

Oral Session Abstracts

101st Annual International Conference of the American Society for Horticultural Science Austin, Texas

Presenting authors are denoted by an astrisk (*)

Oral Session 1—Pomology 1

Moderator: Esmaeil Fallahi

July 17, 2004, 8:00–10:00 AM

Pecos

Temperate Fruits Production in the Tropics: A Review on Apples in Kenya

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Temperate zone fruit crops undergo bud dormancy which can be described as a mechanism for avoiding the exposure of tender flowers and leaves to low winter temperatures. In Kenya, apple growing is mostly hampered by inadequate chilling that causes the plants to have prolonged dormancy leading to poor flowering and consequently low yield. Although the chilling requirements are obligatory, under subtropical and especially tropical conditions avoidance is possible. To achieve this, it is necessary to select cultivars with low chilling requirements. This has proven effective in Zimbabwe with cultivar Matsu which is grown without a need for artificial breaking of dormancy. In Kenya like Zimbabwe, low chilling requiring cultivars such as Anna have been grown successfully. However, for cultivars with high chilling requirements, there is need to apply artificial techniques/methods to enhance bud break. Some of the cultural techniques used are: defoliation after harvesting and bending of the shoots horizontally. Defoliation after harvesting has particularly been used successfully in the island of Java in Indonesia and it enables two crops to be grown per year. Root chilling of rootstock has also been found to enhance bud break of the shoot. In addition, chemicals like KNO₃, mineral oil and thiourea (TU) have been found to be effective in breaking bud dormancy in Kenya. This paper is reviewing the challenges encountered in growing apples in the tropics and Kenya in particular and the progress that has made in addressing them.

Resistant Rootstocks, Preplant Compost Amendments, Soil Fumigation, and Row Repositioning for Managing Apple Replant Disease

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We are testing control tactics for apple replant disease (ARD) complex, a worldwide problem for fruit growers that is attributed to various biotic and abiotic soil factors. In Nov. 2001, “Empire” apple trees on five rootstocks (M.26, M.7, G.16, CG.6210, and G.30) were planted into four preplant soil treatments—commercial compost at 492 kg/ha soil-incorporated and 492 kg·ha⁻¹ surface-applied, soil fumigation with Telone C-17 (400 L·ha⁻¹ of 1,3-dichloropropene + chloropicrin injected at 30 cm depth five weeks prior to replanting), compost plus fumigant combination, and untreated controls—at an old orchard site in Ithaca, N.Y. Trees were replanted in rows perpendicular to, and either in or out of, previous orchard rows. Irrigation was applied as needed, and N-P-K fertilizer was applied in 2001 to all non-compost treatments to

compensate for nutrients in the compost treatment. After two growing seasons, the rootstock factor has contributed most to tree-growth differences. CG.6210 rootstock supported greater growth in trunk diameter, central leader height, and lateral shoot growth ($P < 0.05$), regardless of preplant soil treatments and replant position. Trees on M.26 grew least over a two year period. Replant growth was greater in old grass lanes than in old tree rows, despite higher root-lesion nematode populations in previous grass lanes. Growth responses to preplant soil fumigation were negligible. Preplant compost did not increase tree growth during year one, but did increase lateral branch growth in year two. Results thus far suggest that replanting apple trees out of the old tree-row locations, and using ARD tolerant rootstocks such as CG.6210, may be more effective than soil fumigation for control of ARD in some old orchard sites.

Alternative Orchard Floor Management Practices for Improving Soil Quality and Optimizing Nitrogen Uptake Efficiency

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Information about the use of alternative management practices (AOFMP) in perennial systems to manage soil biota and influence the uptake of nutrients is limited. The objectives of this study are to evaluate AOFMP on soil quality, focussing on soil biology, and on nitrogen uptake efficiency. Research plots are located in Lewis-Brown Farm (LB), Corvallis, OR (‘Fuji’ apple trees) and Mid-Columbia Ag. Research & Extension Cent. (HR), Hood River, OR (‘Red Delicious’ apple trees). Main plot treatments were weed control methods: herbicide or cultivation. Sub plot treatments were soil amendments: no amendment, bark mulch (BM), compost, and green vetch/ barley mulch (VB). A split-plot completely randomized design with 3 replications was used. Depleted NH₃SO₄ was applied to single-tree replicates at bud break in 2001, 2002, and 2003. Compost amended plots contained more fungivorous nematodes than other treatments, although this difference was not significant at LB. At both sites there was a significant interaction between main and sub plot treatments in the number of bacterivores. At LB, the interaction between main and sub plot treatments affected the number of enrichment opportunists and the F-ratio was affected by amendment. At HR, the structural index was also affected by amendment. Compost resulted in the most diverse populations. Soil respiration rates in compost and BM plots were consistently higher than in unamended and VB treated plots. Soil P, pH, and organic matter content were increased by compost amendment and bulk density was decreased. At HR mid-season leaves, fruit, and first year growth from compost treated plots contained the least nitrogen derived from fertilizer, followed by bark mulch. The highest nitrogen derived from fertilizer was in unamended plots.

Cropload Affects Fruit Quality of Honeycrisp Apple

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In 2001 and 2002, we imposed a wide range of croploads (0–15 fruits/cm² of TCA) on 4- and 5-year-old Honeycrisp/M.9 trees by manual hand thinning soon after bloom to define appropriate croploads that give adequate repeat bloom and also the best fruit quality. At harvest

each year we evaluated fruit ripening and quality. Samples were stored for 5 months in air at 38 °F and 33 °F and evaluated for fruit firmness and storage disorders. Cropload was negatively correlated with tree growth, return bloom, fruit size, fruit red color, fruit sugar content, fruit starch content, fruit firmness, fruit acidity, fruit bitter pit, fruit senescent breakdown, fruit rot and fruit superficial scald, but was positively correlated with leaf blotch symptoms, fruit internal ethylene concentration at harvest, and fruit soggy breakdown. There was a strong effect of cropload on fruit size up to a cropload 7, beyond which there was only a small additional effect. Although there was considerable variation in return bloom, a relatively low cropload was required to obtain adequate return bloom. Fruit red color was reduced only slightly up to a cropload of 8 beyond which it was reduced dramatically. The reduced fruit color and sugar content at high croploads could indicate a delay in maturity of but, fruits from high croploads were also softer, had less starch and greater internal ethylene. It that excessive croploads advance maturity. Overall, croploads greater than 10 resulted in no bloom the next year, and poor fruit size, color and flavor, but these fruits tended to have the least storage disorders. Moderate croploads (7–8) resulted in disappointing return bloom and mediocre fruit quality. For optimum quality and annual cropping, relatively low croploads of 4–5 were necessary.

Effects of Various Irrigation Regimes on Tree Growth, Water Use, and Mineral Nutrients of ‘Fuji’ and ‘Gala’ Apples

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Effects of seven different irrigation systems for ‘Fuji’ and two irrigation systems for ‘Gala’ on five rootstocks on tree growth, water use, and mineral nutrients were studied. All forms of drip system used significantly less water than sprinkler systems. Partial root drying sprinkler system used 50% less water than full sprinkler. Application of partial root drying drip at 50% rate of full drip was not sufficient and trees had to receive 75% of full drip to survive. Trees under full sprinkler used about 28 inches of water while those with drip used less than 8 inches of water during the 2003 growing season. Leaf minerals, particularly N and K were affected by irrigation systems. Trees with buried drip required less water than those with above-ground drip system. Calculation of water requirement on a tree-use basis provided an excellent guide for irrigation.

A Rapid and Efficient Method for Determination of Fruit Peel Color

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Peel color is a critical index of external fruit quality and consumer appreciation level. Traditional methods for determination of peel color are based on visual analysis or punctual measurements by colorimeter. In this study we present a method based on digital image analysis that integrates the accuracy of an interactive measurement and the efficacy of an image analysis that describes entire sides of the fruit. A sample of apple, mandarin, grape, and peach fruit was photographed (each fruit on two opposite sides) with a digital camera for determination of peel color. Digital images were converted from RGB to CIE L*a*b* format, and color characteristics were indexed and quantified. The implemented method uses a reference color image cropped from the best fruit (interactively chosen) to calculate a color index for each fruit of the image set. The final index is the weighted sum of the number of pixels of the fruit, where pixels closer to the reference color (distance in the CIE L*a*b* space) are considered more relevant. This color index gives integrated information on fruit color quantity (% of cover color) and quality (hue and saturation). The method represents a rapid and efficient way of determining color of the entire fruit surface and overcomes difficulties and approximation of traditional methods. A modification of the same method can be used to determine peel rugosity (mandarin) and average size and number of grape berries per bunch.

Groundcover Management Systems Influence Soil Microbial Community Composition in an Apple Orchard

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An apple (*Malus domestica* cv. Empire on M9/MM111 rootstock) orchard groundcover management systems (GMSs) study has been underway since 1992 in Ithaca, N.Y. Four GMS treatments are applied each year in 2-m wide tree-row strips: Pre-emergence herbicides (Pre-H: diuron + norflurazon + glyphosate); Post-emergence herbicide (Post-H: glyphosate); mowed-sod (Grass); and composted hardwood bark mulch (Mulch) treatment. The soil (silty clay loam) physical and chemical conditions have been monitored continuously. In May and Sept. 2003, we sampled topsoil beneath trees in each GMS and used PCR-DGGE combined with sequencing to characterize soil microbial community composition. Mulch had more culturable soil bacteria than the Pre-H treatment. Soil in Grass plots had the most culturable soil fungi. Soil microbial respiration rates were higher in Mulch than Grass and herbicide GMSs. Surface vegetation in the Grass and Post-H plots strongly influenced soil bacterial community composition. In Principal Component Analyses, Post-H and Grass treatments comprised one variance cluster, and Pre-H and Mulch treatments another. The soil fungal community was less diverse (fewer DGGE bands) than the bacterial community, and was less affected by GMS. Treatments with more surface vegetation (Post-H and Grass) also had more free-living and phyto-nematodes than Pre-H and Mulch. A total of 47 clones from 12 DGGE bands yielded 31 unique DNA sequences. Of these, 15 were novel sequences with no matches in the GenBank (NCBI) database. Another 10 (27 clones) could be matched with known fungal species at 96–100% identity. The primer pair used, ITS1F/ITS2, amplified a considerable number of Basidiomycetes and Ascomycetes, but there was no amplification for Zygomycetes and Oomycetes.

Soil Organic Matter Content Effects on Apple Root Dynamics

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Soil organic matter is a critical component which is fundamental in plant growth. Several soil factors are influenced by organic matter such as slow release of nutrients, increased water holding capacity, improved soil physical characteristics and improved environment for soil microorganisms. The aim of this work is to investigate the physical effect of organic matter content in the soil on apple root growth and development. Twenty five two-year old apple trees (*Malus domestica*, Borkh) cv. ‘Buckeye Gala’ on M.9 NAKB 337 rootstock were planted in completely transparent acrylic boxes. Plants have been grown in a green house to avoid external rain in a complete randomized design. Trees were planted in a sandy-mix soil amended with soil high in organic matter, “muck”, at four incremental levels. Treatments compared were a control (sandy soil with 0% organic matter) and 1%, 2%, 4% and 8% soil organic matter. The amount of water applied by automatic drip irrigation was comparable for all the treatments to avoid high fluctuation of soil moisture on root dynamics. All treatments have been fertilized with the same amount of mineral fertilizer to avoid the nutrition effect on root dynamics. Digital photos of roots were taken to study their dynamics every one to two weeks during a period of five months. Roots have been highlighted with Photoshop and then analyzed with WinRhizo to measure root length, area, lifespan and dynamics. At the end of the growing period plants have been harvested and fresh and dry weight was evaluated to assess the root/shoot ratio. The effects of the treatments on root length, area, lifespan and dynamics, and root/shoot ratio will be discussed.

Oral Session 2—Human Issues/Commercial

Horticulture/Teaching Methods

Moderator: Mary Lamberts

July 17, 2004, 8:00–9:45 AM

Trinity B

“The Summit”: Strategic Planning the Future of Ag and Natural Resource Programs for Extension in North Carolina

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Most administrators regard strategic planning as a structured process to produce fundamental decisions and actions shaping and guiding what their organization is, does, and why it does it. A concerted focus on the future is usually involved in the effort. In North Carolina, all Extension Agriculture and Natural Resource Agents, Specialists, Directors and State Staff recently utilized such a structured process in a 3-day conference entitled “The Summit”. The success of this strategic planning process can be measured by the degree to which the process lead to strategic management within NCCE. The Summit used a framework that fully explored forces affecting or impeding strategic thinking. That framework was a day of laying groundwork and with various keynote speakers helping to set the stage; a day of stakeholder direction and attendee active listening and debate; and a day of group reflection. The results of this conference were chronicled in “White Paper” written by a team representing all major in-house stakeholders. While many of the usual problems affecting Extension were reviewed, stakeholder input to both administration and staff is re-shaping the way NCCE uses resources and directs programs. Ten recommendations came out Action te Such an outcome is strategic management, and the framework of The Summit may allow other similar organizations to also have successful strategic planning meetings.

Targeted Horticultural Education with the Greenhouse Tomato Short Course

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The Mississippi (MS) Greenhouse Tomato Short Course has been held every March since 1989. The purpose of this 2-day, intensive training is to educate growers so they will be able to successfully grow greenhouse tomatoes as a viable horticultural business. With a mixture of experienced, novice, and prospective growers, it is just as important to provide current growers with research based, practical information, as to expose potential growers to the realities of the business, helping them make an informed decision before investing time and money. Beginning as a small program for a handful growers in the conference room at the Truck Crops Experiment Station, it has gradually grown in number and diversity of participants and invited speakers, depth of subject matter, and geographic origin of growers and speakers. The 2003 program had 142 participants from over 20 states and 4 countries, making it the largest such program in the United States. This is in keeping with the recent trend. The typical lineup of topics includes the basics of producing a commercial crop of hydroponic greenhouse tomatoes, the budget for establishing and operating a greenhouse business, marketing and promotion, pest and disease

identification and management, and the grower’s point of view. Other topics, varying year to year, include heating, cooling, and ventilation of greenhouses, record keeping, new technologies, biological control, diagnostics, and alternative crops. For 2004, the subject of organic production will be introduced. With targeted extension programming such as this Short Course, the greenhouse tomato industry in MS has grown from 15 growers in 1989 to 135 growers today, producing \$6.5 million in annual gross sales. Complete information can be found at www.msstate.edu/dept/cmrec/ghsc.htm.

Simple Teaching Tools for Verifying Hand Washing Skills

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U.S. agricultural producers are required to provide varying amounts of safety training to their employees depending on the nature of their operation(s). Hand washing is an integral part of several types of safety training including pesticide safety education, the Worker Protection Standard and Microbial Food Safety of Fruits and Vegetables. Generally instructions are to “wash thoroughly,” though some employees are told they should wash for 20 seconds. An easy way to get growers to “buy into” methods that verify hand washing is to include such demonstrations as part of pesticide safety education programs and workshops that grant Continuing Education Units (CEUs) for the renewal of pesticide applicator licenses. It is important that the demonstrations be highly visual so participants actually experience the difficulty in removing a contaminant from hands even though they have performed “thorough” hand washing. It also allows them to observe the ease of cross contamination from soiled hands. Once growers see how easy and inexpensive it is to do this type of training, they are being encouraged to use these demonstrations with various types of employees: mixer-loaders and other handlers, harvesting crews, packinghouse employees, and even field workers who routinely handle plants and may be spreading diseases. Details on different methods of training and grower reactions will be presented.

Commercial Field-grown Ornamentals: An Innovative Example of Successful Transition from Cotton Farming on the Texas High Plains

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Over 5 million acres of cotton (*Gossypium hirsutum* L.) are grown annually on the Texas High Plains, providing important resources to local, state and national economies. In recent years, growers have shown interest in farm diversification in order to increase profits. After determining a market, Agri-Gold, Inc. (Olton, Texas; population 2100) successfully diversified from cotton farming by starting with 30 acres of land and 7 canna lily (*Canna xgeneralis*) varieties, but has now grown to produce 500 acres of cannas, 350 acres of irises (*Iris* sp.) and 100 acres of daylilies (*Heimerocallis* sp.). Agri-Gold annually markets 75 varieties of cannas, and over 90 iris and 150 daylily varieties while providing important employment opportunities to 50 full-time personnel and 150 part-time seasonal laborers. Crops are grown and marketed for their reproductive structures (rhizomes, bulbs, and crowns) and sold to retail chains throughout the United States. Warm, dry, sunny days and cool nights provide a quality environment for the reproductive growth of these crops. The arid climate and well-drained soils suppress diseases that may occasionally attack, and there are few natural insects that feed on the roots and foliage. Environmentally friendly products such as composted manure (locally produced) and biologicals, as well as integrated pest management (IPM) strategies are routinely included in field management and production decisions. Recent cooperative research efforts between Agri-Gold and Texas Cooperative Extension have evaluated herbicides for control of yellow (*Cyperus esculentus* L.) and purple nutsedge (*Cyperus rotundus* L.), as well as biological treatments

for improved root growth and control of winter storage rots.

Response of Small Farmers in Missouri to a Specialty Crop Survey

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Specialty crop production has the potential to diversify traditional crop agriculture and improve profits. The primary purpose of this research was to determine the number of small farmers in Missouri who grow crops other than the traditional crops (soybeans, corn, wheat, cotton), and to identify issues they face in their production. A survey questionnaire consisting of fifteen questions was sent to 401 small farmers in Missouri in Fall 2002. The response was a 27% return rate. Most (77%) of the respondents grew tomato and many (50%) used irrigations. Among those who did not grow the nontraditional crops, 46% cited lack of interest as the reason while 32% cited lack of labor. The reasons given by 80% of respondents who at one time grew nontraditional crops but stopped, were lost interest, profit, and insufficient labor. Many respondents also grew herbs and other specialty vegetables in addition to the nontraditional crops. Garlic and chives were grown by 19% of respondents. Most (80%) respondents who grew specialty crops were interested in seminars, workshops or field days on their production, marketing or financing. Among respondents who grew nontraditional crops but stopped, 39% cited drought as the reason while 25% cited insects. These results indicate that small farmers of specialty crops in Missouri need training and information, to profitably produce the nontraditional crops.

Growing Healthy Children: Can Gardening Improve Fruit and Vegetable Attitudes in Minority Children?

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Child obesity has become a national concern. Obesity in children ages 6–17 has more than doubled in the past 30 years. Only twenty percent of children today consume the recommended daily servings of fruits and vegetables. This trend is even more pronounced in minority populations. Past studies have reported that horticulture based curriculum, including gardening, can improve children's attitudes toward eating fruits and vegetables. To investigate whether children of a minority population can benefit from gardening supplemented with nutritional curriculum, research was conducted with elementary schools in the Rio Grande Valley of Texas. Elementary school teachers participating in this research agreed to have school gardens and complete all activities in a nutritional curriculum provided to them through the Texas Extension Service. Children in the participating schools completed a pre- and post-test evaluating their attitudes and snack preferences toward fruits and vegetables and their knowledge before and after gardening supplemented with nutritional information. Statistically significant differences were detected between pre- and post-test scores for all three variables. After comparing pre- and post-test scores, it was concluded that gardening with supplemental instruction, had a positive effect on all three variables including students attitudes and snack preferences toward fruits and vegetables and their nutritional knowledge.

The Effects of a School Gardening Program on the Math and Science Achievement of 3rd, 4th, and 5th Grade Students

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Science and math achievement scores of 3rd, 4th, and 5th grade elementary students were studied using a sample of 196 students from McAuliffe Elementary School, located in McAllen, Texas. Students in the experimental group participated in the Junior Master Gardener™ program in addition to the traditional classroom-based math and science methods.

In contrast, students within the control group were taught math and science using only traditional classroom-based methods. No statistically significant differences were found in comparisons of science students' achievement scores, indicating that those students using the Junior Master Gardener™ program as a method to learn science benefited similarly to those who learned using only traditional science classroom-based instruction. However, results indicated statistically significant differences in comparisons of students' math achievement scores showing that those students who received traditional math instruction had more improved math achievement scores compared to those taught using the Junior Master Gardener™ program. Results also found no statistically significant differences between demographic groups indicating that males and females and students from different ethnicities benefited similarly from participation in the Junior Master Gardener™ program.

Oral Session 3—Weed Control and Pest Management

Moderator: TBA

July 17, 2004, 8:00–9:45 AM

Brazos

Annual Flower Response to Simulated 2,4-D and Dicamba Spray Drift

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Greenhouse studies were conducted to evaluate simulated drift injury to annual bedding plants. Dahlia, gazania, geranium, marigold, petunia, and salvia in the early stages of flowering were sprayed with either 2,4-D (dimethylamine salt) or dicamba (diglycolamine salt) at rates one-fifth, one-tenth, or one-twentieth the lowest labeled rate of for turfgrass. Interactions between species by time, species by treatments, and treatments by time were significant for visual injury. Species sensitivity from most sensitive to least sensitive was marigold > dahlia >> geranium = petunia > gazania = salvia. Dahlia was more sensitive to dicamba than 2,4-D while the opposite was true for marigold. Petunia flower initiation was reduced as dicamba or 2,4-D rate was increased. The duration of the trial may have limited flowering differences among treatments with the remaining species. Dahlia loss of apical dominance as an injury response was greater with dicamba than 2,4-D. Typical injury symptoms for dahlia included stem, leaf, and petiole epinasty along with multiple shoot growth. Gazania injury included slight leaf rolling and leaf stretching. Geranium injury included leaf curling and fewer flowers per cluster. Marigold injury included leaf node swelling and stem wall rupture with massive cellular proliferation. Petunia injury included stem and pedicel epinasty, curling of the outer portion of the corolla, and lower flower production. Salvia injury included stunting, slight flower stem curvature, and partial dieback of the terminal raceme.

The Response of Potted Orchids to Sequential Postemergence Herbicide Applications in Hawaii

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Two experiment were conducted in 1999 and 2000 to determine the response of orchid cultivars, grown as potted plants, to postemergence herbicides. In a film covered commercial nursery in Pahoa, four orchid cultivars were exposed to five sequential herbicide applications. The cultivars used were: Emma White (*Dendrobium*), Wildcat Blood Ruby, Volcano Queen (both *Oncidiums*), and SuFun Beauty (*Vanda*). The herbicides evaluated in this experiment were diuron and clopyralid applied at the anticipated (1×), 2×, and 4× use rate. Spray applications were made directly to crop foliage using a spray to wet application. The first application was applied on 11 Nov. 1999 with sequential applications made at 20-, 208-, 73-, and 69-day intervals for a total of five sprays. Orchid dry weight accumulation was not significantly

reduced and all cultivars responded in a similar way. “Emma White” was the only cultivar to express abnormal growth to clopyralid in the form of J-shaped flower spikes and deformed flowers. The other three cultivars did not show any noticeable injury in response to any of the spray applications. A follow up experiment was conducted on the dry leeward coast of Oahu in a commercial saran house. Diuron was the only herbicide evaluated at one and four times the anticipated labeled use rate. The first application was made on 27 Apr. 2000 with sequential applications made at 50-, 21-, 70-, and 66-day intervals for a total of five sprays. The orchids selected for this experiment included nine Dendrobiums and one Vanda. Treatments were made directly to plant foliage using a spray to wet application. Whole plant dry weight accumulation of the 10 cultivars responded in a similar way and no herbicide treatment reduced dry weight accumulation in comparison to untreated plants.

Effects of Dinitroaniline Herbicides on Root Development in Containers

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DNA herbicides are the most commonly used preemergents in container nursery crops. The objectives of this study were: 1) to investigate differences between DNA herbicide applied as granulars, directed sprays, or in combination with mulch (pine nuggets and cypress) on Taxus, Azalea and Ilex root development; and, 2) to compare efficacy of the above treatments on common groundsel (*Senecio vulgaris*), large crabgrass (*Digitaria sanguinalis*), and annual bluegrass (*Poa annua*). The granular formulations tested were Barricade 65 WG (proflumicarb) at 2.0 lbs active ingredient per acre (a.i./ac) and Treflan TR10 (trifluralin) at 2.0 lbs a.i./ac. The liquid formulations that were used as direct sprays and to treat the mulches were Surflan 4 AS (oryzalin) at 2.0 lbs ai/ac and Pendulum 3.8 CS (pendimethalin) at 3.0 lbs a.i./ac. Evaluations of phytotoxicity and efficacy were taken as rated scores, dry weights, and leaf area measures. Evaluations were taken at 30, 60, 90, and 120 days after treatment (DAT). Efficacy ratings were based on a 0-10 scale with zero being no control, 10 perfect control and 7 commercially acceptable. By 120 DAT, none of the treatments were commercially acceptable. Root (1.52 g) and shoot (3.75 g) weights indicate that Ilex was stunted the most vs. the control (2.42 g roots and 4.87 g shoots) by the direct spray of Pendulum 2X. The Azalea was most effected by the granular application of Barricade at the 2X rate (1.72 g for roots, 4.44 g for shoots) vs. the control (2.23 g for roots, 5.83 g for shoots). Taxus roots were most stunted by Treflan 1X (0.81 g) vs. control (1.01 g). Shoot weights were the lowest with Cypress+1X Pendulum (0.90 g), vs. the control (0.96 g); however, the Treflan 1X treatment gave the second lowest shoot weight for Taxus (0.91 g).

