although yields were higher than in bare soil. However, late planting through plastic with rowcovers significantly reduced bud yields compared to bare soil or black plastic only. While higher temperatures associated with plastic and rowcovers increased plant growth, increased temperatures under covers after the May planting date devernalized artichoke seedlings, which contributed to the lower yields late in the season.

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Effects of Heat Stress on Spinach Seed Germination

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Seed germination of spinach (*Spinacia oleracea* L.) is partially inhibited by a high germination temperature (35 °C). Tolerance of high germination temperatures varies widely depending on the variety used. We ascertained that seed germination of these spinach varieties was thermoinhibited at 35 °C and secondary dormancy was not induced as seeds germinated when transferred to optimum germination conditions (20 °C). Treatment with 99% oxygen and 10 ppm kinetin significantly increased germination of thermoinhibited varieties at 35 °C. During

heat stress, all organisms produce heat shock proteins (HSPs), which may function as molecular chaperons, are possibly required for the development of thermotolerance, and may be crucial for cell survival during heat stress. Western blotting of SDS-PAGE gels using antibodies to various heat shock proteins indicated that spinach varieties with the highest degree of thermotolerance have higher levels of HSP expression than varieties with the lowest degree of thermotolerance during germination. These results suggest that thermotolerance could be further improved, either through a breeding program or possibly by genetic engineering.

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Evaluation of New Elms from China for Stress Tolerance

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The high resistance of Chinese elms to Dutch elm disease and elm leaf beetles makes them excellent trees for the urban landscape. There are many new Chinese elms being developed through the tree breeding program at The Morton Arboretum. Many new elms are already on the market or will be available soon from nurseries. There is little known about the stress tolerance, e.g., cold, heat, drought, etc., of new elms from China. The objectives of this study were 1) to determine the midwinter cold hardiness of new Chinese elms and 2) to determine the leaf heat tolerance and stem cold hardiness of new elms from the nursery. The stem cold hardiness of nine new elms from China was evaluated in Feb. 1998 and 1999 from the elm breeding program at The Morton Arboretum by using an artificial freezing test. The LT₅₀ (the temperature at which 50% of the tissues were killed) of the most to least hardy genotypes for Feb. 1998 were *Ulmus macrocarpa* (> -36 °C), *U. wilsoniana* # 673 (-34 °C), *U. parvifolia* R-89-120 (-34 °C), *U. wilsoniana* # 669 (-34 °C), *U. wilsoniana* # 997 (-33.8 °C), *U. szechuanica* (-30 °C), *U. gaussenii* R-94-85D (-30.7 °C), *U. bergmanniana* var. *lasiophylla* R-9422SD (-27.7 °C), and *U. castaneifolia* #R-9411-11-SD (-25.9 °C). Four new elms from Schmidt Nursery, Boring, Ore., were also evaluated for leaf heat tolerance in August and cold hardiness in Dec. 1998 and Feb. 1999. The LT₅₀ of cold hardiness of stem tissues of cultivars in December were *U. parvifolia* 'Emer 1' P.P. 7551, Athena® elm (-23.5 °C), *U. parvifolia* 'Emer 1' P.P. 7552 Allee® (-26.5 °C), *U. Accolade*™ (-33.5 °C), and *U. Danada Charm*™ elm (-31 °C). The LT₅₀ of the most to least heat-tolerant cultivars were *U. parvifolia* 'Emer 1' P.P. 7551, Athena® elm (53.8 °C), *U. parvifolia* 'Emer 1' P.P. 7552 Allee® (52.1 °C), *U. Accolade*™ (50.8 °C), and *U. Danada Charm*™ elm (50.6 °C). Growth, dormancy development, spring budbreak, and performance of these cultivars will be compared.

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Seasonal Characterization of the Phenolic Layer Beneath Floral Buds of *Rhododendron* spp.

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It has been previously shown that dormant, cold-hardy floral buds of *Azalea* possess layers of highly lignified and suberized cells below the bud axis and beneath each bud scale. Two species of deciduous *Azalea* were analyzed bi-weekly using differential thermal analysis (DTA) throughout their dormant season to determine the development of cold hardiness as denoted by low temperature exotherms (LTEs). Other buds collected at the same time were observed using fluorescence microscopy to document the relationship between the development of the barrier and the onset of cold hardiness. Preliminary analysis showed when buds were maximally cold hardy the barrier was most intact, and as buds began to lose hardiness, the layer started to degrade. These results suggest that in fact this layer of cells does act as the long-proposed bud barrier. In a comparison between the species, the hardier species (*R. japonicum*) was found to have a denser layer of phenolic-rich cells compared to buds of the less hardy species (*R. occidentale*). This finding further supports the relationship between the layer of cells and the existence of cold hardiness in bud tissues.

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Juvenility Influences Cold Acclimation Ability in *Rhododendron* Populations

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Winter survival in woody plants is controlled by environmental and genetic factors that affect the plant's ability to cold-acclimate. A juvenile period in woody