Evaluation of Pendemethlin for Selected Containerized Perennials

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Specialty crops generate \$40 billion in annual sales comprising a significant portion (40%) of total agricultural sales. The diversity of plant material is a limiting factor for new herbicide registration. The IR-4 program facilitates the labeling of new or experimental pesticides for minor use crops. The objective of this experiment was to determine the ornamental phytotoxicity and efficacy of Pendemethalin for selected 1-gallon perennials. Phytotoxicity was evaluated on *Armeria maritima*, *Boltonia*, *Buddleia davidii*, *Cercis Canadensis*, *Delphinium*, *Fragaria*, *Oenothera*, *Panicum virgatum*, *Papaver orientale*, *Phlox subulata*, *Rudebeckia fulgida*, *Scabiosa columbara*, *Schizachyrium scoparium* and *Sedum spectabile*. Herbicide was applied at 1X, 2X, and 4X rates according to IR-4 protocols with a weedy check included. Pendemethalin was applied twice throughout the study, the second spray occurring two months after the first. Visual ratings were taken of efficacy (scale, 0–10)

and phytotoxicity (scale, 1–10, 10 = complete kill) at 15 and 45 days after treatment (DAT). *Buddleia* displayed symptoms of phytotoxicity at the 4x rate but grew out of the initial effects of the herbicide. By trials end, *Oenothera* at 1x, 2x, 4x rates, *Fragaria* and *Phlox* at 2x and 4x and *Canadensis* at 4x had significantly reduced plant quality. All remaining species had acceptable plant quality. Efficacy was evaluated following the same protocol as above with a weedy seed check using a 1/8th tsp. mixture of *Digitaria sanguinalis*, *Poa annua*, and *Senecio vulgaris* per 1-gallon pot. Overall no treatment provided an acceptable level of weed control. The herbicide provided little control of Groundsel, was moderately effective in controlling the Bluegrass, and provided 100% control of the Crabgrass.

Weed Seedbank Community Composition in a 35-Year-Old Tillage and Rotation Experiment

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Community composition of the soil seedbank were characterized 35 years after the implementation of a long-term study involving cropping sequences (continuous corn, corn-soybean, corn-oat-hay) and tillage systems (conventional-, minimum- and no-tillage). Germinable seeds within the top 10 cm of soil in early spring were identified and enumerated in 1997, 1998 and 1999. Species diversity, which was characterized by richness (S), evenness (E) and the Shannon-Weiner index (H'), was significantly influenced by crop rotation rather than tillage. Generally, diversity measures were greatest in the corn-oat-hay sequences as compared to the corn-soybean rotations and the corn monoculture. Species richness and H' typically declined with increasing soil disturbance (no-tillage > minimum-tillage > conventional-tillage), whereas E increased with more intense tillage. A synthetic importance value (RI), incorporating both density and frequency measures, was generated for each species in each plot. Multiresponse permutation procedures (MRPP) were used to examine differences in weed community composition with respect to management system for all three years. Results suggest that the weed seed community in a corn-oat-hay rotational system differs substantially, in structure and composition, from communities associated with continuous corn and corn-soybean systems. No tillage systems were significantly different in composition as compared to conventional tillage and minimum tillage treatments. Crop sequence and tillage system are important cultural methods of shifting weed species number and diversity, and therefore, community structure. Manipulation of these factors could help to reduce the negative impact of weeds on crop production.

Density and Time of Emergence of Yellow Nutsedge Affect Squash Yield

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A field experiment was conducted in Live Oak, Fla., to determine the effect of yellow nutsedge (*Cyperus esculentus* L.) (YN) density and time of emergence on the yield of direct-seeded squash (*Cucurbita pepo* L.). YN densities (0, 20, 40, 60, and 100 plants/m²) were established from tubers planted at different times onto polyethylene-mulched beds, so that YN would emerge the same day as the crop or 5, 15, or 25 days later than the crop (DLTC). YN was not controlled after its emergence. The extent of squash yield loss was affected by YN density and time of emergence. When YN emerged the same day as the crop, the yield of squash was reduced by ≈7% (20 YN/m²) to 20% (100 YN/m²). When YN emerged 15 DLTC, crop yield loss was ≈13% at the density of 100 YN/m². Regardless of density, YN emerging 25 DLTC did not significantly reduce crop yield as compared to weed-free squash. Thus, in soils with high YN densities (≈100 viable tubers/m²) herbicides and/or other means of YN suppression in squash should be effective for at least 25 days after crop emergence to prevent significant yield loss.

If squash yield losses <5% were acceptable, YN control may not be necessary when densities <20 YN/m² emerge at any time during the squash season or when <100 YN/m² emerge >25 DLTC. However, YN emerging during the first 15 days of the squash season may produce tubers, which could increase the YN population at the beginning of the following crop season.

A Comparison Between Two Species of Nematode (*Steinernema carpocapsae* and *Steinernema feltiae*) Applied through a Foliar Spray to Control Leafminer (*Liriomyza trifolii*) in *Dendranthema grandiflora*

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The use of beneficial nematodes as part of integrated pest management strategies is increasing especially for the control of soil inhabiting arthropods, however few studies have been published evaluating the efficacy of foliar applications for control of leafminer (*Liriomyza trifolii*). The objective of this study was to determine the more effective species of commonly used *Steinernema* (*S. carpocapsae*, *S. feltiae*) in the control of leafminer (*Liriomyza trifolii*). Greenhouse cut flower stocks of *Dendranthema grandiflora* grown in raised beds were infected with a well-established population of *L. trifolii*. Plants were treated with a coarse aqueous spray containing commercial preparations of each of the two nematode species at a rate of 1 million nematodes/5 square meters and a water control. Treatments were replicated three times in a randomized block design. Two days after treatment, larvae of *L. trifolii* were removed from the leaves and examined for parasitism.

Oral Session 4—Postharvest 1

Moderator: Chris Watkins

July 17, 2004, 1:30–3:00 PM

Trinity B

Aroma Production in Climacteric Fruit: A Comparison of Tomato, Apple, and Banana

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Volatile aroma compounds produced by apple, banana, and tomato are produced throughout development, however, those associated with ripening and edible quality are dependent upon ethylene action. In apple and banana, characteristic aroma is, in large part, dependent upon the formation of volatile esters. In tomato, many of the characteristic aromas are dependent upon tissue disruption and result from aldehydes and alcohols following lipid degradation. For apple and banana, the enzyme alcohol acyl-CoA transferase (AAT, EC 2.3.1.84) is the enzyme responsible for the final reaction in the pathway for ester formation and catalyzes the union of an alcohol and the CoA derivative of fatty acids. In both tissues, AAT gene expression was detected prior to the onset of ester production. In apple, AAT expression was found to be closely tied with the onset of autocatalytic ethylene synthesis. In banana, ethylene synthesis peaked and began to decline well before ester synthesis began. However, the expression of AAT increased as ester production increased for both tissues. Tomato fruit, like apple and banana, produced characteristic aromas following the onset of the ethylene climacteric, suggesting changes in the activity of various components of the lipoxygenase pathway. In all three tissue types, there are continuous, significant shifts in the aroma profile as fruit ripen age, suggesting shifts in specific metabolic pathways associated with precursor synthesis or degradation.

Temporary Relationship Between C₂H₄ Evolution and C₂H₄ Receptor Genes

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'Granny Smith' apples were stored at 1 °C, 5 °C and 20 °C, then treated at the preclimacteric stage with 2 ppm MCP, various O₂ concentrations, and MCP + low O₂. All the treatments greatly retarded the onset of the C₂H₄ climacteric, and hence ripening. MCP + low O₂ was much more effective than were the applications of MCP and low O₂ singly. Even at 20 °C, 4.04 kPa O₂ inhibited the rise in C₂H₄ evolution for 145 d. Neither low O₂ nor MCP inhibited the System 1 C₂H₄ evolution. The suppression of the climacteric rise in C₂H₄ evolution was accompanied by a strong inhibition of the accumulation of ERS1 C₂H₄ receptor and ACS transcripts. On the other hand, ETR1 receptor was constitutively expressed. When climacteric fruits were treated with MCP, and with low O₂ + MCP the rate of C₂H₄ evolution decreased sharply. This occurred simultaneously with a decrease in ERS1 mRNA. Moreover, the decrease in ERS1 mRNA paralleled the decrease in C₂H₄ evolution. The data thus indicate that the initiation and sustenance of the C₂H₄ climacteric requires the presence of functional C₂H₄ receptors. The expression of ETR2 and ERS2 is also under investigation.

Effects of Postharvest Delay before Application on Responses of Apple to 1-MCP

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Most information about the effects of 1-methylcyclopropene (1-MCP) on apple fruit that is available in the literature involves its application immediately after harvest. However, depending on the storage facility, fruit may be treated within a few days of harvest, especially if destined for rapid CA storage, or after longer time periods. We have investigated the effects of: 1) 1, 2, 3, 4, 6, and 8 d delays before 1-MCP treatment on 'McIntosh', 'Cortland', 'Jonagold', 'Empire' and 'Delicious' apple quality stored in air for 2 and 4 months, and in CA for 4 and 8 months; and 2) 1, 7, 14, and 21 d delays on 'Cortland', 'Jonagold', 'Empire' and 'Delicious' apple quality stored in CA for 5 months. 'McIntosh' and 'Empire' apples were harvested at two maturities. Our data show that responses of apple cultivars to 1-MCP can be affected by delay treatments, but that within each cultivar, these effects vary according to harvest maturity, storage type, and length of storage.

Phytochrome Regulation of Carotenoid Biosynthesis during Ripening of Tomato Fruit

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The accumulation of carotenoids such as lycopene and beta-carotene greatly influences the quality of ripe tomato (*Lycopersicon esculentum*) fruit because cellular levels of these compounds determine the intensity of red color. As well, lycopene has anti-cancer properties and beta-carotene is a Vitamin A precursor. Recent work has demonstrated phytochrome regulation of the carotenoid pathway but the mechanism is not completely understood. This work investigates phytochrome regulation of 1-deoxy-D-xylulose 5-phosphate synthase (DXS) and phytoene synthase (PSY), two key enzymes of carotenogenesis. A simple procedure for the assay of PSY from crude pericarp extracts was developed and mRNA levels of *DXS* and *PSY1* genes were measured by relative RT-PCR. Discs from mature green tomatoes were ripened in total darkness, or in darkness interrupted by brief daily treatments of red light, or red light followed by far red light. After ten days of

incubation, lycopene levels of red light-treated discs had reached ≈ 12 mg/100 g fresh weight; nearly a 50% increase over discs ripened in total darkness. This increase was not observed in discs treated with red light followed by far red light, demonstrating the red/far red reversibility (and thus phytochrome control) of carotenoid accumulation. Similar patterns of phytochrome control are observed for PSY activity but not for *DXS* and *PSY1* transcript levels, suggesting the mechanism of control may be at the level of post-translational modification of PSY. Potential applications of this regulation of carotenoid accumulation will be discussed.

Heat-shock Treatments Alter the Kinetics of Ion Leakage from Chilled Tomato Pericarp Tissue

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Heat-shock induced chilling tolerance in excised discs of tomato fruit pericarp tissue significantly alter the kinetics of chilling-induced ion leakage from the discs into an aqueous isotonic mannitol solution. Pericarp discs were excised from mature-green tomato fruit, trimmed of locular material to 5-mm thickness, held overnight (ca. 16 h) at 20 °C and then subjected to various heat-shock (45 °C) treatments before being chilled at 2.5 °C for up to 30 days. Two discs were immersed in 20 mL of 0.3 M mannitol in a 50-mL plastic centrifuge tube and the conductivity of the aqueous solution periodically measured. The tube was capped and frozen at -20 °C. Total conductivity was measured once the tube had warmed to 20 °C with shaking. The percent ion leakage was calculated as the percent of total, and subjected to an analysis to partition rates of leakage into symplastic and apoplastic components. The symplastic component was not affected by the heat-shock treatment, while the apoplastic component showed reductions consistent with reduced chilling-induced damage to the cellular membrane. The protective heat-shock treatments also significantly increased the tissues resistance to fungal infection.

Responses of Fresh-cut Watermelon to 1-Methylcyclopropene and CaCl₂

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Having been held in 10 $\mu\text{L}\cdot\text{L}^{-1}$ 1-MCP or air for 18 h, seedless watermelon (*Citrullus lanatus* Matsum and Nakai, cv. Millionaire) fruits were cut to obtain tissue cylinders which were rinsed with 2% CaCl₂ or deionized water. Respiration rate, ethylene production, firmness, electrolyte leakage, total soluble solids, titratable acidity, microbial growth rates (aerobic bacteria and yeast counts), and activities of ACS, ACO, PLC, PLD, LOX were determined during 7 days at 10 °C to investigate the effects of 1-MCP and CaCl₂. Ethylene was not detected in cylinders, while wound-induced respiration rates increased over time. Although 1-MCP stimulated ACS activity, it completely inhibited ACO activity and lowered respiration rate. CaCl₂ had little effect on ACS activity, but stimulated ACO activity and maintained tissue firmness throughout storage. 1-MCP abolished the effect of CaCl₂ in retaining or stimulating PLC, PLD and LOX activities, but inhibited aerobic bacteria synergically with CaCl₂. Results suggest that 2% CaCl₂ stimulated activities of PLC, PLD and LOX, which are key enzymes catalyzing phospholipid degradation. Results also provide evidence indicating that 1-MCP counteracts CaCl₂ in aspect of lipolytic enzymes through unknown mechanisms. Furthermore, we provide results that 1-MCP and CaCl₂ have a synergic effect in inhibiting the growth of aerobic bacteria. We suggest that CaCl₂ may be applied together with 1-MCP as a complex treatment to extend shelf life of fresh-cut products.

Oral Session 5—Plant Biotechnology

Moderator: Robert Griesbach

July 17, 2004, 1:30–2:45 PM

Pecos

Molecular Heterogeneity of the Chalcone Synthase Intron in Petunia Species

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The genetic distance for three *Petunia* species was determined based upon an intron in the chalcone synthase gene. The sequence of the intron was obtained for *P. integrifolia* ssp. *integrifolia* var. *depauperata*, *P. integrifolia* ssp. *integrifolia* Torres ecotype, *P. altiplana* and *P. littoralis*. These species are very closely related and believed by some taxonomists to be part of a large single species complex. In all the taxa, the intron contained multiple repeated and inverted sequences. The *P. integrifolia* ssp. *integrifolia* Torres ecotype intron differed from the *P. integrifolia* subsp. *integrifolia* var. *depauperata* intron in 3 of 930 nucleotides. While, the *P. littoralis* intron differed from the *P. integrifolia* subsp. *integrifolia* var. *depauperata* intron in 15 of 930 nucleotides. As compared to the *P. integrifolia* subsp. *integrifolia* var. *depauperata* intron, the intron in *P. altiplana* intron was longer (1125 bp), had a section of 338 nucleotides with a completely different sequence, and differed by 27 of 787 nucleotides in the common sequence.

Evaluation of Different Types of Daylily Explants for Somatic Embryogenesis

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To improve somatic embryogenesis of Daylilies (*Heimerocallis hybrid*); six types of explants namely immature seeds, immature embryos, mature embryos, young inflorescence, ovary-sections and filaments of daylily flower buds were investigated as source of explants. Explants from field grown plants were surface sterilized and followed by culturing on MS medium supplemented with 1.5 mg/L NAA and 0.5 mg/L BAP for four weeks. Explants were scored for development of embryogenic tissue and formation of somatic embryos with/without the formation of an intermediate callus stage. Both mature and immature embryo explants produced direct development of embryogenic tissue followed by somatic embryos. Young inflorescence explants developed compact calli and produced roots around cut ends and showed no somatic embryogenesis. Ovary explants exhibited swelling and not produced embryogenesis. Production of embryogenic callus and formation of somatic embryos in filament explants depended on the sizes of flower buds. Explants from 0.5 to 1.2 mm size flower buds produced calli and formed somatic embryos while explants from sizes over 1.2 mm flower buds only non-embryogenic calli. Immature seeds failed to grow. The results indicated that immature and mature embryos and filaments from young flower buds responded better than other explants for developing somatic embryos in daylily.

Somatic Embryogenesis and Plant Regeneration from Various Explants of Golden Pothos

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Pothos (*Epipremnum aureum* Linden & Andre), a climbing vine with leathery, shiny-surfaced, solid green or variegated heart-shaped leaves, is widely grown as an ornamental tropical foliage plant in hanging baskets or on poles as climbers for interiorscaping. Since pothos easily develops roots from nodes, its propagation is mainly from eye cuttings. Eye cuttings, however, frequently carry diseases from stock

plants into production greenhouses. The objectives of this study were to investigate if somatic embryogenesis could be induced from a common cultivar 'Golden Pothos' and germinated somatic embryos could be a means of clean propagule production. Using a modified MS medium supplemented with 2 mg·L⁻¹ CPPU or TDZ and 0.2 mg·L⁻¹ NAA or 0.5 mg·L⁻¹ 2,4-D, somatic embryos formed directly at cut edges of leaf explants, around petiole and stem explant ends, and along their side surfaces. Most somatic embryos matured and grew into multiple buds or shoots; some of them developed into whole plants on the original medium. Somatic embryos also germinated and developed into plants on MS medium containing 2 mg·L⁻¹ Zeatin and 0.2 mg·L⁻¹ NAA, MS or 1/2 MS containing 2 mg·L⁻¹ BA with or without 0.2 mg·L⁻¹ NAA. Shoots elongated and roots grew on PGR-free medium. Plantlets grew healthy in shaded greenhouses after transferring to soilless substrates. This study suggests that the established method of somatic embryogenesis can be used to generate disease-free propagules of pothos for production.

Rapid In Vitro Propagation of *Aruncus* 'Misty Lace', a New Heat-tolerant, Dwarf, Hybrid Goatsbeard

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Tissue culture is a useful means to clonally propagate new ornamental plant selections, particularly when plant material is limited and/or conventional propagation methods are ineffective. An efficient in vitro multiplication protocol was established to propagate a new goatsbeard hybrid (*Aruncus dioicus*, × *A. aethusifolia*). The hybrid is of interest because it exhibits a dwarf habit, delicate white flower panicles and fern-like leaves, yet is tolerant to heat and humidity. Experiments were conducted to evaluate explant type (nodes, stems, leaves, and floral parts), disinfection procedures, and media formulations including varying concentrations of 6-benzylaminopurine (BAP) and naphthalene acetic acid (NAA). Rapid plant regeneration was obtained with a shoot organogenesis system using a half strength Murashige and Skoog medium supplemented with 4.4 µmol BAP, 0.54 µmol NAA, 30 g·L⁻¹ sucrose, and 3.0 g·L⁻¹ GelGro. Studies compared the performance and yield of plants rooted using different in vitro and ex vitro methods. Ex vitro rooting of shoots during greenhouse acclimatization under mist was most effective. Regenerated plants exhibited uniform and rapid growth, and performed well in greenhouse and field evaluations.

The Gene *slm1-1* Regulates Abscission, Dehiscence, Meristem Arrest, and Apical Dominance in *Arabidopsis thaliana*

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Cell separation regulates basic developmental processes such as abscission and dehiscence and is one of the horticultural traits first to be selected by mankind. Abscission is characterized by an active cell separation process where organs are detached from the main body of the plant through the dissolution of the middle lamella. Crops with early abscission can have significant reduction in yield. For example, canola, *Brassica napus*, loses 5% to 10% of crop due to early pod shatter. By screening T-DNA mutagenized populations of *A. thaliana* for delayed abscission, we have identified several genes that regulate cell separation, *slm1-1* (slender lasting inflorescence and meristem) is one such gene. During our investigation of *slm1-1* we have employed phenotypic, physiological, genetic, and molecular assays. Phenotypically, *slm1-1* displays traits such as delayed abscission of floral organs, lack of anther pollen dehiscence (making *slm1-1* functionally male sterile), delayed meristem arrest, and strong apical dominance. Phenotypic characterization includes scanning electron microscopy, bright field microscopy, and stereoscope microscopy. Physiological assays include reporter gene expression and break strength analyses. Genetically, *slm1-1* is regulated by a single recessive gene. Molecular assays characterizing

slm1-1 include TAIL-PCR, RT-PCR, and preliminary microarray of abscission zones. We have also begun to map based cloning of *slm1-1*. We believe that understanding genes that regulate cell separation in *A. thaliana* will contribute to crop improvement. Applications could include reducing loss during harvesting, regulation of pollination, changes in branching patterns, and longevity of flowering.

Oral Session 6—Viticulture and Small Fruits

Moderator: Carolyn DeMoranville

July 17, 2004, 1:30–3:30 PM

San Marcos

Effect of Prohexidione-Ca and IBA on Establishment and Yield of Green-Top Bare-root Strawberry Transplants

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Bare-root transplants received from high latitude nurseries for Florida production have limited root systems, very long petioles and wilt soon after planting. Further dessication occurs when leaves come in contact with black plastic mulch used in the annual production system. Conventional irrigation practices for the establishment of bare-root transplants of strawberry consist of overhead water application for at least 8 hours/day for 10–14 days after planting. Plant growth regulators (PGRs) have been used to modify the growth characteristics of many plants species. A split-block experiment was implemented at the GCREC-Dover, Dover Fla., to determine the effect of the use Prohexidione-Ca (PC) and IBA [(indole-3) butyric acid] on growth, yield and establishment of strawberry. Main blocks consisted of over head establishment irrigation for 4, 8, and 12 days, and sub-plots consisted of treatments of PC applied in the nursery at a rate of 62.5 mg·L⁻¹ 2, 4, or 6 weeks before digging, PC applied in the nursery at 31.25 mg·L⁻¹ 2 weeks before digging, a root dip of transplants in 100 mg·L⁻¹ IBA just prior to transplanting. The experiment was conducted for four growing seasons. Data were recorded for marketable yield, number of marketable berries (>10g), and disease incidence. Significant differences were detected for duration of establishment irrigation and growth regulator treatment. No interaction was shown between establishment irrigation and growth regulator treatment.

Determination of Proanthocyanidins in Fresh Grapes

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Medical benefits derived from grape extracts and red wine have been recently documented. In these regards, fresh grapes were collected from six Italian table grape varieties grown at the Rutgers Fruit Research and Extension Center in Cream Ridge, N.J. These samples were analyzed for proanthocyanidins (PACs) which are the nutraceutical compounds considered to be bioactive in grapes. Seeded red grapes, seedless red grapes, seeded purple grapes and seedless green table grapes were also purchased from a New Jersey supermarket and analyzed for PACs. An LC/ESI-MS analytical method under low CID level of 20% was used to quantitate the PACs. Separated proanthocyanidins (PACs) were individually analyzed and determined by their molecular ion peaks under positive ion mode, and led to the identification of dozens of proanthocyanidins (PAC). Using HPLC/ESI-MSD, the proanthocyanidin monomers, (+)-catechin (C), (-)-epicatechin (EC), (-)-catechin gallate (CG), and (-)-epicatechin gallate (ECG) in these fresh grape samples were quantified under MRM mode. These identified catechins are the same phytochemicals that exist in green tea which is renowned for these same healthful components. This research revealed that the total concentration of PAC monomers in the six fresh table grape samples

from New Jersey grown grapes ranged from 0.009% to 0.04%, which is much higher than that found in the four fresh table grape samples purchased from supermarket that contained concentrations from trace level to 0.005%. While the New Jersey grown grapes could not be directly compared to the supermarket grapes, this study provides a base-line data of expected PAC levels from standard supermarket grapes, and shows that these Italian grape varieties grown in New Jersey were rich in PACs.

Terroir Evaluation for Winegrapes in Nebraska

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Terroir embodies a defined place, integrating soils, geology, climate, the cultivar, and the role of cultivation, culture, and history in producing wine (Wilson, 1999; White, 2003). The understated topographic changes, thick loess soils, diffuse climatic boundaries (humid to arid), and brief viticultural history contribute to a misconception that “terroir” may not be applicable or that niche microclimates for vineyards may not exist in Nebraska. With many new cultivars and selections now available that are adapted to growing environments once considered marginal vineyard settings and the wealth of geospatial resource databases (soils, climate, and topography) available, we have begun to combine traditional field cultivar evaluation studies with the geophysical data to determine appropriate site/cultivar suitability. Our data have shown that cultivars that were previously considered unlikely to be successful may be suited to viticulture in specific locations, e.g., Riesling, Lemberger, Cynthiana/Norton, Vignoles, and Chambourcin in southeast Nebraska (our “vinifera triangle”). Mean hardiness ratings (scale 1 to 9, where 1 = dead and 9 = no injury) have been obtained for more than 50 cultivars and selections, ranging from 1.86 for Viognier to 8.66 for Frontenac and 8.71 for Saint Croix, for example. Data for most of the cultivars under test will be presented and matched with “terroirs”, providing growers with a vineyard decision support system that can help match genotypes to their specific vineyard sites and help avoid poor cultivar selection.

Effect of Shading and Water Stress on Growth of ‘Campbell Early’ Grape (*Vitis hybrid*)

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Three-year-old ‘Campbell Early’ grapevines were subjected to 4 levels of shading (0, 30, 60, and 90%) combined with 3 levels of soil moisture content (12, 34.6, and 100 kPa), and their growth responses were examined. Increase in shoot length of vines grown without soil water stress (12 kPa and 34.6 kPa) and light stress (non-shading and 30% shading) was higher than those grown under 100 kPa and heavy shading. Leaf number showed a gradual increase in proportion to decreasing shading and increasing light level, showing some overgrowth with 30% shading. Leaf area increment of vines with sufficient soil moisture (12 kPa) was the highest, but 30% shading reduced the rate by one half. Chlorophyll content of vine leaves grown under 12 kPa or 34.6 kPa increased regardless of shading level, but that of 30% shading became more important after 30 days. The qP and qN values of vines grown under 12 kPa and 34.6 kPa decreased with the shading level, and under 100 kPa, even non-shading vines showed a drastic decrease. When grown under 12 kPa, photosynthetic rate of non-shaded vines was higher than shaded vines, but when water-stressed, that of non-shaded vines showed a sharp decrease. Increasing shading and water stress level resulted in decrease of sucrose and starch content and increase of reducing sugar.

The Effect of Interrupting Short Day Cycles with Day-length Extension on Floral Bud Initiation in Strawberry (*Fragaria xananasa*)

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Experiments were conducted to investigate the potential effect on floral bud initiation in strawberry (*Fragaria xananasa*, cv. Chandler) by interrupting inductive short day cycles with a day-length extension treatment. Vegetative plants were exposed to 10-, 15-, or 20-day cycles of inductive short days in growth chambers. After receiving an inductive short day treatment plants were transferred to a greenhouse where they were exposed to non-inductive long days, which stimulated panicle elongation. Dissections of apical meristems immediately following each cycle of short days revealed that cycles of 20 days resulted in detectable floral bud formation. After 15 days in the greenhouse, all short day treatments had initiated floral buds. In the greenhouse, under long days, subsequent flowering in cohorts of plants which had previously received inductive short days showed a positive correlation between interruption of short days with day length extension and reduction in the number of floral buds initiated on earliest emerging panicles. These results suggest potential for manipulation of floral bud induction and potentially fruit size in Chandler, and perhaps other cultivars by interruption of a cycle of inductive short days with a day length extension treatment.

Comparative Study on Fresh Transplant Production in the Major Strawberry Growing Areas of Egypt

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This study was carried out during 2002 and 2003 seasons in sandy soils at three different major strawberry production areas i.e. Ismailia (East Delta), Qalubia (Middle Delta), and Nobaria (West Delta) to compare runner formation and fresh transplant production under four different nursery planting dates i.e. 1, 15, and 30 Apr. and 15 May. Camarosa cultivar was used. Data were recorded on number of main runners, number of fresh transplants dug in September, crown diameter, number of roots, root length, number of leaves, and carbohydrates content in roots and crowns of transplant. Results indicate that, there were significant increases in number of main runners, number of fresh transplants, number of roots, root length, and total carbohydrates in roots and crowns in Ismailia (East Delta) location as compared with other tested locations. On the other hand, Nobaria location showed the lowest value for the above mentioned studied characters. As for nursery planting date, planting nursery mother plants on 1 or 15 Apr. resulted in significant increments in number of runners and marketable fresh transplants as well as number and length of roots and total carbohydrates in roots and crown. However, plants planted in mid May gave the highest values of crown diameter. The study concluded that early establishment of strawberry nursery (first or mid April) is preferable to increase number and quality of fresh transplants. Moreover, Ismailia area (East Delta) was the best for transplant production as compared with the other tested locations. These results may be due to its microclimate condition.

Fruit Set, Retention, and Developmental Rates Vary in Massachusetts Cranberry Cultivars

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Cranberry fruit development was studied in 3 years at the Univ. of Massachusetts Cranberry Station farm. Beginning at 4 weeks from 50% out of bloom and continuing until late Sept, 5 replicate samples of 25 fruiting uprights were collected biweekly from each of 7 cultivar beds. Fruit were removed from uprights and sorted into size classes using stacked soil sieves (16-, 12.5-, 9.5-, and 5.6-mm grids). Fruit from

each class was counted and weighed. ‘Ben Lear’, a native Wisconsin selection and the fourth most planted cultivar in Massachusetts, consistently produced the greatest yield (mass) of fruit. This was attributed to consistent fruit retention and large fruit size (majority of fruit at harvest were >12.5 mm in dia). In comparison, ‘Pilgrim’, a large-fruited hybrid cultivar, was near the median for fruit yield due to poor fruit set (≈ 1.2 berries per upright compared to ≈ 1.6 for ‘Ben Lear’). ‘Stevens’, the hybrid cultivar of choice in the MA cranberry industry, had yield similar to ‘Ben Lear’ in only 2 of 3 years. Fruit set and retention in ‘Stevens’ was less than that in ‘Ben Lear’, but larger mass of individual fruit in ‘Stevens’ generally made up for fewer fruit produced. Native cultivars ‘Early Black’ and ‘Howes’, which account for >50% of the MA cranberry acreage, had variable yield attributable to variable fruit set and retention by year. These cultivars bear small fruit (≈ 1 gm/berry; only half of berries >12.5 mm in diameter). Growth curves showed evidence of a ‘lag phase’ in cranberry fruit mass accumulation occurring approximately at the mid-point of fruit development. Although much of the final fruit mass had accumulated by Sept, additional mass did accumulate up to the harvest of the beds (≈ 1 Oct.). This has implications for growers who harvest fruit in early Sept for ‘white’ cranberry juice.

Oral Session 7—Pomology 2/Growth Regulators in Fruit and Nut Production

Moderator: Kirk W. Pomper

July 17, 2004, 3:30—5:30 PM

Trinity B

Effect of a Synthetic Fabric Row Cover on Soil Moisture Content, Growth and Fruiting of Young Sweet Cherry Trees (*Prunus avium* L. cv. ‘Regina’/Gisela 6)

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A ‘Regina’/Gisela 6 sweet cherry orchard was planted in April 2001 to evaluate a row cover (RC) made of black, woven polypropylene fabric, in water conservation. Trees were trained to a central leader and planted at 3 m x 5.4 m. Soil water content and tree growth variables were compared for trees growing with or without a 2.4 m-wide RC. Irrigation of all trees replenished approximately 80% of weekly evaporation rate. Trees with RC maintained consistently higher (30% to 40%) soil moisture content at 30 cm depth than non-RC trees. In Spring 2003, trees in RC had significantly larger trunk cross sectional area (34%), height (7%), total wood length (65%), total number of branches (20%) and number of 1-year-old-shoots (45%) compared to trees with no row cover. Length of 1-year-old wood for trees in RC was two-fold that of non-covered trees. In Summer 2003, RC had no clear effect on bloom time, intensity or duration. Fruit yields were light and not affected by RC, but fruit size was slightly larger for trees in RC. Although trees were not fertilized, foliar nitrogen content was significantly higher and leaf green color was notably darker green for trees with RC. During Spring and Summer 2003, soil temperatures under RC at 5-cm and 10 cm depths were generally 1 °C to 2 °C warmer than in non-covered ground. The RC did not affect air temperature at 10 cm and 30 cm above ground. It is speculated that RC promoted tree growth by a combined increased available soil moisture and warmer root temperatures, which favor root development and nutrient uptake, particularly in the absence of competing weeds. Increased branching in trees with RC is unclear. It is possible that light quality above RC triggers developmental changes resulting in increased vegetative budbreak.

The Relationship Between the Content of Pear’s Stone Cells and Pulp Quality

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The freezing method combined with enzymolysis was used to determine the content of stone cells of 70 pear varieties for the purpose of identifying the relationship between the content of stone cells and pulp quality. The results demonstrated that the content of stone cells was strongly correlated with pear quality. The majority of the stone cells in all the varieties had diameters of 0.25–0.5 mm; the weight of the stone cells with diameters in this range differed significantly among pear varieties. In addition, the varieties with a higher content of stone cells contained a higher content of coarse pulp than the varieties with a lower content of stone cells.

Peach Latent Mosaic Viroid Reduces Tree Growth and Affects Fruit Quality in Peach

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‘Coronet’ peach on Lovell rootstock was planted near Clemson, S.C., in Dec. 1995 in 4 rows (= reps) 6.1 meters apart with trees 2.2 meters apart in-row. Trees were trained to a Kearney-V. In the 2nd leaf (Aug. 1997), ‘Ta Tao 5’ buds were grafted to half (= 6-tree plot) the trees in each row. These trees received 2 ‘Ta Tao 5’ chip buds infected with Peach Latent Mosaic Viroid (PLMVd) per scaffold at ≈ 0.75 to 1.15 m above ground. Dot blot hybridization confirmed that the chip buds successfully (100%) inoculated the treated trees, whereas the controls tested negative. Data collected in 2003 included bloom date, tree size, dormant and summer pruning times, fruit maturity date, fruit yield, mean fruit weight, skin color, soluble solids, flesh firmness, titratable acidity, and pH. Flowering and fruit maturity were delayed by ≈ 4 days in PLMVd-inoculated (PI) trees. PI trees produced larger fruit, but yield was 23% less than that of non-inoculated trees. Both fruit size and yield had been larger in PI trees in previous years. There were no differences in yield efficiency in 2003, but PI trees were 26% smaller in trunk cross-sectional area and 9% shorter. PI trees took 34% and 23% less time to dormant and summer prune, respectively and had 34% and 28% less wood removed by dormant and summer pruning, respectively than control trees. PLMVd increased fruit firmness, and PLMVd fruit lost firmness at a much slower rate. PLMVd did not significantly affect skin color, but PLMVd fruit were slightly less red. Soluble solid levels were higher in PLMVd fruit than control fruit during the first harvest, but were lower by the last harvest. Acidity was significantly higher and the soluble solids to acidity ratio significantly lower in PLMVd fruit. Control fruit had a slightly higher pH.

Cultural Practices that Impact Stone Fruit Quality

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Quality of stone fruit is defined by fruit size, color, firmness, flavor, shape, general appearance, adhesion and size of the stone and fruit surface characteristics (e.g. fuzz, abrasions, pest damage). Cultural practices, such as pruning, nutrition, irrigation, growth regulator usage and pesticide applications can influence these quality characteristics to a greater or lesser extent. Adequate potassium nutrition can improve soluble solids and fruit size in plums. Excess nitrogen fertilization can soften peaches. Well-timed calcium sprays are thought to improve the firmness of sweet cherries, as are applications of gibberellin. Ethylene synthesis inhibitor usage can alter the timing of ripening, reduce early fruit drop and improve storage. Irrigation scheduling is a tool that can be used to regulate final fruit size and firmness, as well as time of maturation. Selective pruning is used to structure a tree’s architecture for improved light penetration to improve fruit size and color. These and other production practices will be discussed in relation to how they affect fruit quality in stone fruit.

Yield and Fruiting Characteristics of 28 Selections in the Kentucky Pawpaw Cultivar Trial

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The pawpaw [*Asimina triloba* (L.) Dunal] has great potential as a new fruit crop. A pawpaw variety trial was established in Fall 1995 in Princeton, Ky, as a joint Kentucky State Univ.–Univ. of Kentucky research effort with the objective to identify superior varieties for Kentucky. A randomized block experimental design was used with 8 replicates of 28 grafted scion selections on seedling rootstock. Cultivars being tested included Middletown, Mitchell, NC-1, Overleese, PA-Golden, Rappahannock, Shenandoah, Sunflower, Susquehanna, Taylor, Taytwo, Wells, and Wilson. The other 15 clones were selections from the PawPaw Foundation. In 2002 and 2003, the following parameters were examined: tree survival, trunk cross-sectional area (TCSA), average fruit weight, total fruit harvested per tree, average fruit per cluster, total yield per tree, and yield efficiency. In 2003, 54% of the trees had survived, with ‘Susquehanna’ (13%) showing the poorest survival. Based on TCSA, most selections displayed excellent vigor, with the exception of the selections: 5-5 and ‘Overleese’. Average fruit weight was greatest in 1-7-2 (194 g), 1-68 (167 g), 4-2 (321 g), 5-5 (225 g), 7-90 (166 g), 9-58 (176 g), 10-35 (167 g), NC-1 (180 g), ‘Sunflower’ (204 g), and ‘Shenandoah’ (168 g), with the smallest fruit in ‘Middletown’ (70 g), ‘Wells’ (78 g), and ‘Wilson’ (88 g). The selections ‘Wilson’ (81), ‘Middletown’ (75), and ‘Wells’ (70) had the greatest average number of fruit per tree, whereas 4-2 (9), 5-5 (17) and 8-20 (15) the fewest. Yield efficiency and average fruit per cluster also varied greatly among selections. Several pawpaw selections in the trial show promise for production in Kentucky.

Almond Spur Autonomy: Leaf Growth, Floral Initiation and Spur Survival

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Spurs are the primary bearing unit in mature ‘Nonpareil’ almond (*Prunus dulcis* (Mill.) D.A. Webb) trees. Our objective was to determine whether almond spurs behave autonomously with respect to various biological activities throughout the season. If autonomous, a spur’s carbohydrate demands are met primarily by its own leaves and, therefore, the sink to source ratio of the spur itself is expected to be closely linked to its growth and development. In these experiments almond spurs differing in leaf area and/or fruit number were monitored for leaf development, fruit set, floral initiation, spur survival and carbohydrate storage. Previous-season spur leaf area had no relation to the number of leaves preformed within the dormant vegetative bud or final spur leaf area in the current season, but spurs which fruited in the previous season began spring leaf expansion later and current-season spur fruiting was associated with lower spur leaf area. There was little or no relationship between final percentage fruit set at the spur level and spur leaf area in either the current or previous seasons. Current-season spur leaf area was positively related to both spur flower bud number and spur winter survival. Carbohydrate storage in dormant spurs increased with increasing previous-season spur leaf area. These data are consistent with the concept of spur autonomy especially with regards to spur activities late in the season. The relationships of some of these same spur parameters to spur light exposure are currently being investigated.

Crop Load Effects on Subsequent Peach Floral Development, Pistil Size at Anthesis and Fruit Size at Maturity

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The effects of low and high crop loads in 2002 on floral development

(Summer 2002), pistil size at anthesis (Spring 2003), and subsequent season fruit size at maturity (Summer 2003) were studied. Trees were all thinned to the same crop load in 2003. Three peach cultivars (Elegant Lady, O’Henry and Fairtime) with different ripening times (mid-July, mid-August, and early-September, respectively) were used to assess the effects of current season crop on floral development for the subsequent season. Based on previous literature, we reasoned that the maximum competition for carbohydrates between maturing fruit and developing buds is likely to occur at fruit maturity, especially under heavy crop loads. In 2003, individual fruit were harvested and weighed at maturity. In all three cultivars, a heavy crop load reduced the percentage of floral buds initiated and delayed floral differentiation. A heavy crop load also reduced pistil size at anthesis and fruit size at maturity in the subsequent season. These data support the practice of vigorous pruning to annually renew fruiting wood in peach to minimize the influence of crop in the previous season on the subsequent season’s fruit and maintain large fruit sizes.

Prohexadione-Ca in Fruit Trees: Modes of Action of a Multifunctional Bioregulator

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APOGEE and REGALIS have recently been introduced in a number of countries for use in pome and other fruit trees. These products contain 27.5% and 10% of prohexadione-Ca (ProCa), respectively. As a result of inhibiting excessive vegetative growth, less summer and dormant pruning is required, the ratio between vegetative growth and fruit formation is improved, and crop protection is facilitated due to the reduction of tree row volume and a more open canopy. Additionally, a lowered incidence of diseases such as fire blight and scab is observed, which is not due to a direct bactericidal or fungicidal effect of the compound. Further, the compound may reduce fruit drop early in the season. Prohexadione is a structural mimic of 2-oxoglutaric and ascorbic acid. Therefore, distinct dioxygenases are blocked, which require these compounds as a co-substrate. Such enzymes catalyze late steps in gibberellin biosynthesis. After treatment with ProCa, less growth-active gibberellins are formed and treated plants remain more compact. ProCa also affects ACC oxidase, another dioxygenase. The resulting reduction of ethylene formation, in addition to the availability of more assimilates for fruit growth, is most likely the cause of reduced fruit drop. 2-Oxoglutaric acid-dependent dioxygenases are also involved in the metabolism of flavonoids and their phenolic precursors: In shoots of apples and pears, ProCa causes considerable changes by inhibiting flavanone 3-hydroxylase. Convincing evidence is now available that ProCa triggers pathogen resistance by inducing the formation of 3-deoxyflavonoids, in particular luteoforol, with phytoalexin-like properties. Morphoregulatory effects caused by ProCa are only of secondary relevance for the reduction of disease incidence.

Oral Session 8—Vegetable Crops Management 3

Moderator: Matt Kleinhenz

July 17, 2004, 3:45–5:15 PM

Pecos

Harvest Pressure, Irrigation Methods, and Amounts Reduce Asparagus Growth and Yield

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Asparagus producers have reported a decrease in plant longevity and plant productivity in asparagus fields. Irrigation methods and amounts and early harvest pressure are thought to be some factors affecting asparagus longevity and productivity. The objectives of this study were to determine how irrigation method (sprinkler/drip), amount (0, 75, 150% ET), and harvest pressure (yes/no) modify asparagus growth in the year after planting. In April 2002, plots were planted with as-

paragus cultivar Jersey Giant. All plots were treated the same during the establishment year. Each plot was 6.1 m long by 2 rows wide. All plots were separated by a guard row. There were 5 replications. Each irrigation method and amount was divided into two harvest treatments. One row was harvested for three weeks in 2003 (952 kg/ha) while the other was not harvested. Irrigation treatments began after harvest. In 2003, 100% ET from 10 June 10 to 14 Sept. was 55 cm. After correcting for precipitation and crop coefficient, the 75% ET treatment received a total of 28 cm of water while the 150% treatments received 47 cm. There was no difference in fern fresh weight between 150% and 75% ET for the drip irrigates asparagus, but both were significantly greater than non-irrigated treatment. In contrast, fern fresh weight decreased linearly as irrigation amounts decreased in the sprinkler treatments. Yield differences are not expected between drip and sprinkler in 2004. Yield reductions are expected relative to irrigation amounts.

Water Conservation Systems and Strategies for Poblano Pepper Production

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Regulations restricting water use, competition for water with large urban sector, coupled with extreme high temperatures have placed a large strain on farming areas in south Texas. In addition, consumer demand for healthy vegetables has increased. The objective of this work was to determine yield and fruit quality to deficit irrigation rates and irrigation systems on poblano pepper cv. Tiburon. In 2002, an experiment was conducted at the TAES-Uvalde with a Center pivot using three irrigation rates, 100%, 80%, and 60% evapotranspiration rates (ETc). Transplants were established on beds 1.0 m apart with plants within rows 45 cm apart. In 2003, we compared production efficiency of four irrigation systems in a urban-rural environment near San Antonio. Beds were 0.9 m (single-row) or 1.8 m (double-row) between centers. Irrigation systems were: 1) furrow irrigation with one line/single beds, 2) subsurface drip (SDI)-no mulch, with one line/single bed, 3) SDI-no mulch, with two lines/double bed, and 4) SDI-white mulch with two lines/double bed. In 2002, summer ratooning of the spring-planted crop under deficit irrigation (<100% ETc) allowed a fall crop with a 2.0 fold yield increase, larger fruit size (greater than 10 cm length) and significantly lower defects caused by sunburn or blossom end rot compared to summer production. In 2003, SDI-white mulch had a 2.4-fold yield increase and 760 mm water savings compared to furrow. Fruit vitamin C content was not affected by irrigation, however, mature red fruits had a 3.6 fold increase compared to mature green fruits. Combining deficit irrigation with ratooning we were able to produce marketable poblano fruits. Additional water savings and increased yield were demonstrated by SDI technology.

Environmental and Management Factors Affecting Carrot Cracking

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Cracking of carrot (*Daucus carota* L.) roots during harvest and handling is a serious problem for the commercial industry, particularly for 'cut and peeled' products. Thirty commercial fields of cv. 'Sugar Snax' in California were surveyed over the period 2000-03. Soil texture was determined, and soil and crop nutrient status, air temperature and soil moisture were monitored. In 10 fields the effect of excessive N fertilization was investigated; 90 -180 kg·ha⁻¹ N was sidedressed in addition to the growers' N regime. At one site a comparison of 10 cultivars was conducted to determine the root cracking sensitivity of commercial cultivars suitable for the cut and peeled market. In all fields roots were hand harvested, with undamaged roots 18-24 mm in diameter selected for study. Roots were cooled to 5 °C and subjected to an impact test to rate cracking sensitivity. Fields varied widely in root cracking sensitivity,

with 4% to 76% of roots cracked in the impact test. Cracking sensitivity was positively correlated with the % silt and clay in soil, and with air temperature in the final month of growth. Irrigation management had no consistent effect on cracking sensitivity. N application in excess of the growers' N regime did not increase carrot yield, but increased root cracking sensitivity by an average of 30%. Root cracking varied among cultivars from 10% to 49%. However, when the periderm was peeled from roots before impact testing, incidence of cracking declined to 2% or less in all cultivars. Periderm strength or flexibility is apparently the dominant factor in carrot cracking sensitivity, and environmental and management variables that affect cracking sensitivity must do so by affecting the periderm structure.

Effects of Saline Water and Two Types of Plastic Mulch on Physiology and Yield of Bell Pepper Plants

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In order to examine the effects of saline water (0.2, 1.5, 4.0, 6.5 and 9.0 dS·m⁻¹) without or with plastic mulch (black or green infrared transmitting) on the physiology and yield of bell peppers (*Capsicum annuum* L. var. Red Night), plants were drip irrigated and grown in greenhouse conditions. Salinity did not significantly decrease the rate of photosynthesis until fruit set after which irrigation with 6.5 and 9.0 dS·m⁻¹ reduced rates by 35%-38% and during fruit development by 50% compared with the control treatment. Plants receiving 4.0 dS·m⁻¹ had significantly lower (30%) photosynthetic rates than the control during fruit development. Stomatal conductance decreased as the rate of salinity increased which in turn affected transpiration. No consistent differences in photosynthesis, stomatal conductance and transpiration rates were obtained with or without plastic mulch. The marketable yield was negatively affected as salinity increased having being reduced by 17%, 64%, 96%, and 100% for saline treatments compared with the control. The number of fruit of fruit per plant was significantly lower at rates of 4.0 dS·m⁻¹ or higher. No significant differences were detected among plastic mulches and non-mulch condition in marketable yield and number of fruits. Water consumption decreased as salinity level increased with decreases of 11%, 20%, 38%, and 52% of the control value. Mulching the soil reduced water consumption by 30% compared with bare soil.

Glucosinolate Concentrations in Differentially Irrigated Cabbage (*Brassica oleracea* L., Capitata Group)

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Glucosinolates are secondary plant products of the Brassicaceae that may influence vegetable flavor and human health. Soil moisture levels and plant water status are thought to influence cabbage head glucosinolate levels. However, no information is available on the effect of irrigation timing relative to plant developmental stage on glucosinolate concentrations in cabbage. To address these gaps in the literature, cabbage (cv. Bravo) was grown in 2002 and 2003 at The Ohio State Univ., Ohio Agricultural Research and development Center in Wooster, Ohio. The four irrigation treatments, arranged in a RCB design, were: 1) irrigation throughout development [no stress (NS)], 2) irrigation only during head development [frame stress (FS)], 3) irrigation only during frame development [head stress (HS)], and 4) no irrigation [frame and head stress (FHS)]. Irrigation was supplied via drip tape and scheduled by the hand-feel method. Differential soil moisture levels among treatments were confirmed with gypsum block, time domain reflectometry (TDR) and gravimetric measurements. Analyzed across years, irrigation timing significantly affected total glucosinolate concentrations, with levels 36% greater in cabbage not irrigated during head development (HS, FHS) relative to cabbage receiving irrigation during head development (NS, FS). Concentrations were highest (29.4 mmol·kg⁻¹) and lowest (19.4 mmol·kg⁻¹) in FHS

and FS cabbage, respectively. Irrigation effects were greater in 2002, when air temperatures were higher and rainfall and relative humidity lower than in 2003. We conclude from the data that head development is the critical stage at which irrigation should be applied in order to influence cabbage glucosinolate levels at maturity.

Effect of Planting Configuration, Spring Cover Crop, and Reservoir Tillage on Onion

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Field trials were initiated near Carrington and Absaraka, N.D., on a Heimdal clay loam and a Spottswood sandy loam, respectively to evaluate onion grade and yield in response to planting configuration, spring cover crop, and reservoir tillage. Results from the Carrington and Absaraka locations during 2002 and 2003 showed that colossal-sized onion was the largest grading size obtained (Carrington, 2003) and that the greatest number of colossal onion were from the bed configuration that had a reservoir tillage treatment. The coarser soil texture at Absaraka allowed for spring and fall formed raised bed comparison (2003) in which the fall formed raised bed tended to have greater yields and more marketable onion. Planting configuration resulting in the greatest total yield varied among locations and years but generally increased with reservoir tillage. Soil moisture and temperature monitoring during the early growing season did not differ greatly. However, differences in soil water potentials at the 6" depth were observed during the last part of the growing season. Cover crop results indicated that a row of canola planted between onion rows for wind erosion protection will reduce onion yields even when ample water is available through routine irrigation. Herbicides for broadleaf control were not applied until onion had two true-leaves due to label restrictions. This delay enabled the canola to grow beyond the recommended stage for broadleaf control and to quickly outgrow the herbicide injury.

Oral Session 9—Mineral Nutrition

Moderator: John M. Smagula

July 17, 2004, 4:00–5:15 PM

San Marcos

Influence of Various Fertilizers on Vegetative and Fruiting Characters of Cape Gooseberry (*Physalis peruviana*)

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A fertilizer trial was conducted to study the effect of Nitrogen (N), Phosphorus (P), and Potassium (K) on vegetative growth and fruit quality characters in cape gooseberry. The experiment consisting of three levels each of N, P, and K (at 5, 10, and 15 g/plant) along with their interactions was conducted in the experimental area, Dept. of Horticulture, Khalsa College, Amritsar, Punjab during the year 2001–2002. The increasing level of N, P, and K help to increase the plant height, where as application of N and K at 10 g/plant and P at 15 g/plant proved their worth for maximizing fruit size. The total soluble solids level of fruits increased significantly with the increment of N level, whereas in case of P and K the total soluble solids increased upto the moderate level and decreased with the further increment. On the other hand, the acidity per cent followed an increase with the each increasing level of all the fertilizers.

Foliar Applied Strontium as a Tracer for Calcium Transport in Apple Trees

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A field experiment was conducted at the Horticultural Research Center in Chanhassen, Minn. to help refine recommendations for use of calcium (Ca) sprays to reduce the incidence of bitter pit in 'Honeycrisp' apple. Specific objectives were to: evaluate the amount of translocation from leaves to fruit using strontium (Sr) as a tracer for potential Ca movement, determine whether there are differences in translocation in early vs. later phases of fruit development, and evaluate the effect of an experimental adjuvant on spray efficacy. Seven treatments tested included the following: 1) Control (no Sr applied), 2) Sr without adjuvant, fruit covered during spray application, full season, 3) Sr without adjuvant, fruit uncovered during spray application, full season, 4) Sr + adjuvant, fruit covered during spray application, full season, 5) Sr + adjuvant, fruit uncovered during spray application, full season, 6) Sr + adjuvant, fruit covered during spray application, late season, 7) Sr + adjuvant, fruit uncovered during spray application, late season. Results from this study strongly suggest that Sr is a suitable tracer for foliar applied Ca. Up to 18% of the Sr applied to leaves was translocated to fruit. Eight full season spray applications more than doubled the concentration and content of fruit Sr compared to four late season sprays. The experimental adjuvant was found to double Sr absorption by and translocation to fruit compared to not using an adjuvant. Implications for foliar application of Ca to apple trees will be discussed.

The Influence of Preharvest Calcium Applications on Postharvest Quality and Yield of 'Sweet Charlie' Strawberry

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Strawberries are a high value commodity with a short shelf life. Florida is the largest producer of winter strawberries in the United States with 2,790 hectares of production, 90% are located in Hillsborough County. Many Florida growers apply additional calcium (Ca) as a foliar spray despite the lack of conclusive evidence of an increase in fruit quality or yield. It is believed that additional Ca will improve cell wall integrity through Ca linkages with pectins with in the cell wall and increase fruit firmness. Preharvest applications of calcium chloride have shown to delay the ripening of strawberry fruit and mold development. The objectives of this two year study were to determine the effects of Ca on yield, growth, and postharvest quality of strawberry when applied to the soil or as a foliar spray. 'Sweet Charlie' strawberry plants were grown on a Seffner fine sand in Dover, Fla. The experimental design was a split-block replicated four times with soil and foliar Ca applications. Main plots consisted of a broadcast preplant incorporation of gypsum (calcium sulfate) 0 kg·ha⁻¹, 36.7 kg·ha⁻¹, and 73.4 kg·ha⁻¹. Sub-plots consisted of foliar applications of 400 mg·L⁻¹ Ca from calcium sulfate, 400 and 800 mg·L⁻¹ Ca from calcium chloride and a water control applied weekly throughout the 2002–03 and 2003–04 growing season. Yield data was collected twice weekly through out the growing season. Fruits were graded for quality based upon size, visual appearance of pathogens degradation, frost/water damage, and misshapen form. Calcium content was determined for leaves, fruit, and calyxes in January and March. Postharvest quality evaluations of pH, titratable acidity, soluble solids, and firmness (Instron 4411) were determined in January and March.

Effect of Foliar Copper and/or Iron Application on Growth and Yield of Lowbush Blueberry

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In a commercial lowbush blueberry (*Vaccinium angustifolium* Ait.) field with low leaf Cu (<7 ppm) and Fe (<50 ppm) concentrations, nine 1.8 m × 15 m treatment plots were established in a randomized complete block design with 6 blocks. Copper Keylate[®] (Stoller Enterprises, Inc.) containing 5% Cu was used as a foliar spray in a volume of 626

L·ha⁻¹. In a similar volume, the Stoller Enterprises Inc. product Fe Keylate®, containing 5% Fe (5% chelated Iron), was used to provide Fe. Ammonium sulfate (0.7%) was added to the solutions to enhance uptake. Treatment plots received either Cu Keylate® at 0.6 kg·ha⁻¹ Cu or Fe Keylate® at 0.6 kg·ha⁻¹ or a combination of both nutrients in one spray. Treatments included a 19 June prune - or crop-year application of Cu, Fe, or Cu + Fe, and a prune-year Cu + Fe June 7 and June 19. A plot receiving no treatment served as a control. Leaf Cu and Fe concentrations were raised to above satisfactory leaf concentrations (Cu > 7 ppm, Fe > 50 ppm) by their respective treatments. Concentrations were significantly higher for each element when they were applied together. Two applications were not better than only one. No carry-over effect was seen in the crop year. Crop-year applications of Cu and Fe were effective in raising their respective concentrations. Stem density, length, number of branches or branch length was not affected by treatments at the end of the prune year. Flower bud density and average number of flower buds per stem were not meaningfully affected by prune year Cu or Fe treatments. Berry yield was not influenced by any treatment suggesting that the Cu and Fe standards are too high.

Photoprotective Mechanisms of Grape Leaves (*Vitis labrusca* L. cv. Concord) in Relation to Iron Supply

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One-year-old 'Concord' grapevines (*Vitis labrusca* L.) were fertigated twice weekly for 11 weeks with a complete nutrient solution containing 1, 10, 20, 50 or 100 μ mol iron (Fe) from ferric ethylenediamine di (o-hydroxyphenylacetic) acid (Fe-EDDHA). Leaf total Fe content did not increase in response to Fe supply, however both "active" Fe (extracted with 2, 2'-dipyridyl) and chlorophyll (Chl) content increased as applied Fe increased. At the lowest active Fe level, leaf absorbance and maximum PSII efficiency (Fv/Fm) were slightly decreased, and non-photochemical quenching was significantly greater. PSII quantum efficiency decreased curvilinearly as active Fe content decreased. On a Chl basis, the xanthophyll cycle pool size, lutein, and beta-carotene increased curvilinearly as active Fe decreased, and neoxanthin increased at the lowest Fe level. Activities of antioxidant enzymes superoxide dismutase, ascorbate peroxidase, monodehydroascorbate reductase, dehydroascorbate reductase, and glutathione reductase followed a similar trend and increased under Fe deficiency, when expressed on a Chl basis. Antioxidant metabolites also increased in response to Fe limitation. On a Chl basis, ascorbate (AsA), dehydroascorbate (DAsA), reduced glutathione (GSH) and oxidized glutathione (GSSG) content was greater at the lowest active Fe levels. We did not find a difference in the ratio of AsA to DAsA or GSH to GSSG. In conclusion, both photoprotective mechanisms, xanthophyll cycle-dependent thermal dissipation and the ascorbate-glutathione antioxidant system, are enhanced in response to iron deficiency to cope with excess absorbed light.

Oral Session 10—Environmental Stress Physiology 1

Moderator: Jeff Anderson

July 18, 2004, 8:00–9:45 AM

Trinity A

Differential Exothermal Characteristics and the Model of Deep Supercooling Dynamics in Relations to Bud Water Contents and Dormant Periods within the Buds of Some Deciduous Fruit Trees

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Differential exothermal characteristics in relations to bud water content and dormant periods were dynamically investigated within the buds of apple, pear, peach, plum, Grape, persimmon, and black walnut from late autumn to early spring. Differential thermal analysis (DTA) indicated that bud cold hardiness and two exotherms, the high temperature exotherm (HTE) and low temperature exotherm (LTE), were different

among species and dormant periods. According to whether buds have deep supercooling during the dormant winter period the species tested can be divided into two groups. The first group, without supercooling, includes the buds of apple and pear, in which LTE was undetectable. The second group, with supercooling, includes the buds of peach, plum, grape, persimmon, and black walnut, in which LTE was detectable. The second group can be further divided into peach and plum subgroup, and grape, persimmon, and black walnut subgroup. Both HTE and LTE can be detected in the buds of peach and plum subgroup, in which bud cold hardiness can be further divided into three different stages; whereas in the buds of grape, persimmon and black walnut subgroup only LTE can be detected, in which bud cold hardiness can be further divided into five stages according to the detection dynamics of HTE and LTE. Bud differential exothermal characteristics and deep supercooling dynamics are closely related to bud water content and cold hardiness stages. No detection of LTE in the buds of apple and pear and no detection of HTE in the buds of grape, persimmon and black walnut were both closely associated with bud water content.

Heat Stress Responses of Four Herbaceous Ornamentals Differing in Heat Tolerance

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The demand for new and/or improved herbaceous annuals and perennials continues to increase, making information on production and viability of these plants a necessity. In Louisiana and the Southern U.S., one of the greatest impediments to production of marketable herbaceous plants and their longevity is high temperature. Herbaceous plants have various stages of vegetative growth and flowering; high temperatures during these developmental stages can have a tremendous impact on plant metabolism, and thus plant growth and development. The goal of this research was to better understand the differences between heat tolerant (HT) and heat sensitive (HS) species and cultivars at various high temperatures in terms of whole plant growth, flowering, photosynthesis, carbohydrate content, electrolyte leakage, chlorophyll content and plant small heat shock proteins (HSP) expression levels. *Salvia splendens* Vista Series (HT), Sizzler series (HS); *Viola witrokiana* 'Crystal Bowl Purple' (HT), 'Majestic Giant Red Blotch' (HS), F1 Nature Series (HT) and F1 Iona Series (HS); *Gaillardia* \times *grandiflora* 'Goblin' (HT) and *Coreopsis grandiflora* 'Early Sunrise' (HS) were grown from seed in growth chambers under 25/18 °C (day/night) cycles. Plants at 4, 6, and 8 weeks after germination were subjected to different high temperature treatments of 25 (control), 30, 35, 40, and 45 °C for 3 h. Results show that there was a significant difference in net photosynthesis, electrolyte leakage, soluble carbohydrate content and HSP levels between HT and HS cultivars. Effects of high temperature on plant growth, chlorophyll content, and number of days to flower, flower size, and marketable quality were also significantly different.

Respiratory Q₁₀ of Lettuce Increases with Increasing Plant Size

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Literature reports on the Q₁₀ for respiration vary widely, both within and among species. Plant size and metabolic activity may be responsible for some of this variation. To test this, respiration of whole lettuce plants was measured at temperatures ranging from 6 to 31 °C during a 24-h period. Subsequently, plant growth rate (in moles of carbon per day) was determined by measuring the CO₂ exchange rate of the same plants during a 24-h period. Environmental conditions during this 24-h period resembled those that the plants were exposed to in the greenhouse. The measured growth rate was then used to estimate the relative growth rate (RGR) of the plants. The respiratory Q₁₀ ranged from 1.4 for small plants to 1.75 for large plants. The increase in Q₁₀ with increasing plant size was highly significant, as was the decrease in Q₁₀ with increasing RGR. However, growth rate had little or no effect on the respiratory Q₁₀. One possible explanation for these findings is that the Q₁₀ depends on the ratio of growth to maintenance respiration (which is directly related to

RGR). The growth respiration coefficient generally is considered to be temperature-insensitive, while the maintenance respiration coefficient normally increases with increasing temperature. Based on this concept, the Q_{10} for the maintenance respiration coefficient can be estimated as the estimated Q_{10} at a RGR of zero (i.e. no growth and thus no growth respiration), which was 1.65 in this experiment. Although the concept of dividing respiration into growth and maintenance fractions remains controversial, it is useful for explaining changes in respiratory Q_{10} during plant development.

Thermal Stability of Pepper Leaf Extracts

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Acute heat stress can denature and aggregate proteins. The objective of this study was to determine how changes in the chemical and physical environment affected high temperature-induced turbidity and precipitation in pepper (*Capsicum annuum* L.) leaf extracts. High temperature stability of leaf extracts decreased as the tissue concentration increased. Control extracts exhibited a time-dependent change in resistance to turbidity and precipitate development, but the presence of polyvinylpyrrolidone stabilized the extracts. Ethylenediamine-tetraacetic acid had a less marked effect on turbidity and precipitation. Solution thermal stability increased as buffer pH increased from pH 6.0 to 7.0 regardless of whether the pH was adjusted before or after tissue extraction. Mannitol strongly stabilized pepper leaf extracts, but a surfactant lowered the thermal stability.

Stomatal Control by Both Absciscic Acid in the Bulk Leaf Tissue and Leaf Environment: A Test of a Model of Stomatal Conductance to Leaf Environment Coupled with an Absciscic Acid-based Model

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A multiplicative model of stomatal conductance was developed and tested in two functionally distinct ecotypes of *Acer rubrum* L. (red maple). The model overcomes the main limitation of the commonly used Ball-Berry model by accounting for stomatal behavior under soil drying conditions. It combined the Ball-Berry model with an integrated expression of absciscic acid-based control mechanisms (g_{fac}). The factor $g_{fac} = \exp(-\beta[ABA]_L)$ incorporated the stomatal response to absciscic acid (ABA) concentration in the bulk leaf tissue $[ABA]_L$ into the Ball-Berry model by down-regulating the slope and coupled physiological changes at the leaf level with those of the root. The stomatal conductance (g_s) down regulation is pertinent in situations where soil drying may modify the delivery of chemical signals to leaf stomates. Model testing results indicated that the multiplicative model was capable of predicting stomatal conductance under wide ranges of soil and atmospheric conditions in a woody perennial. Concordance correlation coefficients (r_c) were high (between 0.59 and 0.94) for the tested ecotypes under three different environmental conditions (aerial, distal, and minimal stress). The study supported the use of the g_{fac} factor as a gas exchange function that controlled water stress effects on g_s and aided in the prediction of g_s responses.

Physiological Mechanism and Genotypic Variation in Drought Tolerance of Processing Carrots

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Processing carrots are mainly grown under rain-fed conditions in Nova Scotia, and thus become vulnerable to frequent periods of drought. Prolonged drought results in significant reductions in the yield and quality of carrot crops. Resistance to water deficit is gene controlled and it is essential to identify the genotypes that withstand water stress.

It is equally important to understand the physiological mechanism(s) that contribute to drought tolerance. Physiological measurements were made on eight carrot varieties exposed to natural drought in a controlled greenhouse. Measurements were made on net photosynthesis, soil moisture, relative water content, membrane injury index, xylem pressure potential, and stem elongation. Overall, the slicer variety Bergen sustained normal plant functions under drought stress better than any of the other varieties. Bergen maintained stem elongation, photosynthetic activity, membrane function, and relative water content under droughted conditions. Another study was conducted to identify carrot varieties that are naturally resistant to drought. A mass screening of 85 slicer, dicer, and cut and peel varieties was conducted under greenhouse conditions. Two-week-old seedlings were exposed to gradual water deficit and observed for visual symptoms of wilting each day as soil moisture declined. Each variety was assigned a wilting score based upon the number of days it withstood drought (min = 1, max = 5). The dicer variety, Prodigy, was the only variety to score a 5 indicating the most drought resistance. Other varieties that withstood drought well were 'Caropak', 'Interceptor', 'Oranza', and 'Berlanda'. Varieties such as KC713126, Cello712113, and Cello711411 were more sensitive to water deficit and began to wilt 8 days after drought was imposed.

Insights into the Role of Rubisco Activase in Heat Stress-limited Photosynthesis

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Rubisco, the primary enzyme governing carbon assimilation, is dependent upon Rubisco activase. The heat sensitivity of activase, including its expression and thermal stability, varies among species and is considered a key component governing photosynthetic performance in response to moderate heat stress (32–35 °C). However, the Rubisco-Rubisco activase association has yet to be examined among woody plants or varieties within a species, the understanding of which will assist cultivar improvement strategies. Using molecular and physiological techniques to study the role of activase in thermal regulation of photosynthesis, we found that net photosynthesis decreased in *Acer rubrum* L. 'Northwood' at 31 °C, whereas the southern variety, *A. rubrum* 'Florida Flame', maintained optimal assimilation rates up to 36 °C. Additionally, the maximal carboxylation rate of Rubisco (V_{cmax}) at 35 °C was 31.7% lower for Northwood in comparison to Florida Flame. The cloned activase sequences from both cultivars show 97% nucleotide homology and 98% amino acid identity, indicating the potential for similar protein product formation and function. Interestingly, sequence analysis indicates that both cultivars produce at least two isoforms of activase derived from alternative transcript splicing. We will discuss activase mRNA processing and protein isoform abundance in relation to Rubisco kinetic properties as a function of heat tolerance in these two thermally contrasting woody plant genotypes.

Oral Session 11 – Water Utilization and Management

Moderator: Eric H. Simonne

July 18, 2004, 8:00–10:00 AM

San Antonio

Changes in Reclaimed Water Use in Florida

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Florida is one of the larger producers of reclaimed water in the U.S., and use of this water has increased greatly in the past ten years. The objective of this study is to compare changes in reclaimed water use by different entities over the past several years. From 1986 to 2002, total reuse treatment capacity and flow in Florida increased by 221% and 183%, respectively. In the 1980s, reclaimed water was considered to be an urban disposal problem, and cities encouraged use of this water by

giving it away for no charge. Because it was free, agricultural irrigation became the largest user of reclaimed water in the mid-1990s and is still one of the larger users. From 1992 to 2002, overall agricultural land area irrigated with reclaimed water increased by 77%. Land area of edible crops irrigated with reclaimed water increased during that period but remained relatively constant around 6070 ha after 1996. Irrigation of other crops increased to 9800 ha. Golf course irrigation increased by 212% to 20,476 ha while residential irrigation increased around 8147% to 33,373 ha during this period. Total flow to ground water recharge and industrial uses increased by 125% and 424%, respectively. While agricultural irrigation is still a large user of this water, other uses such as golf course, residential, groundwater recharge, and industrial are becoming more important. Some cities are no longer willing to provide this water to agriculture for no charge as competition from other entities increases. Agriculture may have to pay for the water, use less water, or develop other water sources.

Monitoring Wetland Mitigation of Nutrient Contaminants from Container Nursery Offsite Drainage

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Container-grown plants from commercial nurseries require large amounts of water and nutrients during their production cycle resulting in substantial runoff contaminated with nitrogen and phosphorus. Thus, mitigation of nutrients from exiting runoff water is a serious concern for horticultural concerns. Wight Nurseries of Monrovia Growers, Cairo, Ga., has installed 3.77 ha of planted wetlands to receive direct runoff in excess of recapture needs from a 48.6 ha drainage basin and excess water diverted from adjacent watersheds. Water flows through trench drains between wetland cells and eventually into stilling ponds before it is allowed to exit the property. Water flow through the wetlands ranges from 1.6 million to 2.2 million liters per day. Two years of monitoring data indicates strong seasonal differences in nitrate and nitrite nitrogen removal efficiencies. Nitrogen removal between April and November averaged 93.3% while removal during winter months averaged 44.1%. Nitrite was not found in wetland discharge water samples. Nitrogen as nitrate in discharge water varied from 0.05 ppm to 4.3 ppm, well below drinking water quality standards, and was below 0.6 ppm between June and November except in September during construction activity. Orthophosphate phosphorus removal was highly variable with highest removal during late spring, averaging 33.6%, and some removal during early fall, averaging 13.8%. However, there was a significant net export of phosphorus from the wetlands during winter months and during periods of low vegetative growth. Phosphorus levels ranged between 0.9 and 1.9 ppm. While there is currently no legal water quality standard, these levels are above the generally accepted level of 0.01 ppm for preventing downstream eutrophication.

Water-holding Polymers: Revisiting Their Role in Bedding Plant Production and Shelf Life

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There are several commercial materials available that have remarkable hydrating properties and many claim them to be ideal for use in horticulture and deliver water to the roots better than other soilless media. These are often referred to as "hydrogels." There is general agreement in the literature that the physical characteristics of hydrogels are altered in the presence of divalent cations such as Ca and Mg. Tap water can reduce the water holding capacity by 70% or more. Unfortunately, the literature agrees on little else in terms of the performance of hydrogels. Some of the confusion is caused in part by comparing one type of hydrogel to another but treating all as equal. There has been no mathematical performance evaluation of hydrogel and what affect the environment may play in that performance to predict potential irrigation savings or shelf life extension. In a series of greenhouse and laboratory

studies, we have evaluated the physical characteristics of several types of hydrogels and characterized bedding plant performance throughout a typical growth cycle. We measured leaf expansion, water content of the media, root growth, flowering, and fresh and dry masses. We have found little to no differences in the rate of leaf expansion when using hydrogels, but enhanced root growth early in production with the hydrogels. Our results indicated that plant growth was enhanced early in production, but any advantage they may have was lost by the end of production. Plants grown in hydrogels needed irrigation less frequently than those without hydrogel, but the effect was diminished over time. Since the use of the material can add about 15% to the cost of potting media, this data is designed to assist growers in hydrogel use and to determine any benefits of the added costs.

Water-use Efficiency of One-year-old Sweet Cherry (*Prunus avium* L.) cv. 'Rainier' on Dwarfing and Standard Rootstocks, under Well-watered and Water Deficit Conditions

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This study was conducted to determine whether standard and dwarfing sweet cherry rootstocks under water deficit conditions respond differently relative to plant growth and gas exchange parameters, water-use efficiency, and leaf carbon isotope composition. One-year-old potted sweet cherry cv. 'Rainier' grafted on the standard rootstock 'Mazzard' and on the dwarfing rootstock 'Gisela 5' were compared under two different water treatments: 1) well-watered, which received daily 100% of the amount of water lost by ET, and 2) a water deficit treatment, which received 50% of the water applied to the control. Relative shoot growth rate, leaf emergence rate and cumulative leaf area were recorded every three to seven days during the experiment. Leaf net carbon dioxide assimilation rate, stomatal conductance, transpiration rate, internal CO₂ concentration, and WUE were measured daily for the duration of the experiment. At the end of the experiment, leaf samples were collected to determine leaf carbon isotope composition. The growth parameters measured were affected similarly in the two rootstocks indicating a similar degree of sensitivity to water deficit in the genotypes tested. Cumulative leaf area was affected earlier by water deficit than relative shoot growth, and leaf emergence rate. Gas exchange parameters were affected earlier than growth parameters. Overall, WUE was not significantly different between dwarfing and standard rootstocks, and did not appear to increase under water deficit condition, indicating that irrigation should be considered as an important practice in sweet cherry orchards, especially when dwarfing rootstocks are selected.

Water Movement in the Root Zone of Strawberry Grown with Plasticulture

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Visualizing the effect of irrigation volume on water movement in and below the root zone of strawberry (*Fragaria xananassa*) plants may be used to determine when to split irrigation. By injecting blue dye (Terramark SPI High Concentrate) during controlled irrigation events with several drip tapes commonly used by area growers, the objectives of this project were to: (1) determine vertical, lateral and longitudinal movements of wetted zones applied by drip irrigation on a Seffner fine sand soil; (2) describe the shape of the wetted zone for increasing irrigation volumes; and (3) determine the irrigation after which water moves below the root zone. Dye tests consisted in preparing mulched beds with different drip tapes (7 total), injecting dye, irrigating with the selected volume of water (V), digging longitudinal and transverse sections of the raised beds, and taking measurements of vertical (depth; D), lateral (width; W) and longitudinal (L) water movement. Increasing V from 279 to 3353 L/100 m, significantly increased D, W and L. Depth and W responses to V were $D = 0.19 V + 26.1$ ($R^2 = 0.80$), and $W = 0.36 V + 13.5$ ($R^2 = 0.78$). Emitter-to-emitter coverage occurred after 4 hours

for 30-cm spacing. Based on expected root depths of 20 cm when the strawberry plants are young and 30 cm when they are fully grown, largest V before water moved below the root zone were 325 and 870 L/100 m, which corresponds to typical irrigation times of 1 and 3 hours, respectively. Greater irrigation volumes may reduce water use efficiency and increase the risk of nutrient leaching below the root zone.

Response of Individual Plant Actual Evapotranspiration to Canopy Closure: A Three Dimensional Model Derived from *Viburnum odoratissimum*

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ng production and in landscapes, woody plants are initially spaced apart to develop to desirable landscape quality. As plants grow and canopies begin to interact, canopies transform from individual isolated canopies to one large, closed canopy system. Changes in individual plant actual evapotranspiration (ET_A) during the transitions between isolated and closed canopies are 30% on average. Such changes can have a substantial impact on supplemental irrigation requirements, both decreasing with closure and increasing with random removal of plants from a closed canopy. Data will be presented demonstrating changes in ET_A as canopy closure progresses from isolated plants through 33%, 67%, and 100% canopy closure. Concurrent data from plants of marketable size grown in 3.8, 10.4, and 26.6 L containers were used to evaluate effects of canopy vertical thickness, and total canopy height, on the changes in ET_A relative to degree of canopy closure. Contributions to ET_A at 100% canopy closure and isolated plants from leaves at various depths within a canopy will be discussed.

Physiological Response of Carambola Trees to Soil Water Depletion in Krome Soils

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The effect of soil water depletion on plant water potential and leaf gas exchange of carambola (*Averrhoa carambola* L. cv. Arkin) in Krome very gravelly loam soil was studied in an orchard and in containers in the field and in a greenhouse. The rate of soil water depletion was determined by continuously monitoring soil water content with multi-sensor capacitance probes. Stem water potential and leaf gas exchange of carambola in containers were reduced when the soil water depletion level fell below 50% (where field capacity = 100%). Although there was a decrease in the rate of soil water depletion in the orchard as the soil dried, soil water depletion did not go below an average of 70%. This was presumably due to sufficient rainfall and capillary movement of water in the soil. Therefore, soil water content did not decline sufficiently to affect leaf gas exchange and leaf and stem water potential of orchard trees. A decline in soil water depletion below 40% resulted in a concomitant decline in stem water potential of the container trees in the field and greenhouse to below -1.0 MPa. Stomatal conductance, net CO_2 assimilation, and transpiration declined significantly when stem water potential was below -1.0 MPa. The reduction of net CO_2 assimilation and transpiration was proportional to the decline in stomatal conductance of container trees in the field and greenhouse. Thus, soil water depletion in Krome very gravelly loam soil must be less than 50% before water potential or leaf gas exchange of carambola is affected. Based on these results, irrigation scheduling should be based on physiological variables such as stem water potential and stomatal conductance or the amount rather than the rate of soil water depletion.

Physiological and Morphological Responses of Some Iranian Commercial Grapevine Cultivars to Water Stress

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Grapevine under arid and semi-arid are subjected to low soil water

availability, accompanied by high levels of temperature and severe transpiration in the summer period. In spite of their deep root system, severe water stress may occur during that period. Therefore, study of morphological and physiological responses of grapevine cultivars to water stress, especially during the different phenological stages, are necessary. The effect of water deficit stress on morphological and physiological responses of four Iranian grapevine cultivars (*Vitis vinifera* L. cvs. Bidaneh Sephid, Yaghooti Shiraz, Khoshnav, and Siaveh) were studied. This investigation was conducted as a factorial experiment in a complete randomized block design with four replications. In this study, 1-year-old own rooted vines were planted outdoor in plastic bags. Water stress was begun 115 days after bud break and contained for 2 months. Some vegetative and biochemical characters of leaves were evaluated; photosynthesis and gas exchange was measured. The results of analysis of variance indicated that water deficit stress decreased total dry weight, root dry weight, leaf area, non soluble carbohydrate concentration, and chlorophyll content. The reduction of leaf area in 'Yaghooti Shiraz' and total dry weight and root dry weight in 'Bidaneh Sephid' were higher than two other cultivars. Under water deficit stress condition, the soluble carbohydrate concentration and proline content in grapevine cultivars increased. Net photosynthesis and gas exchange rate were markedly reduced in water deficit stressed vines.

Oral Session 12—Temperate Tree Nuts/Citrus Crops

Moderator: Leonardo Lombardini

July 18, 2004, 8:00–10:00 AM

San Marcos

English Walnut Production on Marginal Soils

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Orchard hedgerow production systems have been used successfully in fruit and nut crops in California for decades to enhance yield, particularly in the early years of production. English walnuts (*Juglans regia*) are compatible with hedgerow techniques under prime soil conditions but are thought to require deep well drained soil to be commercially productive. Combining the production techniques of micro-irrigation, close spacing, minimal pruning and frequent fertilization in almonds has improved yield substantially on soils exhibiting a shallow, course textured topsoil underlain with a dense clay layer. Paradox hybrid rootstock (*J. regia* x *J. hindsii*) has shown greater tolerance to root lesion nematodes and heavier textured or poorly drained soils than Northern California Black (*J. hindsii*). Fourteen years of evaluation (1986-99) using 'Chandler' and 'Howard' Ctv's English walnuts in a replicated field trial on marginal soil has shown that 1) yields of 6700 kg·ha⁻¹ (inshell) are attainable under these substandard soil conditions 2) Paradox hybrid rootstock out-yields Northern California Black by 30% on both cultivars tested, 3) kernels of high commercial quality for can be produced for both cultivars and 4) slip plow soil modifications may not improve tree growth, yield or crop quality in drip irrigated walnut hedgerow plantings.

Application of Kaolin-based Particle Film on Pecan Trees: Consequences on Leaf Gas Exchange, Stem Water Potential, Nut Quality, and Insect Populations

Leonardo Lombardini*¹, D. Michael Glenn², Marvin K. Harris³

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Trials were established in Summer 2002 and 2003 to test the consequences of the application of a kaolin-based particle film (Surround WP, Engelhard Corp.) on gas exchange, nut quality, casebearer density and population of natural predators (insects and arachnids) on pecan (*Carya illinoensis*, cv. 'Pawnee') trees. Film application started immediately

after bud break and was repeated every 7–10 days for seven (2002) or nine (2003) times during the season. On both years, treated trees frequently showed lower leaf temperature (up to 4 °C) than untreated trees. Leaf net assimilation rate, stomatal conductance and stem water potential were not affected by film application. Nut size and quality did not differ between the two treatments. In 2003, shellout (percentage of nut consisting of kernel) was in fact 54.2% and 55.5% for treated and control trees, respectively. Moreover, the two treatments yielded similar percentage of kernel crop grading as fancy, choice, standard and damaged. Similar were also the percentages of kernels that showed damage caused by stink bugs. Only on one date the number of adult yellow pecan aphids (*Monelliopsis pecanis*) counted on film-treated leaves was lower than in control leaves. In general, the density of common natural predators (lady beetles, green lacewings, spiders) of pecan pests did not differ between the two treatments; however, the number of green lacewing eggs was frequently lower on film-treated leaves. In film-treated trees the number of nutlets damaged by pecan nut casebearer (*Acrobasis nuxvorella*) was significantly higher than that observed on trees treated with conventional insecticide (24.2% infested nutlets vs. 9.3%, respectively) and did not differ from trees that did not receive either product (29.9%).

The Relationship Between Fatty Acid Composition and Cold Hardiness of Pecan Cultivars

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Temperature is a major environmental factor governing the distribution of both wild and cultivated plant species. During acclimation and deacclimation plants undergo a series of metabolic changes that lead to cold hardiness or loss of hardiness. One of these changes is the accumulation of certain lipids. This research was conducted to compare hardiness among three pecan cultivars: 'Desirable', 'Jackson', and 'Owens' growing under Mississippi condition and to determine the relationship between fatty acid levels and cold hardiness of pecan shoots. Differential thermal analysis (DTA), electrical conductivity, and tetrazolium tests were used to determine cold hardiness. Pecan stems were collected from September to March in 2002 and 2003 to determine cold acclimation and deacclimation. Fatty acid composition of pecan stems during this time period was determined by gas chromatography. DTA indicated that pecan stems acclimated in October and deacclimated in March. During cold acclimation, there was a shift in the fatty acid composition to more unsaturated fatty acids. The percentage of linoleic and linolenic fatty acids increased, while the percentage of palmitic and stearic fatty acids decreased. The correlation between unsaturated fatty acids and cold hardiness suggests that unsaturated fatty acid may play a role in membrane fluidity.

Nickel Deficiency is Occuring in Orchard Trees

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Nickel (Ni) is an essential nutrient element for higher plants; although, it has generally been ignored. This is because it appeared that Ni deficiency would not likely occur in field situations. This conclusion is because a) Ni content of nearly all soils is thought to be high enough to satisfy plant requirements, and b) plant Ni requirements were thought to be very low. Thus, plant Ni nutrition has been generally ignored. We report here: 1) the discovery of acute Ni deficiency in field plantings of pecan (*Carya illinoensis*); 2) the wide variety of symptoms associated with Ni deficient; 3) soil management conditions that cause Ni deficiency; and 4) potential impact of Ni deficiency on management strategies for crops. Observations indicate that Ni deficiencies are occurring on many woody crops in orchard or nursery situations. Evidence indicates that Ni deficiency is likely a factor in many complex disorders of unknown cause affecting a variety of crops. Ni deficiency problems are likely to become increasing common and severe as a result of contemporary

management practices. The information presented identifies a need for greater attention to plant Ni nutrition by practitioners of crop husbandry.

Variation in Bioactive Flavonoid Content of Commercial Brands of Orange Juices

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Orange juice is an important source of bioactive compounds like flavonoids and the main human dietary source of antioxidant compounds in developed countries. Citrus flavonoids possess chemo-preventive and anti-inflammatory properties as well as the ability to lower cholesterol and modulate the immune function. In this study, we examined flavonoid content of "concentrated" (n = 12) and "Not-From Concentrate (NFC)" (n = 14) commercial orange juices by an HPLC method to investigate the brand to brand differences and differences within the brand (various types). Correlation between flavanoid content (mg) and price per unit volume was also evaluated. Significant ($P = 0.05$) differences among the brands were observed in the flavanoid content of both NFC and concentrated orange juices. Total flavonoid content was significantly higher in concentrated juices compared to the NFC juices. However, higher content of didymin was found in NFC juices. Within the brand, no significant differences in the total flavonoid content were observed in juice types containing antioxidant vitamins compared to the juice types devoid of these vitamins. Price did not correlate with the total flavonoid content for either NFC ($r = 0.057$) or concentrated ($r = -0.49$) orange juices. Hesperidin was the major flavonoid and followed by narirutin and didymin. Their content (mg/100 mL) in concentrated and NFC juices ranged between 18–55 (Hesperidin); 3–8 (narirutin); and 1–2.5 (didymin), respectively. This study provides valuable information on flavonoid composition of orange juices commonly available in the US market.

Standardization of Potting Media for Citrus Nursery Production in Containers

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Six-week-old rough lemon (*Citrus jambhiri* L.) seedlings uniform in size were transplanted from nursery to pots filled with peat, spent compost of mushroom and leaf manure used at different proportions with soil, sand and farm yard manure and grown in green house environment. Initial physical and chemical analysis of media indicated that electric conductivity (EC), total porosity, bulk density, moisture percentage, available nitrogen, phosphorus and potassium are more suitable for citrus plant growth and development than other media of different compositions. Peat + sand (1:1) had pH 6.7 which is optimum for growth of citrus nursery. After every four weeks plant length, stem diameter, number of leaves and leaf area were measured. Leaf analysis for N, P, K and mortality percentage was measured at the end of the experiment. Peat + sand (1:1) produced highest percentage of transplant success, plant height, stem diameter, and number of leaves as compared to all other treatments tested. At initial stage peat + sand (1:1) gave the highest results in relation to leaf area, but at the end of experiment it was observed that treatment with silt + spent compost (bution) + spent compost (oyster) (1:1:1), produced maximum leaf area with lush green leaves however, mortality rate was very high. This study suggests that peat + sand (1:1) may serve as a standard medium for the container grown citrus nursery.

Pollination Study of Clementine Mandarins, 'Afourer' Mandarin, 'Tahoe Gold' Mandarin and Effect on Fruit Set and Seediness in California

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Compatibilities among mandarin cultivars raise concern, especially related to the seediness issue in mandarin production. A hand cross-pollination study was conducted in 2002 and 2003 at the UC Lindcove Research and Extension Center, Exeter, California. There were 0.86% (1/116) (4 seeds) and 0% (0/137) fruit set from 'Fina Sodea' Clementine x 'Tahoe Gold' mandarin in 2002 and 2003, respectively. There were 13.59% (14/103) (average 1.5 seeds/fruit) and 16.50% (17/103) (average 9.82 seeds/fruit) fruit set from 'Nules' Clementine x 'Tahoe Gold' mandarin (a triploid) in 2002 and 2003, respectively. There were 30.84% (33/107) (average 23.42 seeds/fruit) and 0% (0/110) fruit set from 'Fina Sodea' Clementine x 'Afourer' mandarin in 2002 and 2003, respectively. There were 39.62% (42/106) (average 25.36 seeds/fruit) and 4.92% (3/61) (average 31.66 seeds/fruit) fruit set from 'Nules' Clementine x 'Afourer' mandarin in 2002 and 2003, respectively. There was 28.32% (32/113) (average 12 seeds/fruit) from 'Afourer' mandarin x 'Fina Sodea' Clementine in 2002. There was 28.04% (30/107) (average 9.47 seeds/fruit) from 'Afourer' mandarin x 'Nules' Clementine in 2002. These results showed pollen of 'Afourer' mandarin can cause large number of seed in both Clementine cultivars. The pollen from the triploid 'Tahoe Gold' mandarin can set fruit and cause seeds in diploid 'Nules' Clementine but not in diploid 'Fina Sodea' Clementine. These results imply that proper buffer distance is needed between Clementines and 'Afourer' mandarin in order to produce seedless mandarins in California.

Determination of Pollen Parentages of Mandarin Seedlings Using AFLP Markers and Implications for Seedless Mandarin Production in California

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Acreages of 'Nules' Clementine and 'Afourer' mandarin have increased rapidly in California. One way to produce seedless mandarins is using Navel oranges or Satsuma mandarins as buffer to prevent cross-pollination. In order to determine the number of necessary buffer rows or spacing to prevent cross-pollination, we used AFLP markers to determine the pollen parentages of 'Nules' and 'Afourer' seedlings from two sites. The AFLP markers were able to identify Clementine as pollen parents of 26.6% (25/94) of the 'Afourer' seedlings from one site. The pollen of Clementine was able to travel across minimum of 32 rows to pollinate 'Afourer' mandarins. We found 12.73% (14/110) of the 'Afourer' seedlings at the east side of the site were progenies of 'Minneola' tangelo. Pollen of 'Minneola' was able to travel across minimum 94 rows to pollinate 'Afourer' mandarins. 12.73% (14/110) of the 'Afourer' seedlings at the east end of the site were progenies of Clementine. Pollen of Clementine was able to travel minimum 54 rows to pollinate the 'Afourer' mandarin at the east end of the site. The AFLP markers also identified 'Afourer' mandarin as pollen parents of almost all 'Nules' seedlings (98.63%, 72/73) at a second site. The pollen of 'Afourer' was able to travel across minimum of 74 acres of empty ground from the east or minimum of 91 rows of Navel (128 acres) from the north to pollinate 'Nules' Clementine. The results showed how far can compatible pollens traveled to cause seeds in mandarins in California. The implication from the results in seedless mandarin production in California is discussed.

Oral Session 13—Herbs, Spices, and Medicinal Plants

Moderator: Karen Panter

July 18, 2004, 10:00 AM–12:00 PM

San Antonio

Somatic Embryogenesis in *Centella asiatica*, a Valuable Medicinal Plant

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Centella asiatica L. (Apiaceae family), also called 'Indian Pennywort,' is a prostrate, faintly aromatic, and stoloniferous perennial herb with long petiolated leaves. In the Ayurvedic medicine, it is reputed as a nervine tonic along with antibacterial, antifeedant, antileprotic and wound healing properties. *Centella* contains glycosides, indocentelloside, brahmoside, and asiaticoside. Its leaves are rich in carotenoids and vitamins B and C. In vitro culture techniques which offer a viable tool for mass propagation of plants have recently become increasingly popular for conservation of rare, endangered and threatened medicinal plants germplasm. *Centella* tissue culture has been reported to experience high incidences of microbial contamination which drastically reduces survival of explants. Thus, the main purpose of this study was to develop an efficient micropropagation technique for *Centella asiatica* to reduce explant contamination and rapidly disseminate superior clones for research and production. Here we present induction and further development of somatic embryos, using *Centella* stolons as explants. Somatic embryos were induced in response to 2,4-D shock on MS medium. Initially, somatic embryos appeared as highly nodular callus and eventually developed into somatic embryos that exhibited globular, heart shaped and cotyledonary stages. After auxin shock, cultures were regularly transferred to MS basal medium where somatic embryos completed various developmental stages and then germinated to give rise to new plantlets. In this presentation, we will demonstrate complete protocols for the successful sterilization of *Centella* explants prepared from plants that had abundance of fungal and bacterial contamination.

Effect of Selected Growth Stimulators on the Yield of Cilantro

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Field experiments were conducted in Citra, Fla., to determine the effect of acetylthioproline (AP, 250 mg·L⁻¹), gibberellic acid (GA₃, 50 mg·L⁻¹), triterpenic acid (TTA, 300 mg·L⁻¹), a commercial glycine-rich complex of free amino acids and short-chain peptides (ACP, 1500 mg·L⁻¹), and two commercial cytokinin-rich seaweed extracts (CST and CTR, both at 30 mg·L⁻¹) on the yield of cilantro (*Coriandrum sativum*). Aqueous solutions of the AP, ACP, GA₃, CST, CTR, and TTA were sprayed on the leaves of cilantro at 15 and 30 days after crop emergence (DAE). Fresh and dry cilantro shoot yields were determined after harvest (60 DAE). No toxicity was apparent from the treatments. For any given treatment, fresh and dry shoot yields were positively correlated. TTA did not significantly affect cilantro yield. GA₃, AP, and ACP increased fresh cilantro yield by 23%, 19%, and 16%, respectively, as compared to control plants. When CST or CTR were applied, fresh cilantro yield was 12% higher than in control plants.

Evaluation of Hot Pepper Cultivars Grown on Guam

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Hot peppers (*Capsicum* sp.) were introduced to Guam and other Mariana Islands and became a "necessary" ingredient of local cuisine. Seven hot

pepper accessions, including four local cultivars, were grown in calcareous soils on Guam and evaluated for total yield, marketable yield, the number of fruit, and weight of fruit. 'Hot Beauty', a Taiwan cultivar, produced the highest total and marketable yields. 'Group Zest', another Taiwan cultivar, was the earliest maturing cultivar and produced the largest fruits. 'Guafi', a local cultivar, was the latest maturing cultivar. Consumer preference for hot pepper is being studied as fresh market and as processed hot sauce.

Evaluating Rosemary Cultivars for Use as Christmas Tree-shaped Topiaries

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Greenhouse production of rosemary, *Rosemarinus officinalis*, as small potted Christmas tree topiaries for holiday sales have become necessary for many companies marketing to large retail outlets. Topiaries must be sheared multiple times to obtain an acceptable Christmas tree shape. Cultivars vary in physical attributes suggesting that they may respond differentially to mechanical shearing during production. This study assessed 16 rosemary cultivars for their potential as potted Christmas tree shaped topiaries. Beginning July 2001, rosemary plants derived from vegetative propagation of shoot tips were grown in a greenhouse with temperatures set at 73/65 °F day/night. Plants were pinched immediately after transplant and provided high fertility and maximum light. From August to October, plants were pruned monthly for a total of three shearing events. The crop was considered mature on the targeted market date of 5 Dec. Final plant quality was visually assessed using a 1 to 5 scale that accounted for plant-to-pot ratio, canopy density, foliage quality, taper, and overall appeal with one point being removed for each factor not meeting industry expectations. The cultivars varied in their performance as Christmas tree shaped topiaries with most being unacceptable. Many of these cultivars had minimal basal branching, perhaps due to selection for use as standard ball shaped topiary performance. Six of the cultivars, 'Athens Blue Spire', 'Taylor's Blue', 'Herb Cottage', 'Golden Rain', 'Shady Acres', 'Rex', and '302100', were suitable for commercial use having visual ratings ranging from 3.8 to 4.5. We suggest that these cultivars be examined for additional attributes that may enhance their performance as Christmas tree shaped topiaries.

Gypsum Effect on Performance of American Ginseng

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Woods cultivation of North American ginseng (*Panax quinquefolium* L.) can generate income for forest land owners and decrease collection pressure on wild populations of this increasingly scarce forest herb. For woods cultivation, supplemental calcium by soil application of gypsum (CaSO₄·2H₂O) is often recommended, but the effects of this practice on soil characteristics, plant growth and quality of American ginseng are not well characterized. In a greenhouse pot culture experiment, 3-year-old seedlings were treated with 0, 1, 2, 3, or 4 Mt/ha gypsum and grown for 12 weeks. Gypsum application decreased soil pH slightly and elevated soil electrical conductivity and available soil calcium. Tissue levels of calcium were not affected by gypsum treatment but a significant increase in both shoot and root dry weight occurred. Total ginsenosides, which are the pharmacologically active components of ginseng, were increased slightly in roots but not in shoots of plants treated with 4 Mt/ha gypsum. Rb1, the most abundant ginsenoside in roots, was elevated in roots of plants treated with 3 Mt/ha gypsum. Ginsenoside Rg1 was elevated in shoots of plants treated with 2 Mt/ha gypsum. Regardless of gypsum treatment, qualitative differences (relative concentrations of different ginsenosides) between roots and shoots were observed.

Effects of Media and Mycorrhizal Inoculants on Osha (*Ligusticum porteri*) Rooting

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Osha (*Ligusticum porteri*) is a Rocky Mountain native used as a medicinal herb. Studies are underway to commercially propagate and produce the plant. In an attempt to increase rooting success of crown cuttings taken from osha, five different media were used in conjunction with three commercial mycorrhizal inoculants and a control. Field soil and a pre-mixed commercial product were tested in combinations of 100/0, 75/25, 50/50, 25/75, and 0/100 percent by volume. Each of three commercially-available mycorrhizal inoculants were tested with each media. Crown cuttings of osha were taken and stuck on 29 Aug. 2003 and were placed on a greenhouse mist bench. Data were taken on days to rooting. Results showed no differences among the media or the inoculants and no interactions were present. There was no benefit in decreased days to rooting with additions of mycorrhizae. There were no responses to different media.

Natural Plants Treatment for Ovarian Cysts in Women Without Surgery

Ebenezer Oluwafemi Olapade^{*1}, Ebenezer Oluwafemi Olapade, Jr.², Clement Akinlayo Oluwadayomi Olapade³, Christiana Oluwabusayo Olapade⁴, John Babajide Olapade⁵

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Women normally have two ovaries as part of their reproductive organs. The ovaries function by secreting the important reproductive hormone — estrogen which regulate the monthly menstrual cycle at puberty. Each ovary also produce the eggs that carry the female gametes required to fuse with the male sperm cells in the formation of foetus. One of the abnormalities of the ovaries that had been long recognized is the development of sacs with membranous wall enclosing fluid, semi-solid matter or altered blood described as ovarian cyst which alter the size of the ovaries and make them larger. This abnormality usually disorganize the regular monthly cycles along with other complications including pains and infertility in women. The causes for the development of ovarian cysts are not clearly understood while surgical operation had been the most popular method of treatment. There is ethno-medicinal evidence for the treatment of ovarian cysts in Nigeria which dates back to more than one hundred years. This paper describes how 274 of clinically confirmed cases of ovarian cysts in women between the ages of 22–52 years were treated successfully without surgery at the NARL specialist clinic, Ibadan, Nigeria in the last 16 years (1988–2004) using natural plant medicines made with the fiber of *Cocos nucifera* and a few other tropical plants. The implications of this finding are discussed.

Recent Successes in the Use of Natural Herbal Remedies for the Treatment of Intra-uterine Fibroids Without Surgery

Ebenezer Oluwafemi Olapade^{*1}, Ebenezer Oluwafemi Olapade, Jr.², Clement Akinlayo Oluwadayomi Olapade³, Christiana Oluwabusayo Olapade⁴, John Babajide Olapade⁵

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Many physiologically active women after reaching the age of puberty suddenly discover that their menstruation becomes irregular with longer periods of heavier flow. This situation often arise when the womb is empty without conception for a long time. The uterus is found to contain some growing masses of tissues called fibroid which may be tiny, single, many or very big. They could occupy the lumen of the uterus and referred to as intra-uterine fibroids or could develop within the walls of the uterus or on the outside wall of the uterus. They alter

the shape and size of the uterus in most cases. Intra-uterine fibroids grow in size and in several cases prevent conception in young women who are eager to get pregnant, thereby leading to frustration, and anxiety. The origin and cause of fibroids is not well understood. Ethno medicinal knowledge refer to fibroids as false pregnancy because women carrying fibroids are thought to be pregnant for several years without delivering the baby. Years of ethno medicinal research at the NARL Specialist Clinic, Ibadan, Nigeria led to the compounding of natural plants which include *Calotropis* sp, *Citrus* sp and a few tropical plants that have proved successful as a remedy for intra-uterine fibroids without surgery. The existing fibroid masses within the uterus gradually diminish in size, until they disappear completely. The re-growth of fibroid masses within the uterus is suppressed or inhibited. This will be helpful in many cases where women who have not reached menopause can have free uterine cavity devoid of fibroids especially when they are not pregnant for several years. The problem of infertility due to fibroids can also be avoided.

Oral Session 14—Plant Biotechnology

Moderator: Ralph Scorza

July 18, 2004, 10:15 AM–12:15 PM

Trinity A

Extended Shelf Life in Transgenic ‘Galia’ Melon (*Cucumis melo* L. var. *reticulatus* Ser.)

Hector Nunez-Palenius^{*1}, Daniel Cantliffe², Harry Klee³, Donald Huber⁴

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‘Galia’ is a high-quality muskmelon cultivar that is grown in greenhouses or tunnels to maximize fruit yield and to help improve fruit quality. Maximum fruit quality and flavor are achieved when ‘Galia’ are harvested at maturity. This however leads to reduced firmness and short shelf life. In vitro regeneration and transformation of ‘Galia’ melon is a strategy that can be used to increase fruit shelf life. Melon cotyledons were transformed with the ACC oxidase gene in antisense orientation according to the protocol described by Nunez-Palenius et al. (2001, 2003). Experiments were conducted to compare fruit quality parameters between transgenic (TT) and wild type (WT) fruits from plants grown in greenhouse conditions. The melon plants were grown using commercial growing practices that included pruning and training to one vertical stem and the use of soilless media and drip fertigation. Wild type fruits were harvested at 37, 42, and 50 days after pollination (DAP), whereas transgenic fruits were harvested at 42, 50, and 56 DAP. TT fruits were harvested with that delaying period since their ripening process was slower than WT. Thirteen preharvest parameters were evaluated in transgenic and wild type fruits. Wild type and transgenic weight, length, width, soluble solids, titratable acidity, pH, firmness, flesh thickness, seed cavity size and seed number parameters were not significantly different. Ethylene production and ACC oxidase from 42 DAP wild type fruits were greater than from transgenic fruits. Transgenic (ACC oxidase) galia melon fruits had a delayed fruit ripening process compared with wild type fruits.

Can Agricultural Biotechnology Help Guava Growing in Temperate Climate

Bipul K. Biswas^{*1}, Nirmal Joshee², Anand K. Yadav³

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Guava (*Psidium guajava* L.), also called ‘apple of tropics,’ is immensely nutraceutical and horticulturally important. Being a tropical plant, it cannot stand temperatures below 25° F and needs frost protection to grow in temperate regions. To adapt in cold climate, cold hardy guava cultivars are needed. Conventional ways are uneconomic in time

and efforts. Still, transgenic plants developed using biotechnological approaches of tissue culture and rDNA technology, appear to have great potential. Thus, protocols for *in vitro* propagation of guava were developed via organogenesis and somatic embryogenesis using nodal explants from mature trees and young zygotic embryos, respectively. Nodal explants induced multiple shoots when cultured on MS medium fortified with KIN, BAP and Ad.S. Adding $a(NO_3)_2$ to medium was useful to prevent *in vitro* shoot tip browning of adventitious shoots. Rocker liquid culture greatly increased growth of multiple shoots compared to the agar-based medium. It appears to be a good tool for woody plant tissue culture. Induction of somatic embryos in guava was also achieved on MS medium supplemented with IAA auxin. About 80% to 90% somatic embryos germinated normally. To achieve Agrobacterium-mediated gene transfer in guava, on-going co-cultivation of organogenic tissues of guava is to optimize protocols for freeze tolerance gene (CBF1, CBF2, CBF3) transfer. Plasmid vectors containing selectable markers (*nptII* gene for antibiotic selection and GUS reporter gene as scorable gene mediated selection), with CaMV 35S promoter gene has been introduced into guava tissues and the resultant plants showed antibiotic resistance. Details of the experimental procedures and up-to-date results will be discussed.

AFLP Analysis of Genetic Relationships among Container-grown *Anthurium* Cultivars

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Anthurium is the largest genus in the family Araceae, consisting of about 1000 species. Anthuriums are valued for their colorful spathes and traditionally used as cut flowers. With the introduction of compact cultivars through breeding, a series of container-grown cultivars have been released and widely produced as flowering foliage plants. However, limited information is available about genetic relatedness among these container-grown cultivars. This study analyzed genetic relationships of 58 cultivars using amplified fragment length polymorphism (AFLP) markers with near infrared fluorescence labeled primers. Forty-eight *EcoR* I + *2/Mse* I + 3 primer set combinations were screened from which six primer sets were selected and used in this investigation. Each selected primer set generated 94 to 115 scorable fragments. A total of 647 AFLP fragments were detected of which 401 were polymorphic (67%). All cultivars were clearly differentiated by their AFLP fingerprints. A dendrogram was constructed using the unweighted pair-group method of arithmetic averages (UPGMA) technique and a principal coordinated analysis (PCA) was used to analyze the relationships. The 58 cultivars were divided into three clusters; clusters I, II, and III had 40, 10, and 8 cultivars, respectively. Most commonly grown cultivars were positioned in cluster I, where had Jaccard similarity coefficients among them ranged from 0.7 to 0.98. Eighteen of the 40 shared Jaccard similarity coefficient of 0.8 or higher, indicating that genetic diversity for cultivated container-grown *Anthurium* is needed.

EST Analysis for the Study of Cold Stress in Blueberry (*Vaccinium* spp.)

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To gain a better understanding of changes in gene expression associated with cold stress in the woody perennial blueberry (*Vaccinium* spp.), a genomics approach based on the analysis of expressed sequence tags (ESTs) was undertaken. Two cDNA libraries were constructed using RNA from cold acclimated (mid winter conditions when the plants are cold stressed) and non-acclimated (before they received any chilling) floral buds of the blueberry cultivar Bluecrop. About 600 5'-end ESTs were generated from each of the libraries. Putative functions were assigned to 57% of the cDNAs that yielded high quality sequences

based on homology to other genes/ESTs from Genbank, and these were classified into 14 functional categories. From a contig analysis, which clustered sequences derived from the same or very similar genes, 430 and 483 unique transcripts were identified from the cold acclimated and non-acclimated libraries, respectively. Of the total unique transcripts, only 4.3% were shared between the libraries, suggesting marked differences in the genes expressed under the two conditions. The most highly abundant cDNAs that were picked many more times from one library than from the other were identified as representing potentially differentially expressed transcripts. Northern analyses were performed to examine expression of eight selected transcripts and seven of these were confirmed to be preferentially expressed under either cold acclimating or non-acclimating conditions. Only one of the seven transcripts, encoding a dehydrin, had been found previously to be up-regulated during cold stress of blueberry. This study demonstrates that analysis of ESTs is an effective strategy to identify candidate cold-responsive transcripts in blueberry.

Development of Linkage Maps for Pecan Using Fluorescently Labeled Amplified Fragment Length Polymorphism Markers

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Pecan, [*Carya illinoensis* (Wangenh.) C. Koch], is a member of Juglandaceae family and is one of the most important nut crops produced in the United States. The objective of this study is to generate the first genetic linkage maps for pecan. Maps were constructed for the cultivars 'Elliot' and 'Pawnee' using the double pseudo-testcross mapping method whereby a separate linkage map is made for each parent using markers heterozygous in that parent. First generation maps consisted primarily of randomly amplified polymorphic DNA (RAPD) markers. We have now used fluorescently labeled amplified fragment length polymorphism (AFLP) markers to produce more complete maps. In the development of the AFLP markers, 64 primer combinations were originally screened to find the most informative combinations. Ten primer combinations were then chosen to produce markers for the maps. The maps currently consist of approximately 100 RAPD and 100 AFLP markers on each cultivar map. 'Pawnee' is a high quality commercial pecan cultivar with a very early ripening date. 'Elliot' possesses high levels of resistance to pecan scab, caused by the fungus *Cladosporium caryigenum*. The maps will be used to find markers linked to scab resistance genes and other traits of interest to the breeding program.

Isolation and Characterization of a Putative Ascorbate Peroxidase from Citrus Center

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Ascorbate Peroxidase (APX) is a heme-containing, non-glycosylated enzyme that destroys harmful hydrogen peroxide via the ascorbate glutathione pathway in plants. This enzyme is considered to be an indispensable part of the electron-scavenging pathway and is involved in preventing oxidative damage in plants. Using differential display RT-PCR and 5' RACE a full length c-DNA clone was isolated, from citrus, with very high similarity at the nucleotide and amino acid level, to ascorbate peroxidases from several plant species. It is well known that APXs have highly conserved motifs like the Arg-38, Ars-71, Glu-65 and Asp-208 residues around the distal Hist-42 and proximal His-163. These residues are essential for binding the ligand heme. Additionally, Trp-179 is conserved in most APXs and is the third participant in hydrogen bonding network, together with His-163 and Asp-208. All these conserved motifs were present in the putative APX from citrus in addition of the presence of the peroxidase active site motif residues (APITRLRLAWHSA) and the peroxidase heme-ligand

motif (DIVVLSGGHTL). Expression analysis in *E. Coli* reviewed a recombinant protein of 27 Kda.

Gene Expression Analysis a Cold Responsive Gene from *Poncirus trifoliata* during Acclimation and Deacclimation

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In Texas, the freezes of 1951 and 1962 together killed 125,000 acres of citrus trees and the freeze of 1983 killed 40,000 acres. The low temperature is one of the most important abiotic stresses to be understood and manipulated molecularly. Cold hardiness is found in the deciduous citrus relative, trifoliolate orange, which can withstand temperatures as low as -26 °C when it is cold acclimated. Exposure of the cold hardy trifoliolate orange plants to temperature from 28 °C to -5 °C enabled us to isolate and characterize one novel citrus low temperature gene (clt) with two transcripts, called clt-a and clt-b from leaves and twigs. Clt-a was produced when plants were subjected to low temperatures (starting at 10 °C), while cltb was constitutively expressed. Both clt-a and clt-b have the same open reading frame of 165 nucleotides and encodes a small protein of 54 amino acid. However, clt-a has an additional 98 bp nucleotides at the 3'-untranslated region (UTR), which is absent in clt-b. Expression analysis using relative quantitative RT-PCR demonstrated that clt-a is expressed exclusively at low temperatures, while clt-b is expressed constitutively (expression verified from 2 °C to -5 °C). In the process of deacclimation from -1 °C to 28 °C, the clt-a transcript degraded dramatically after 2 °C and was completely absent at 28 °C, while the clt-b transcript remain stable. When the acclimated plant was taken from -1 °C to room temperature, the clt-a gene degraded within 2 hours. Moreover, when acclimated plant was continuously exposed at -1 °C for 20 days, both transcripts clt-a and clt-b remained stable. Involvement of alternative splicing in transcript stability will be discussed.

Short interfering RNAs are Associated with Virus Resistance in a Woody Perennial Fruit Tree (*Prunus domestica*)

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We have shown that high-level resistance to plum pox virus (PPV) in transgenic plum clone C5 is based on post-transcriptional gene silencing (PTGS), otherwise termed RNA silencing (Scorza et al. Transgenic Res. 10:201-209, 2001). In order to more fully characterize RNA silencing in woody perennial crops, we investigated the production of short interfering RNA (siRNA) in transgenic plum clones C3 and C5, both of which harbor the capsid protein (CP) gene of PPV. We used as a control, plum PT-23, a clone only transformed with the two marker genes, NPTII and GUS. We show in the current report that C5 constitutively produces two classes of siRNA, the short (21-22 nucleotides) and long (≈27 nucleotides) species in the absence of PPV inoculation. Transgenic susceptible clone C3 and the control clone PT-23, when healthy, produce no siRNA. Upon infection, these clones produce only the short siRNA (21-22 nt). This siRNA production suggests that plum trees naturally respond to virus infection by initiating PTGS or PTGS-like mechanisms. This study also suggests that high-level virus resistance in woody perennials may require the production of both the short and long size classes of siRNA, as are produced by the resistant C5 plum clone.

Oral Session 15—Product Quality, Safety, and Health Properties

Moderator: Dennis Osborne

July 18, 2004, 10:30 AM–12:00 PM

Trinity B

Using Bilingual Flip-charts to Train Fresh Produce Field and Packinghouse Workers

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One key to protecting the nation's food supply is training packinghouse and field workers in food safety principles. Southern producer/packers are typically grower/packers. Such producers usually are seasonal, have their own packinghouse operation and are small scale. They use migrant and seasonal labor. Also worker training, sanitary practice and facilities are either somewhat limited or completely lacking in such operations. Further, the use of seasonal and migrant labor dictates the use of Spanish language interpreters for training. These trainers are in marked shortage. To help meet this need for trainers and training materials we developed a bi-lingual (Spanish/English) "flip chart" GAPs training aid. It contains 48 charts explaining food safety principles to be considered in the field and in the packing operation. These educational materials can be used by small farmers, growers and packers for training sessions. Such material is particularly useful in preparing for third-party audits.

Effect of the Combination of MCP and Sanitizer on Storage Life of Fresh-cut Cilantro

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The effects of 1-methylcyclopropene (MCP), sanitizer and their combination on ethylene action, microbial growth and storage life of fresh-cut cilantro were studied. Fresh cilantro was treated with 1.5 $\mu\text{L}\cdot\text{L}^{-1}$ MCP for 18 hours at 10 °C. The treated and nontreated cilantro leaves were cut and washed in water, chlorine, and mixed solution of sodium chlorite and citric acid (SANOVA). Samples were dried, packaged with 29.2 $\mu\text{mol}\cdot\text{kg}^{-1}$ Pa s oxygen transmission rate films, and stored for 14 days at 5 °C. Results indicated that MCP affected respiration rate of fresh-cut cilantro and the headspace gas composition (O_2 and CO_2) of sample packages. The combined treatment had lower tissue electrolyte leakage and ethanol concentration, and delayed color changes during storage. SANOVA and the combination of MCP and SANOVA were effective in reducing aerobic microbial population and coliform population. Samples treated with MCP and SANOVA had good quality with high overall quality score at the end of storage.

Total Phenolic and Flavonoid Contents of Organically and Conventionally Grown Lettuce, Collards and Chinese Cabbage

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Organic vegetables have been suggested to produce higher levels of phytochemicals, which play active roles in disease prevention. We measured total phenolic and aglycone flavonoid (apigenin, kaempferol, luteolin, and quercetin) contents in leaves of organically- and conventionally-grown lettuce ('Kalura' and 'Red Sails'), collards ('Top Bunch') and Pak Choi ('Mei Qing') greens during spring and summer trials, using the Folin assay and HPLC, respectively. Postharvest changes in phenolic contents of organic and conventional lettuce were also inves-

tigated after 17-day storage at 4 °C. Production system did not cause a significant difference in total phenolic levels of lettuce and collards in either trial, but total phenolics were significantly higher in organic Pak Choi in the summer trial, possibly due to greater flea beetle damage in the organic plots. Organic production did not affect the aglycone flavonoid levels of lettuce and collards in the spring trial except that apigenin increased in organic samples. In the summer trial, however, concentrations of kaempferol, luteolin and quercetin tended to increase in organic lettuce and collards; only luteolin showed promising increase in Pak Choi. Species and cultivars both had significant effects on total phenolic and flavonoid contents. After 17-day storage, total phenolic content significantly increased in both organic and conventional lettuce although the concentrations of aglycone flavonoids remained relatively constant. Total phenolic content was higher in organic 'Red Sails' at a marginal significance level after storage, while it did not differ between organic and conventional 'Kalura'. We noted a dominant presence of glycoside flavonoids in lettuce before and after storage, which warrants further study.

A Survey of Composition and Content of Carotenoids, Sugars, and Ascorbic Acid in Watermelons with Various Flesh Colors

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About 40 watermelon samples with various flesh colors (red, pink, orange, and yellow) were tested for their carotene, sugar, and ascorbic acid contents. Carotenoids were separated and purified by using a preparative HPLC system and identified by comparing the spectra with standard compounds by using a diode array detector. Sugar and ascorbic acid contents were measured by HPLC methods. Red and pink colored watermelon contained lycopene as the major carotenoid, with a wide range of variation (5 to 51 $\mu\text{g}\cdot\text{g}^{-1}$). Beta-carotene was the second major carotenoid and was less than 6 $\mu\text{g}\cdot\text{g}^{-1}$. There were also lutein and violaxanthin in less than 1.5 $\mu\text{g}\cdot\text{g}^{-1}$ range. Yellow and orange flesh watermelons contained a complex mixture of carotenes. Prolycopene, lycopene, or beta-carotene was the major component, depending on the variety, and the contents were less than 24, 3, and 9 $\mu\text{g}\cdot\text{g}^{-1}$, respectively. There were also minor carotenoids, such as violaxanthin, lutein, neurosporene, zeaxanthin with a 0 to 3.5 $\mu\text{g}\cdot\text{g}^{-1}$ range. Neurosporene, zeaxanthin, and prolycopene were not found in the red watermelons. There was great variation in total sugar content, range being from 22 to 102 $\text{mg}\cdot\text{g}^{-1}$, while the °Brix was from 4.0 to 15.5. Sucrose, glucose, and fructose were the main sugars in the watermelon and their composition were grouped as sucrose-dominant or fructose-dominant groups. Some varieties with very low levels of sucrose were generally low in the total sugar content. Watermelon contained fairly low levels of ascorbic acid, less than 58 $\mu\text{g}\cdot\text{g}^{-1}$ and some varieties had nearly no ascorbic acid. Estimation of total carotenoid in the yellow watermelons by measuring absorbency at 435, 485, or 503 nm was tested and 435 nm showed the highest correlation coefficient ($r^2=0.845$).

Grapefruit-Drug Interaction: Levels of Furocoumarin in Different Varieties

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Grapefruit juice contain furanocoumarin derivatives which are known to interact with various drugs such as felodipine, leading to the increased bioavailability. Due to very low concentrations of furocoumarin in grapefruit juice, isolation of these compounds has been a challenge to researchers. Five grapefruit (*Citrus paradisi* Macf.) varieties such as

'Marsh White', 'Duncan', 'Rio Red', 'Orange Flesh', and 'Mexican Red' were harvested and analyzed. Samples were extracted successively three times with ethyl acetate until all furocoumarins were extracted. The dried extract was reconstituted in methanol and used for quantification using high-performance liquid chromatography. Furanocoumarins were quantified by gradient elution with methanol and water as mobile phase with a flow rate of 1.1 mL/min at 240 nm. The concentrations of bergamottin, dihydroxybergamotin (DHB) and dimer of DHB were shown to distinctly differ among varieties. Red colored grapefruit showed lower concentrations of the furocoumarins compared to white colored grapefruit. Among the five varieties, 'Rio Red' grapefruit contain lower concentrations of bergamottin and DHB. Further studies are continued to quantify other dimers and commercial varieties. Knowledge of furocoumarin levels in grapefruit may eventually help the consumer to make decision about eating grapefruit and/or drinking juice while taking certain medications.

Temperature and Genotype Affect Anthocyanin Concentrations in Lettuce (*Lactuca sativa*)

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In addition to their physiological and metabolic roles, anthocyanin (Antho) levels in lettuce contribute to visual and nutritional value-based assessments of crop quality. Although 7 genes are now thought to help regulate Antho synthesis, deposition and/or degradation in lettuce, the genetic and abiotic controls of Antho levels remain less well characterized in lettuce than other plants. Previous greenhouse studies demonstrated that Antho levels in diverse lettuce varieties are a function of temperature and lighting regimen. Here, three strongly related Lolla Rossa-type varieties ('Lotto', 'Valeria', and 'Impuls') varying in the number of genes controlling intensity of anthocyanins were subjected to differential temperature conditions in growth chambers to better discern the independent and interactive effects of temperature (T) and variety (V) on Antho levels. Fifteen day-old seedlings were placed into one of three chambers maintained at 20 °C day/night (D/N), 30 °C/20 °C D/N or 30 °C D/N. Antho levels were measured in leaf tissue collected 30 d after transplanting. The entire experiment was replicated twice. Although significant, the T x V interaction resulted from differences in the magnitude, not direction, of the change in Antho concentrations among varieties with changes in T. This suggests that T was a main driver of Antho levels in this study. Regardless of V, Antho concentrations were highest, moderate and lowest after growth at 20 °C D/N, 30 °C/20 °C D/N and 30 °C D/N, respectively. Likewise, regardless of T, Antho levels followed the pattern 'Impuls' (three genes) > 'Valeria' (two genes) > 'Lotto' (one gene). Correlations among instrumented and human eye-based evaluations of color are also being tested in samples from both studies.

Oral Session 16—Teaching Methods

Moderator: Marihelen Kamp-Glass

July 18, 2004, 1:30–3:30 PM

Trinity B

Engaging Students in the Higher Order of Thinking and Communication

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Students of today have been raised on 20 second sound bytes, video games, multiple choice and true false exams, extra credit, and over

extended parents. It is difficult to engage most of them in a two minute conversation. They have not been taught the skill of cognitive thinking. We as professors need to help them reach that higher level of oral and written communication. This can be done through adding discussion in the class room, on a field trip, or in an e-College or Blackboard venue. This presentation is about how good discussions must be prepared in advance, how to lead a purposeful discussion and other way to promote their cognitive skills.

Writing Across the Curriculum: Where does Horticultural Science Fit In?

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In Fall 1999, the Univ. of Minnesota implemented a writing intensive requirement for undergraduates. As part of the requirement, students must take one writing intensive (WI) course in their major. Formal and informal writing in critical draft review are key components of intensive writing. The Dept. of Horticultural Science offers an Environmental Horticulture Major which currently has only one writing intensive course in its curriculum. Teaching faculty (13/14), responsible for 21 courses in the curriculum, were interviewed and syllabi were reviewed to gather information on what types of writing are currently being assigned and to discuss where WI courses should be placed in the Environmental Horticulture curriculum in the future. The majority of classes utilize formal writing and the majority of faculty review, or are willing to review, a draft of an assignment. Informal writing assignments are less common, indicating a deficient area of the curriculum. With slight modifications, many classes in the curriculum can meet the requirements to become WI. Faculty agreed that WI courses should be placed in upper level, smaller classes that place less emphasis on production techniques or plant identification.

Strengthening Floriculture Academic Programs through Student Enterprising, Institutional Commitment, Industry Support, and Competitive Grants

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Floriculture, among the fastest-growing agricultural segments in New Mexico, is creating job opportunities for graduates. Limited faculty resources restrict growth in floriculture academic programs, particularly for curricular modernization, extracurricular activities, and capacity building of the student:industry relationship. Federal funding has provided a Program Coordinator to lead our floriculture academic programs, responsible for raising technical quality of floriculture courses, recruitment and retention of undergraduates, and establishment of regional alliances with industry to exploit job opportunities. During the first year of the program (2003), deliverable products included course modules, fund raising protocols, and public school workshops. Results demonstrate an affinity for students of Hispanic origin to the program (over 40% of enrollments). Industry support included over a 2-fold increase in 2003 horticultural internship placements, financial aid, and donations of expendable materials. Floriculture student participation in intra-campus governance and off-campus community service projects also defrayed program costs and resulted in institutional gain. Over 80% of the 25 students enrolled in the beginning floral design and floral crops judging class agreed or agreed strongly that they had an obligation to engage in fund raising efforts to strengthen the floriculture academic program. Our intent is to build the floriculture teaching program into a template that can be replicated into the future through sustained institutional commitment. The program can serve as a model for other academic departments seeking diversification of horticulture academic programs and recruitment of a diverse student body, but struggling with limited human resources.

Student Expectations and Evaluation of a Horticulture Study Abroad Course

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Beginning in 1998 students in the Dept. of Horticulture at Iowa State Univ. have been given an opportunity to enroll in a semester-long study abroad course, culminating in a two-week visit to the country of interest. Students participating in a recent study abroad experience to England were asked several questions prior to their departure including: 1) their motivation for participating and goals for the site visit; 2) fears or concerns related to the trip; 3) expectations about the course and trip; and upon arriving home 4) their overall evaluation of the course and trip. A questionnaire containing ten closed-ended and six open-ended questions was given to all 25 students enrolled in the course. We learned most students participated in the course to learn about and experience a different place and culture. Thirty-nine percent of responding students said issues related to packing for the trip was their biggest concern or fear. Twenty-six percent were concerned about using a foreign currency while another 17% said interacting with other students on the trip was their greatest concern. A large majority (90%) of students felt the course and trip met their expectations and 80% said they would participate in another international experience. Other survey questions revealed students gained better insight about themselves, became more tolerant of people and other customs, felt they were better able to adapt to new situations, developed close friendships with traveling companions, and experienced an increased interest in horticulture.

Do Early Progress Grade Reports Change Student Performance in a Required, Introductory Horticulture Course?

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In a required introductory horticulture course during a 5-year period, students received early progress grades 1/3rd of the way through the course reflecting 20% of the possible points to be awarded in the class. It was thought that student knowledge of their grade performance may result in changes in behavior and class performance. The early progress and final grades both had a bell-shaped distribution with 45% and 48% of students receiving grades better than "C" for early progress and final grades, respectively. There was a significant although low correlation between early progress grades and final grades for the course ($r^2 = 0.58$). About 50% of the students received a final grade equal to the early progress grades, and 27% received grades higher than the early progress grades. The greatest change in performance were students who received a "D" early progress grade; 60% of those students improved their final grade. Nearly 25% of the students received final grades lower than the early progress grades. Of students receiving failing early progress grades (12%), nearly 60% withdrew from the course and only 10% received passing final grades.

Contrasting Demographics of Nontraditional Students in Two Off-Campus Horticulture Degree Programs

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The Academic Program at Fort Lauderdale (APF), founded in 1984, and the Academic Program at Homestead (APH), founded in 2000, were established to enable place bound students to earn the Univ. of Fla. B.S. degree in horticulture. Although both programs are located within 60 miles of each other in the same general geographical area in southeastern Florida, there are significant demographic contrasts, as well as some similarities, between them. According to data published by the U.S. Census Bureau, the area defined by a 10-mile radius around the site of the APH has a population of $\approx 83,500$, while the same area at the site of the APF has a population of more than 1,100,000, a 13-fold difference. The student profile at the two programs indicates a higher enrollment at APF, a higher average student age at APH, and a higher distance traveled to attend class at APF. Similarities include a student

body comprised of people working in the horticultural industry who are working to earn a B.S. degree for career advancement, as well as an increasing number of students who are not currently working in horticulture but who are planning a career change.

Enhanced Histological Technique for Observation of Spathe Pigmentation in *Anthurium* species and Hybrids

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A hybridization strategy for certain coloration could be developed based on accurate histological information of parental material together with the knowledge of heritability of color and color intensity. A sample of 12 *Anthurium* species and hybrids were histologically examined for pigmentation in spathes using a new method employing vacuum infiltration of spathe tissue with polyethylene glycol (PEG) prior to cross-sectioning. PEG infiltration displaces intercellular air spaces between cells. This method greatly improved the clarity of the cross sections and consequently improved observations of spatial localization of anthocyanins and chloroplasts. This infiltration method accurately identified the spatial localization of pigments for future breeding reference, notably among *Anthurium* species.

Oral Session 17—Vegetable Crops 1

Moderator: Jonathan Schultheis

July 18, 2004, 1:30–3:30 PM

San Antonio

Plug Tray Cell Volume Effects on Sweet Corn Transplant Root Architecture and Biomass Accumulation

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Sweet corn (*Zea mays* L.) is difficult to transplant due to poor root regeneration. Despite reduced yields, growers are transplanting sweet corn to hasten maturity time to target profitable early markets in the Northeast. Researchers have ascribed the negative impacts on yield to restricted rooting volume. Therefore, the impacts plug cell volume had on sweet corn transplant root architecture and biomass accumulation were investigated. 'Temptation' sweet corn was sown in volumes of 15, 19, 14, and 29 mL correlating to transplant plug trays with plug counts of 200, 162, 128, and 72 plugs per tray. Plug cells were exposed to three substrate environments; a dairy manure based organic compost media, a commercial soil-less germination mix, and the soil-less media supplemented 2X with 200 ppm soluble 3–3–3 organic fertilizer. A 4 × 3 factorial randomized complete-block experimental design with two blocks and five replicates per treatment was repeated twice in the greenhouse. For each experiment a total of three center cells were harvested from each replicate for analysis using the WinRhizo Pro root scanning system (Regent Instruments Inc., Montreal). Three cells per treatment were also transplanted into 8-inch pots to stimulate field transplanting. Based on mean separation tests ($n = 30$), increased cell volume before transplanting significantly increased root surface area, average diameter, and root volume after transplanting ($n = 18$). Mean root surface area for a 29-mL cell was 30% greater than a 15-mL cell before transplanting and 22% greater after transplanting. Plug cell volume also significantly impacted shoot and root biomass ($P < 0.0001$). A 14-mL increase in cell volume resulted in a root and shoot dry weight increase of about 15%.

The Effects of Cover Crop and Fertilizer Rate on Celery (*Apium Graveolens* L.) Growth and Development

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Cover crops are commonly used to improve soil fertility and enhance crop performance. Field experiments were conducted to determine the effects of different cover crops and fertilizer rates on celery growth and development. The experiment was a two-way factorial with a split plot arrangement. The main plot factor was cover crop and included cereal rye (*Secale cereale*), hairy vetch (*Vicia villosa*), oilseed radish [*Raphanus sativus* (L.) var. *oleiferus* Metzg (Stokes)], and no cover crop. The sub-plot factor was fertilizer rate with three levels: full (160, 80, 400), half (80, 40, 200), and low (80, 0, 0) kg/ha of N, P₂O₅, K₂O, respectively. The cover crops were grown during Fall 2002 and incorporated prior to celery transplanting in May 2003. During celery growing season, stalk length, above and below ground biomass were assessed at 23, 43, 64, and 84 days after planting (DAP). The biomass produced by oilseed radish (719 g/m²) exceeded that of cereal rye (284 g/m²) and hairy vetch (181 g/m²). At 23 and 43 DAP, celery fresh root (4.8 and 11.4 g/root) and shoot (6.1 and 53.6 g/shoot) biomass of oilseed radish exceeded the values of all other cover crops. At 84 DAP however, celery shoot fresh weight was similar in all cover crop treatments. Celery plants were tallest in the cereal oilseed radish and rye treatments early in the season; however final plant height at harvest was not affected by type of cover crop. The amount of fertilizer applied had a significant effect on celery growth starting at 64 DAP and continued until harvest. These results suggest that the large biomass produced by oilseed radish played an important role in early season celery growth.

Influence of Honey Bees on Pumpkin Yields in Illinois

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Most small pumpkin growers in Illinois have traditionally relied upon natural insect pollinators to achieve fruit set and development. Many growers fail to understand the importance of pollination and are not aware of the potential benefits of using honey bee colonies to improve pollination and subsequent fruit set of pumpkin. Therefore, a study was conducted over the 2000 and 2001 growing seasons to measure the effectiveness of honey bee colonies on jack-o-lantern pumpkin production. Yields (kg·ha⁻¹) of several cultivars (e.g., 'Appalachian' and 'Howden') almost doubled when honey bee colonies were present during flowering. Pumpkin weights with the inclusion of honey bees averaged 31,547 kg·ha⁻¹ compared to 22,353 kg·ha⁻¹ for those without honey bees. However, the number of pumpkins per ha was not as drastically influenced by the addition of honey bees; total pumpkin fruits per ha averaged 1,896 with honey bees as compared to 1,704 without honey bees. These results indicate that there were sufficient natural pollinators to induce pumpkin fruit set under field conditions during the study, but fruit size can be significantly increased with the addition of a strong honey bee colony during flowering. Since pumpkins are generally sold on a weight basis, growers should realize greater revenues with the inclusion of honey bee colonies in pumpkin fields.

Triploid Miniwatermelon Production in the Southeastern United States, 2003

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Demand for triploid watermelons has outpaced the demand for diploid watermelons in the United States in recent years. The size of most triploid watermelons sold in U.S. markets is from 6 to 9 kg. Recently, a new produce item, seedless watermelons weighing about 1.8 to 3.6 kg, have been introduced and created excitement in the produce industry. Several vegetable seed companies have developed proprietary miniwatermelon hybrids. Syngenta Seeds and Seminis Vegetable Seeds have received the most publicity, with the PureHeart and Bambino

brands being featured in the 15 June 2003 *New York Times*. The 2003 season was the first year that cultigens (cultivars and advanced lines) were generally available. At least four trials were conducted in the southeastern United States to evaluate yields and quality of mini-watermelons; Bradenton, Fla., Ediston, S.C., Charleston, S.C., and Kinston, N.C. Cultural practices and the number of cultigens varied among locations (9 to 17). Fruit less than 3.6 kg that yielded best in all locations were 'Petite Perfection' (Syngenta) and RWT 8149 (Syngenta). Other cultigens that yielded well in at least one location were: 'Precious Petite' (Syngenta), 'Vanessa' (Sunseeds), ZG 8905 (Zeraim Gadera), SR 8103 WM (Sunseeds), SW 8002 (Southwestern), and HA 5130 (Hazera). Rind thickness varied from 6 to 25 mm and soluble solids ranged from 10 to 13%, depending on location and cultigen. New cultivars will be made available in 2004. Key characteristics that seem important to overall success in the market of the triploid miniwatermelon is consistent quality. This includes high yields of uniform sized fruit from about 1.6 to 3.8 kg; high soluble sugars (11% to 13%); and fruit with bright red, crisp flesh with a thin rind that endures shipping.

Investigating Eggplant Germplasm

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Eggplant cultivars comprise one of the most diverse botanical groups in world foodcrop agriculture. Their dietary origins are in China, Japan, Thailand, Africa and Europe. Over the last 60 years in the United States, eggplant has transitioned from a minor ethnic crop into a major vegetable commodity. Four years of horticultural studies in New Jersey have compared 33 worldwide cultivars. Eggplant cultivars included : Asian types—Long Purple, Millionaire, Machiaw, Orient Charm, Bride, Pingtung Long, Ichiban, Thai Round Green, Thai Long Green, and Thai Hard Skin; Indian types—Kermit, Bharta, and Pushpa; African types—Bitterballs, Kinalia, Kinalia XL, and Gangan; European types—Megal, Red Egg, Bambino, Cloud Nine, Rosa Bianca, Comprido Verde Claro; and New York; and several Russian types. These studies utilized raised beds and black plastic with drip irrigation at 30" spacing between plants and five to six feet between single row beds. Two replications were used in initial screening surveys and with four replications for in-depth studies of superior candidates. Over 4 years, the sites were planted from June 5 to 20 June. Harvests began in mid-July and ended in mid-October. The selected eggplant cultivars all exhibited typical bi-modal bearing throughout the season in growth zones 7 and 8. Individual fruit weights ranged from 2.6 to 13.4 oz per fruit. Fruit length ranged from 2.3 to 10.7 inches. Basic fruit colors were white, red, green, purple, and black with several types having variegation and striping. Yields differed significantly among varieties and ranged from 10,000 to 40,000 pounds per acre over the course of the season with multiple harvests. Marketable yields ranged from 2,750 to 8,750 boxes per acre (30 pound boxes).

Eggplant (*Solanum melongena* L.) Yield Comparisons of Managed Buffelgrass (*Pennisetum ciliare* L.) Living Mulch Systems to a Conventional Monoculture Bare Ground System in Hawaii

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Two long-term field experiments were conducted from 1998 to 2000 to compare the yields of marketable eggplant in a buffelgrass living mulch system to a conventional monoculture bare ground system. The initial experiment compared the yields in the conventional treatment to living mulch treatments, that were chemically suppressed at three levels of sethoxydim applied at 0.1, 0.2, and 0.3 kg·ha⁻¹ a.i. Regression analysis did not reveal a significant linear response of eggplant yield to increasing levels of sethoxydim. The average cumulative yield of the three living mulch treatments, 130 days after transplant (DAT), was 4,296 kg·ha⁻¹ compared to 2,079 kg·ha⁻¹ for the conventional

treatment. The higher yield in the living mulch treatments was due to a mite infestation that was much more pronounced in conventional plots. In the follow-up experiment, three different living mulch management (mechanical suppression, chemical suppression, and untreated) treatments were compared to a conventional monoculture bare ground treatment. There was no mite infestation affecting this experiment and cumulative yields of marketable fruit at 159 DAT were 5,362, 4,521, 4,155, and 2,535 kg·ha⁻¹ for conventional bare ground, mechanical suppression, chemical suppression and untreated living mulch treatments, respectively. Orthogonal comparisons showed that the yields from the conventional treatments were not significantly different from the suppressed living mulch treatments. However, the eggplant yields from the unmanaged living mulch treatments were significantly reduced in comparison to the conventional and also the suppressed living mulch treatments.

Effects of Mulch Type and Planting Date on Tomato Earliness within a High Tunnel

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High tunnels are passive solar greenhouses that are used to extend the traditional growing season for many horticulture crops. Growing conditions within a high tunnel are significantly different from growing conditions encountered in field production. Tomatoes (*Lycopersicon esculentum* Mill.) are well suited for high tunnel culture having an upright growth habit and a significant economic premium for precocious harvest. The objective of this research was to investigate three planting dates (15 Mar., 30 Mar., and 10 Apr.) and three mulch types (black plastic, bareground, and clear plastic) with or without row covers, for early tomato production within a high tunnel in the Central Great Plains. High tunnels increased the average daily temperature by ≈6 °C. Early planting (i.e., mid- to late March) resulted in significantly earlier yield (i.e., early July). Using clear plastic mulch increased total marketable yield, but was not significantly different from black plastic. Row covers and plastic mulch are necessary for early tomato production. Row covers are specifically necessary for frost protection, but can be removed when the risk of frost has decreased.

Interaction of Source–Sink Relationship for Translocation and Distribution of C¹⁴ Carbohydrates in Watermelon (*Citrullus vulgaris* S.)

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The pattern of C¹⁴ carbohydrate translocation and distribution from source leaf to various plant parts in watermelon grown in the greenhouse and field was investigated. Seedling-grown plants were pruned to have two branches with only one of them carrying a fruit. When leaves at four different positions (on fruit-bearing node, on fifth node above and below it, and on fifth node from the base of the non-fruit-bearing stem) were exposed to ¹⁴CO₂, the distribution of C¹⁴ compounds to different parts (fruit, stem, leaf, root) of the plant varied. In all treatments, the fruit was the strongest sink, followed by stem, leaf and root tissues. The highest percentage of C¹⁴ photo-assimilates was transferred out of the source when the leaf borne on the fruit-bearing node was exposed to ¹⁴CO₂ in both greenhouse and field grown plants. Translocation of C¹⁴ compounds from the leaves on the fifth node above and below the first fruit-carrying node was similar. Only 29% of C¹⁴ was transferred from the source leaf borne on the fifth node of the non-fruit bearing branch in the greenhouse, as compared to more than 46% of C¹⁴ from other source leaves. Accumulation of C¹⁴ in the root tissues was highest when source leaves were borne on the non-fruit bearing branch. In general, field-grown plants had higher percentages of C¹⁴ translocated as compared to greenhouse-grown plants.

Oral Session 18—Genetics and Germplasm/

Biotechnology

Moderator: Jude Grosser

July 18, 2004, 1:30–3:00 PM

Trinity A

Significance of Horticultural Plants on Biodiversity Conservation

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Horticultural plants include fruit, vegetable, ornamental, turf, medicinal, beverage, spice, and other economic species. Although these plants originally derive from wild populations and play a vital role in our daily life, their importance on protecting biodiversity has not been addressed. With tremendous driving force of their monetary value, farmers, gardeners, breeders, and researchers have domesticated, selected, and bred many new horticultural crops, which ultimately increase biological diversity in cultivated plant communities. Both morphological and molecular data from 90 accessions of cultivated *Cephalotaxus* and 48 accessions of cultivated *Chamaecyparis thuyoides* demonstrated their wide range of morphological differences and more than 43% of genetic dissimilarity coefficients. In US alone, one new cultivar of *Loropetalum chinense* var. *rubrum* was released to the nursery industry every year since the first plant was introduced from Wuhan Botanical Garden in 1983. Obviously, human activities rapidly accelerate evolutions. To preserve and reproduce new and rare taxa, regeneration of these plants is challenging. Rooting of *Magnolia grandiflora* stem cuttings, overcoming *Cephalotaxus* seed dormancy, experimenting *Pinus strobus* embryogenesis, and overwintering *Stewartia* cuttings should be applied for reproduction studies of unusual horticultural clones. For plants that could not be regenerated with today's propagation methods, their seeds, tissues, pollen, and embryos should be preserved as some USDA labs do for heirloom horticultural crops. In the future, with aid of advanced science and technology, we should be able to regenerate those plants from preserved materials and increase biological diversity.

Differential Expression of *Capsicum* Anthocyanin Structural Genes in Response to Temperature Stress

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Anthocyanins contribute to color development in economically important vegetables, fruits and floral crops. Their expression is critical to product sensory quality attributes, potential nutritive value, and stress response. Anthocyanins are synthesized in response to numerous environmental factors including temperature and light stress and pathogen attack. We have developed several *Capsicum* lines, including '02C27', expressing anthocyanin pigmentation differentially in various tissues (leaf, stem, fruit and flower). HPLC analysis demonstrated that the anthocyanins within the fruit, flower and leaves of *Capsicum* '02C27' were identical and that the major anthocyanidin was a delphinidin glycoside. Line '02C27' exhibits anthocyanin foliar pigmentation that is accumulated differentially in response to temperature stress. Under unfavorable low temperature (20 °C day/18 °C night), mature *Capsicum* leaves contained 4.6 times less anthocyanin per gram fresh weight than under high (30 °C day/28 °C; day/night) temperatures. Besides containing less anthocyanin in mature leaves, young immature leaves did not develop color as quickly under the lower temperature. Utilizing cloned and sequenced gene fragments of pepper chalcone synthase (CHS), dihydroflavonol 4-reductase (DFR), and anthocyanidin synthase (ANS), we evaluated the role of transcription in regulation of flavonol biosynthesis. Analysis of anthocyanin composition and gene expression data indicated that the block in anthocyanin formation in

less pigmented leaves occurred at anthocyanin synthase. In contrast to wild type plants, this mutant also exhibited reduced flowering and failed to set fruit under high temperature, long day conditions.

Utilization of Tepary Bean for Improvement of Heat Tolerance in Common Bean

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High temperatures (>30°C day and/or >20°C night) in tropical lowlands and production areas in temperate zones reduce yield and quality in common bean (*Phaseolus vulgaris* L.). Tepary bean (*P. acutifolius* A. Gray) is a crop adapted to hot arid climates and is grown in the American Southwest and parts of Mexico under temperatures that are too high for pod formation in common bean. Interspecific hybridization may enable transfer of heat tolerance traits from tepary bean to common bean. Twenty-five tepary bean plant introductions (PI) with the ability to set seed under controlled-environment conditions were evaluated under high (35 °C day/32 °C night) and control (27 °C day/24 °C night) temperature treatments during reproductive development. Four accessions (PI 200902, PI 312637, PI 440788, and PI 440789) exhibited normal pod formation and comparatively high yield when exposed to high temperature, while common bean controls displayed zero pod and seed set. These four PIs showed a mean decrease in seed yield of 72.9% from control to high temperature treatment, as compared to 90.3% among all tepary beans. These accessions were hybridized with the dry bean cultivar 'ICA Pijao', and the heat-tolerant bean cultivars 'Carson' and 'CELARK' and breeding line 'Cornell 503'. Immature embryos were cultured to obtain interspecific hybrids. Fertility of F₁ hybrids and generation of backcrosses are discussed.

Mapping Phytophthora Root Rot Resistance in Red Raspberry using SCARs, CAPs, AFLPs, and RGAs

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RAPD and AFLP markers were first used to construct a molecular map in a BC1 red raspberry population consisting of 70 individuals that segregated for Phytophthora root rot resistance. RAPD markers linked to root rot resistance were identified by bulk segregant analysis and through QTL analysis. Two common genomic regions were identified by both analyses and were estimated to explain ~50% of the phenotypic variation. RAPD markers flanking the QTL were cloned and made into sequence specific markers for potential use in marker assisted selection. In addition to the linked markers, RAPDs spread throughout the linkage map were also sequenced and developed into either SCARs, CAPs, or codominant SSRs. Attempts were made to locate red raspberry resistance gene analogs using degenerate primers designed on conserved regions encoding known resistance genes. Results on the type and map position of identified RGA's and selection efficiency of linked markers analyzed in red raspberry cultivars of characterized root rot resistance will be discussed.

Molecular Analysis of Fruit Size Regulation in Apple

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Fruit size is a commercially valuable trait. Although several factors are known to affect fruit size in apple, insights into the molecular aspects of its regulation are lacking. Our research aims to understand fruit size regulation using a combination of approaches. Analysis of a large fruited mutant of 'Gala', 'Grand Gala' (GG), showed that it was 40% heavier than 'Gala' at harvest. Increase in size of GG fruit was caused by an increase in the cell size apparent at full bloom. Flow cytometry revealed the presence of multiple levels of ploidy (up to 16C) in GG during early fruit development. Increase in ploidy of GG is hypothesized to be due to endoreduplication, a process normally absent

in apple. Endoreduplication is a modification of the cell cycle where DNA replication is not followed by cell division, resulting in increased DNA content accompanied by increased cell size. To understand if the cell cycle is altered in GG, four key cell cycle regulators, MdCDKA1, MdCDKB1, MdCYCB2 and MdCYCD3 have been partially cloned from apple using RT-PCR and RACE. As cell number at the end of the cell division phase is correlated with fruit size at harvest, expression analysis of these genes can provide valuable insights into their role in the regulation of cell number and fruit size. Analysis of cell cycle gene expression in GG may provide key insights into the altered molecular regulation that leads to endoreduplication in the mutant. Parallel approaches being employed to study whether environmental and cultural factors regulate fruit size through an influence on the cell cycle will also be discussed.

Expanding the Seasonal Availability of 'Valencia' Sweet Orange via Somaclonal Variation

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Sweet orange (*Citrus sinensis* L. Osbeck) is the most horticulturally important and widely grown Citrus species in Florida and worldwide, and 'Valencia' is the most important cultivar for processing. Frozen concentrate orange juice has been the primary product of the Florida and Brazilian industries, but recently there has been a strong shift to not from concentrate (NFC) product in Florida. The higher quality NFC has a greater consumer appeal, and brings a higher market price. The development of higher quality oranges with expanded maturity dates will facilitate this change and should increase the competitive ability of the Florida industry. No true sweet orange cultivars have been developed by conventional breeding due to biological impediments, and alternative methods to obtain genetic variation are being investigated, including studies of somaclonal variation. We have produced nearly 1000 somaclones of 'Valencia' sweet orange using organogenesis, somatic embryogenesis, and protoplasts. Following several years of fruit evaluation, early and late maturing high quality somaclones have been identified based on juice analytical data (brix, acid, ratio, juice percentage, juice color, and lbs. solids). These clones have also performed exceptionally in taste panel evaluations comparing them with the traditional mid- and late-season cultivars. Second generation trees of the most promising clones have been propagated for further evaluation, and superior processing clones will be released to the Florida industry in the near future. An overview of this program including pilot plant juice quality data and taste panel results will be presented.

Oral Session 19—Vegetable Breeding

Moderator: John Scott

July 18, 2004, 3:30–5:30 PM

Trinity B

RFLP-based Analysis of Recombination Among Resistance Genes to Fusarium Wilt

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Tomato (*Lycopersicon esculentum*) line E427 has resistance genes to three races of *Fusarium oxysporum* f.sp. *lycopersici* derived from *L. pennellii* (L.pen) accession LA 716 and *L. pimpinellifolium* (L.pimp) accession PI 126915. E427 was crossed to susc. Bonny Best and F₂ and backcross seed were obtained. Progeny were inoculated separately with *Fusarium* wilt races 1, 2, or 3. Lines with suspected recombination of resistance were selfed and re-inoculated until disease reactions were homozygous. Four lines were obtained with resistance to both races 2 and 3, but susceptible to race 1. These lines had the L.pen alleles at

RFLP markers linked to I-3 on chromosome 7 and lacked L.pimp alleles linked to I and I-2 on chromosome 11. Complementation (F_2) data indicated race 2 resistance on chromosome 7 was controlled by a single dominant gene. Three lines were resistant to race 2, but susceptible to races 1 and 3. These lines had L.pimp alleles at TG105 indicating the presence of I-2, and no L.pen alleles at markers linked to I-3. Three lines were resistant to race 1, but susceptible to races 2 and 3. All three had L.pimp alleles at TG523 confirming linkage to I on chromosome 11 and no L.pen alleles at markers tightly linked to I-3. However, one of the lines had L.pen alleles at CT113 on chromosome 7. This and F_2 complementation data suggests the possible location of a race 1 resistant locus, II. Two lines that were Fusarium wilt race 3 resistant and susceptible to race 1 had intermediate resistance to race 2. These two lines did not have the *L. pennellii* alleles at TG183, TG174, and CT43 near the I-3 locus indicating crossovers in this region reduced race 2 resistance.

Molecular Marker Variability for Southern Root-Knot Nematode Resistance in Sweetpotato

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Using two sweetpotato (*Ipomoea batatas* (L.) Lam) F_1 populations from diverse environments we investigated the AFLP marker profiles of the genotypes for association studies between the molecular markers and southern root-knot nematode (*Meloidogyne incognita*) resistance expression. Population one consisted of 51 half-sib genotypes developed at the Louisiana State Univ. AgCenter. The second population consisted of 51 full-sibs developed by the East African and International Potato Center sweetpotato breeding programs. Results for nematode resistance expression indicate a binomial distribution among the genotypes. Using analysis of molecular variance, logistic regression and discriminant analysis, AFLP markers that are most influential with respect to the phenotypic trait expression were selected for both populations. A comparative analysis of the power of models from the two statistical models for southern root-knot nematode resistance class prediction was also done. The diversity and possible universal similarity of influential markers between the two populations and the expected impact in sweetpotato breeding programs will be discussed.

Transfer of Powdery Mildew Resistance from *Brassica carinata* to *B. oleracea*

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Powdery mildew is a fungal disease of crucifers, caused by *Erysiphe polygoni* D.C. and it can be problematic during seed increase in greenhouses. Crosses were made between *Brassica carinata* (Ethiopian mustard) accession (PI 360883) and *B. oleracea* cultivars 'Titleist' and 'Cecile' to transfer resistance to powdery mildew to *B. oleracea* germplasm. It was not possible to obtain interspecific hybrids between Ethiopian mustard and *B. oleracea* through natural seed set. However, interspecific hybrids and backcross one (BC_1) progenies were produced via embryo rescue following sexual crosses. Four interspecific hybrid plants were produced with the aid of embryo rescue from cultured pistils with *B. carinata* as the maternal parent, and their interspecific origin was confirmed through plant morphology and analysis of RAPD polymorphisms. No interspecific hybrids were obtained when 'Titleist' was used as a maternal parent. Interspecific hybrid plants were male sterile and they were used as maternal parents to produce BC_1 plants. Twenty one BC_1 plants were obtained through natural seed set and embryo rescue, although embryo rescue was not necessary to produce first backcross generation plants. When tested in greenhouse with powdery mildew, all interspecific hybrids and eight of the BC_1 plants were resistant to the disease. Crosses are being made to produce BC_2 plants with $2n = 18$ chromosomes for introgression of the resistance in *B. oleracea*.

Breeding Snap Beans for Cucumber Mosaic Virus (CMV) Resistance

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Cucumber mosaic virus (CMV) is an aphid-transmitted virus that infects snap bean growing regions in New York State and Wisconsin. The core collection of common bean accessions (*Phaseolus vulgaris*), the complete collection of scarlet runner bean accessions (*Phaseolus coccineus*) and snap/dry bean cultivars were screened for resistance to CMV. Although variation in foliar symptom expression was observed, no resistance was observed in 93 snap bean and 16 dry bean cultivars tested, and only one of the 406 accessions from the core collection (PI 309881) was symptomless. PI 309881 did not have common bean characteristics, and was later identified as a tepary bean (*Phaseolus acutifolius*) accession based on morphology and PCR-RFLP of chloroplast DNA. Screening of 260 *P. coccineus* accessions was inaccurate when a visual rating of foliar symptoms was used. It was necessary to determine infection using ELISA and test plant screening with grey zucchini. Using this approach it was determined that 80 *P. coccineus* accessions were susceptible to CMV; however, the remaining accessions provided possible sources for transfer of CMV resistance to snap bean. Crosses of *P. coccineus* accessions were made to breeding line 5-593 and backcrossed to 5-593 and snap bean cultivar 'Hystyle'. PI 309881 was crossed with ICA Pijao in order to develop interspecific hybrids. Populations were developed from the interspecific crosses/backcrosses and evaluated for CMV resistance using ELISA and visual ratings of foliar symptoms.

Increasing Anthocyanin Content in Tomato Fruit for Improved Antioxidant Activity

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Tomato lines carrying the genes *Aft*, *atv*, *Abg*, *hp-1*, and an as yet undetermined gene from the introgression line LA2099 have been combined to produce fruit with elevated anthocyanin content. The antioxidant activity of juice made from anthocyanin-expressing tomatoes was compared to juices made from tomatoes with varied carotenoid content. The contribution of anthocyanin to the total antioxidant activity of the whole fruit in current material is small, but with potential for significant improvement. The increase in flavonoids in the elevated anthocyanin lines has increased water-soluble antioxidant activity of the fruit in vitro.

Differential Expression of Carotenoid Biosynthesis Genes among Different Colored Flesh in Watermelons [*Citrullus lanatus* (Thunb)]

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Carotenoids are plant compounds that serve a variety of essential functions in the plant and have also been found to have several health-promoting activities in humans. Carotenoids found in watermelon (*Citrullus lanatus*) flesh are responsible for the various colors such as red, yellow and orange. Previous inheritance studies of flesh color revealed that six genes were involved in color determination. The relationship and interaction of these genes suggests that some color-determining genes may be the result of mutations on the structural genes encoding enzymes in the carotenoid biosynthesis pathway. In this study we were able to isolate and sequence six genes encoding enzymes involved in the carotenoid biosynthetic pathway, and determine their expression in different colored watermelon fruit. The cDNA was synthesized from total RNA using RACE (Rapid Amplification of cDNA ends) kit (SMARTTRACE cDNA Amplification Kit; Clontech, Palo Alto, Calif.). Degenerate primers were designed based on published homologous

genes from other species and were used to isolate gene fragments and full-length cDNAs of phytoene synthase, phytoene desaturase, β -carotene desaturase, β -cyclase, β -carotene hydroxylase and zeaxanthin epoxidase. RT-PCR was carried out to examine any differential expression of cloned genes in white, yellow, orange and red-fleshed watermelon. All cloned enzyme-encoding genes were expressed regardless of flesh colors. These results indicate that carotenoid biosynthesis may be regulated at the post-transcriptional level. One interesting feature supports this hypothesis. In case of β -cyclase, a 229-bp leader intron was identified, and an unspliced mRNA with this leader intron existed dominantly in cDNA pool of all samples.

Formation of Composite Carrot (*Daucus carota*) Populations and Early Cycle Selection for Increased Levels of α -tocopherol, α -carotene and β -carotene

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Carotenoids (provitamin A) and tocopherols (vitamin E) are powerful antioxidants in plants and in the human diet. Carrot (*Daucus carota*) has been selected for increased levels of carotenoids, contributing to its orange color and reported health benefits. Selection for increased tocopherol has shown success in seed oils, but little progress has been made in the edible portions of most vegetable crops. HPLC measurement following a simultaneous heptane extraction of both compounds has shown a significant ($P \leq 0.001$) positive correlation of α -tocopherol with α -carotene ($r = 0.65$) and β -carotene ($r = 0.52$). To increase both the tocopherols and carotenoids in plants, 3 populations have been established from select open-pollinated varieties grown in 2002. These populations consist of half-sib families with these differing selection schemes: based strictly on increased α -tocopherol levels; an index to increase α -carotene, β -carotene and α -tocopherol; and a random population in which no selection is occurring. After one cycle of selection, populations were grown on muck soil during the summer of 2003. Compared with the random population, an increase of 24.68% in α -tocopherol concentration was recorded for the population selected strictly on α -tocopherol while increases of 8.47% in α -tocopherol, 9.31% in α -carotene and 7.31% in β -carotene were recorded for the population with index selection. The continuation of these carrot populations shows promise to produce carrot germplasm with improved human nutritive value.

Mapping of Major Carrot Color Genes and Expression of Carotenoid Biosynthetic Genes

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While the carotenoid biosynthetic pathway has been studied several horticultural and agronomic crops, very little information exists for this conserved pathway in carrot, a primary source of dietary carotenoids. Though orange carrots are the most familiar color to Western consumers, yellow, red, and white carrots also exist and have been historically important. Modern carrot breeders are showing renewed interest in these unusual color phenotypes. Beta- and alpha-carotene are the primary pigments in orange carrot roots. Yellow carrots accumulate xanthophylls (oxygenated carotenoids), red carrots accumulate lycopene (the precursor to alpha- and beta-carotene), and white carrots accumulate no detectable pigments. Differences between these phenotypes are usually monogenic or oligogenic. Our research has focused on identifying putative genes for carotenoid biosynthetic enzymes in the carrot genome, mapping them, and examining expression patterns in various tissues and carrot root pigment phenotypes. We are using this information to create a carrot pigment biosynthesis function map incorporating biosynthetic enzymes, major carrot color genes, and gene expression information.

Oral Session 20—Vegetable Crops Management 2

Moderator: George Clough

July 18, 2004, 3:45–5:30 PM

San Marcos

Common Smut Infection Reduces Sweet Corn Ear Processing Quality

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Impact of natural infection of common corn smut (*Ustilago maydis*) on processing characteristics of three F₁ hybrid sweet corn (*Zea mays* L.) cultivars was evaluated in a two-year study with early and late spring-planting dates. At harvest maturity, size and location of galls were recorded and quality characteristics measured. Galls on the lower stalk, upper stalk and tassel reduced fresh weight and diameter of husked ears while galls on the base of the plant reduced fresh weight only. Ear length was reduced by galls on the upper stalk. As gall size increased from 0 to >10.2 cm. diameter, ear fresh weight and diameter decreased. The presence of galls >10.2 cm diameter reduced ear length. Kernel depth was not affected by size or location of gall. Additional ears of the same three cultivars were sampled from commercial fields planted in mid-season near Walla Walla and Patterson, Wash. Galls located on the upper and lower stalk reduced fresh weight, length, diameter and kernel depth, while galls on the tassel or base had reduced or no effect on these parameters. As gall size increased, fresh weight, length, diameter, and kernel depth decreased.

Variety and Planting Date Effects on Anthocyanin Concentrations in Field-grown Lettuce (*Lactuca sativa*)

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Anthocyanins (Antho) are the source of red color in plants and the intensity of redness is an important quality parameter in red leaf lettuce. Despite the importance of Antho in leaf lettuce, little information is available regarding the effects of major production-related factors, such as planting date, on their levels. To address this issue, field studies were conducted in 2002 and 2003 in which Antho levels were measured in nine lettuce varieties planted in early and late summer (ES and LS, respectively) using a RCB design. Leaf tissue was sampled 30 d after transplanting. Data for three strongly related Lolla Rossa-type varieties ('Lotto', 'Valeria', 'Impuls') are reported here. The planting date \times variety interaction was significant; however, Antho concentrations were higher following planting in LS than ES, regardless of variety. Planting date effects were more pronounced in 2002, when differences in average daily temperature between ES and LS plantings tended to be larger. Regardless of planting date and year, Antho levels followed the pattern 'Impuls' (three genes) > 'Valeria' (two genes) > 'Lotto' (one gene). Correlations between human visual and two types of instrumented assessments of color are being tested in samples from the same study.

Critical Tissues for Nutrient Diagnostics and Optimal Nutrients for Enhancing Yield of Processing Carrots

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Carrot (*Daucus carota* L. var *sativus*) production in Nova Scotia is challenging as carrots are grown under cool temperatures, rainfed

conditions, and in mineral soils usually of low fertility. Growers must rely on fertilizer inputs to optimize yields. Excess application can result in high costs and may lead to soil and environmental problems. There is no up-to-date solidly-based, fertilizer recommendation available for carrot production in Nova Scotia. A greenhouse trial was conducted to identify the critical tissue(s) at various growth stages and optimal tissue nutrient concentrations for yield and quality. This will provide a diagnostic tool for assessing plant nutrient health and the opportunity to correct nutrient deficiencies to prevent yield losses, as well as provide an up-to-date fertilizer recommendation. Dicer carrot seeds, variety Red Core Chatenay were grown in sand culture system that used a gravity-fed drip irrigation system. Nine fertility treatments consisting of a complete 20–20–20 plus micronutrients fertilizer was used to deliver at 0, 50, 100, 150, 200, 250, 300, 350, and 400 ppm equivalent of N, P, and K. Soil and plant tissue samples were taken at 4 and 9 weeks and at final harvest at 13 weeks. Critical tissues varied for each element studied at each of the growth stages. Results suggest 0 and 50 ppm treatments did not provide enough fertilizer to obtain maximum growth while plants receiving above 300 ppm were found to be more susceptible to disease. The treatment with 100 ppm N, P, and K was optimal, being significantly higher in yield and quality than all treatments except 150 ppm.

Effects of Cover Crops on Soil Microbial Biomass in Vegetable Cropping Systems

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The inclusion of cover crops into cropping systems may influence soil microbial activity which is crucial to sustained crop production. A study was conducted to measure short term effects of summer and winter cover crops on soil microbial biomass carbon (MBC) in a cucumber–tomato rotation system. The experiment was established in Summer 2002 as a factorial of summer cover crops (planted either as fallow or after harvest of cucumbers) and winter cover crops (planted in September). The design was a split-block with four replications. The main plot factor was summer cover crop and consisted of five treatments; sorghum sudangrass fallow (SGF), cowpea fallow (CPF), sorghum sudangrass after cucumber (SGC), cowpea after cucumber (CPC) and bareground fallow (BGF). The sub-plot factor was winter cover crop and consisted of three treatments including cereal rye (CR), hairy vetch (HV) and bareground (BG). In spring of 2003, soil samples were collected in each treatment at 30 days before (30 DBI), 2 days after (2 DAI) and 30 days after (30 DAI) cover crop incorporation. MBC was measured using the chloroform fumigation-incubation method. Both summer and winter cover crops affected soil microbial activity. MBC in the summer cover crop treatments at 30 DBI was 47.7, 51.4, 49.2, 43.7 and 42.5 $\mu\text{g}\cdot\text{g}^{-1}$ soil for SGF, CPF, SGC, CPC and BGF, respectively. At 30 DAI, 113.1, 88.9, 138.5, 105.6, and 109.3 $\mu\text{g}\cdot\text{g}^{-1}$ soil was obtained in SGF, CPF, SGC, CPC, and BGF plots, respectively. Soil MBC was similar at 2 DAI in the summer cover crop treatments. Among winter treatments MBC was similar at 30 DBI and 30 DAI, but significant at 2 DAI with values of 62.8, 53.3, 59.3 $\mu\text{g}\cdot\text{g}^{-1}$ soil for CR, BG, and HV, respectively.

The Effects of Plant Populations on Pickling Cucumber Canopy Dynamics and Yield

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Michigan is the national leader for pickling cucumber production. However, over the last few years growers have witnessed a considerable decline in marketable yield, mainly attributed to fruit rot caused by *Phytophthora capsici*. *Phytophthora* develops rapidly under high relative humidity, a situation commonly found with narrow rows.

Growers are interested in using wider rows but would like to know if there are any associated yield reductions. This study was conducted in 2003 to measure the effects of cucumber plant populations on canopy dynamics and fruit yield. Cucumbers were grown with between-row spacing of 30.5, 45.7, 61.0, and 76.2 cm, and in-row spacing of 10.2, 12.7, and 15.2 cm. A split-plot design with four replications was used. Row spacing was the main plot factor, and in-row spacing the subplot factor. Soil covered by plant canopy was monitored throughout the growing season using digital image analysis techniques. At harvest, the number of fruits per plant and marketable yield for the different grades were measured. Cucumber canopy remained open during the major part of the growing season when wide rows (61.0 and 76.2 cm) were used. The number of fruits per plant increased from an average of 1.5 fruits at 30.5 cm to 2.0 fruits per plant at 61.0 cm. Further widening of row spacing to 76.2 cm slightly reduced the number of fruits per plant. Therefore, the optimum row spacing would be 61.0 cm if the number of fruits per plant was the only parameter being measured. Cucumber marketable yield was similar with 30.5, 45.7, and 61.0 cm spacing between the rows. With 76.2-cm rows, yield reduced slightly. These results suggest that cucumber plant density can be reduced substantial with limited yield penalty.

Effect of Nitrogen Fertilization on Yield and Canopy Reflectance of Pepper (*Capsicum annuum*)

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Research at Padova Univ., Italy, during Summer 2003, was carried out to determine the effect on nitrogen fertilization on yield and canopy reflectance of sweet bell pepper (*Capsicum annuum*). Pepper var. Tolo-meo LRP 4993 (Syngenta) was transplanted into plots (24 m²) on 20 May, maintaining 40 cm between plants and 75 cm between rows (3.3 plant per m²). The experimental design was a randomized block with four replicates. Treatments were 6 nitrogen fertilization rates ranging from 0 to 300 kg·ha⁻¹. Nitrogen was distributed at planting and as top dressing, 44 days after planting. All other production techniques were typical of pepper production in the Veneto region. Beginning the second week after transplanting, canopy reflectance was measured weekly using a multispectral radiometer MSR 87 (Cropscan Rochester, Minn.). Fruits were harvested at breaking color stage starting from 21 July to 9 Oct. (8 harvests). At harvest, total and marketable yield, fruit averaged weight and nitrogen content were determined. Maximum yield was recorded at the 120 kg·ha⁻¹ nitrogen treatment, while higher rates proved ineffective at increasing production. Nitrogen rates positively affected fruit weight. The nitrate content of fruits also increased with the nitrogen rates although it remained below the level dangerous for human health. Canopy reflectance was able to detect the different nitrogen treatments only during the late stages of the growth cycle making difficult its use as a tool to drive nitrogen fertilization.

Insect Trap Catch Improvement with Light-Emitting Diode Modification

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Insect traps are vital component of many entomological programs for detection and monitoring of insect populations. We equipped yellow (YC), blue (BC) sticky card (BC) with 530 nm lime green (LED-YC) and 470 nm blue (LED-BC) light-emitting diodes, respectively that increased trap catches of several insect pests. The LED-YC traps caught 1.3, 1.4, 1.8, and 4.8 times more adult greenhouse whitefly *Trialeurodes vaporariorum* (Westwood), sweetpotato whitefly *Bemisia tabaci* (Gennadius) biotype B, cotton aphids *Gossypium hirsutum* (L.), and fungus gnats *Bradysia coprophila* (Lintner), respectively, compared with standard YC traps. The LED-YC traps did not catch more

Eretmoceris spp. than the standard YC traps. *Eretmoceris* spp. are important *B. tabaci* parasitoids used in greenhouse biological control programs. For whitefly control in greenhouse the 530 nm lime green LED equipped plastic cup trap designed by Chu et al. (2003) is the better choice than LED-YC trap because it catches few *Eretmoceris* spp. and *Encarsia* spp. whitefly parasitoids released for *B. tabaci* nymph control. The LED-BC traps caught 2.0–2.5 times more adult western flower thrips *Franklinella occidentalis* (Pergande) compared with the standard BC traps.

Oral Session 21—Mineral Nutrition

Moderator: Jiwan Palta

July 18, 2004, 4:00–5:15 PM

San Marcos

Does Controlled-Release Fertilizer Technology Increase Nutrient Uptake Efficiency *Per Se* in Ornamental Plant Production?

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Many agronomic and horticultural studies on nutrient uptake and use-efficiency have indicated, in general, that agricultural crops are poor competitors for nitrogen (N) and phosphorus (P) in soil-based systems, with estimates of overall nutrient efficiency being less than 50% for N and 10% for P. Low efficiencies are due to losses from leaching, runoff, gaseous emissions and soil fixation, but uptake efficiency is also affected by rate and timing (i.e. seasonal effects) of applications. Controlled-release fertilizers (CRF's) have been promoted as a technology that can slowly release nutrients; the release rate is most often a function of prill coating and temperature. There are few data in the ornamental literature that have directly compared the total uptake efficiency of CRF's to soluble fertilizer sources. From 1999–2002, we collected three annual N and P budgetary datasets, comparing two species (*Rhododendron* cv. azalea and *Ilex cornuta* cv. 'China Girl') with different growth rates and hence nutrient requirements. Plant N and P uptake efficiencies were usually less than 20% of the total applied, but all datasets included a significant soluble fertilization component. In 2003, a new study with *Ilex cornuta* cv. 'China Girl' was initiated, where nutrients were supplied only from two CRF sources, as we want to determine whether this technology can significantly increase nutrient uptake efficiency at similar rates. A preliminary analysis of the data indicate that total N and P uptake efficiencies between different CRF sources were similar, but leaching losses between sources varied during the growing season. It appears that the primary determinant of uptake efficiency is not source material or timing, but the overall rate of nutrient application.

Use of Mixture Experiments to Determine the Effect of Counter-ions of Bicarbonate on Bean (*Phaseolus vulgaris* L.) 'Poncho' in Hydroponics

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Mixture experiments were used to study the effect of Rb, K, and Na in combination with a number of bicarbonate concentrations on bean plants grown in hydroponics in a controlled environmental chamber. The objective was to separate the cation effect from the bicarbonate effect. The first experiment was a 3-component mixture-amount experiment using various ratios of Rb, K, and Na at 0 and 7.5 mM of bicarbonate. In the 0 mM bicarbonate control, the pure blends were ranked: Rb > Na > K for their effect on reducing shoot dry mass. The high toxicity to the Rb ion was probably due to direct Rb toxicity in addition to any general salinity effect. At 7.5 mM bicarbonate, shoot dry mass was decreased with all the counter-ions compared to the 0 mM bicarbonate control, and

their toxicity was ranked: Rb > Na ≈ K. The next series of experiments were 2-component mixture-amount experiments at various ratios of K and Na at 2.5, 5 and 7.5 mM bicarbonate. In the 0 mM bicarbonate control, shoot dry mass decreased with increasing proportions of Na, indicating a specific Na toxicity. The same trend was observed at 2.5 mM bicarbonate. In the 7.5 mM bicarbonate treatment, both Na and K were equally toxic. At low concentration of bicarbonate, the Na is more toxic than the bicarbonate. At higher concentrations of bicarbonate, both Na and bicarbonate exhibit similar levels of toxicity.

Nitrogen, Phosphorus, and Potassium Fertilization Effects on Nutritional Composition of Lettuce

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Lettuce (*Lactuca sativa* L.) is an essential salad crop in the American diet. Nitrogen (N), phosphorus (P), and potassium (K) are required for successful lettuce production and can influence lettuce quality. The objective of the study was to evaluate changes in nutritional composition of romaine ('Green Tower') and iceberg ('Sharp Shooter') lettuce in responses to N, P and K fertilization during fall production in Salinas, Calif. Sixteen treatment combinations of fertilizer were selected to provide a range of treatments. N was applied at 0, 112, 225, and 338 kg·ha⁻¹ as ammonium nitrate; P was applied at 0, 112, and 225 kg/ha as super phosphate; and K was applied at 0 and 112 kg·ha⁻¹ as muriate of potash. Nutritional content of fresh tissue of two types of lettuce was analyzed using high performance liquid chromatography (HPLC). Among the parameters analyzed were lutein, beta-carotene, chlorophyll a, and chlorophyll b. Yield was increased with increasing N fertilizer level, but was not affected by P or K application rates. The best post harvest quality, however, was at moderate P application rate. Increasing the N and P rates gradually increased glucose content in lettuce but decreased the shelf life. Significant differences between the two types of lettuce were found in chlorophyll, lutein and beta-carotene content. No significant correlations were found between soil fertilizer application levels and nutritional content of lettuce. However, the ratio of chlorophyll a and b were greater with the increase of fertilizer rate. Nutritional composition including vitamin C will be presented.

Supplemental Calcium Application to Potatoes Reduces the Incidence of Black Spot Bruise Induced by Mechanical Harvest

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Supplemental calcium application has been shown in our previous work to improve tuber quality and reduce internal defects. We evaluated the response under field conditions of five commercially significant cultivars to a combination of calcium nitrate, calcium chloride and urea (168 kg·ha⁻¹ per season) over three seasons. We were able to determine that the cultivar with the greatest response to supplemental calcium for reduced bruising, 'Atlantic' had the lowest levels of tuber tissue calcium. Conversely, cultivars with least response to supplemental calcium, 'Dark Red Norland' and 'Superior', had the highest levels of tuber tissue calcium. 'Snowden' was both intermediate in response to calcium and tuber tissue concentration. Based on data for 3 years, we determined that across cultivars the calcium concentration at which tubers no longer respond is ≈250 ppm and ranges for individual years from 195 to 242 ppm. These results suggest that seasonal variation for individual cultivars may affect the tuber need for calcium for reduced bruising. Although the exact mechanism is not known, we believe that calcium supplemented to bulking tubers may lead to improved cell membrane stability, increased wall structure or enhanced ability of tubers to repair following injury. The results of our study show that supplemental calcium fertilization has the ability to significantly reduce the incidence of tuber bruising for several cultivars.

Effect of Sawdust Age and Nitrogen Application on the Decomposition Rates of Two Types Sawdust Used for Blueberry Production

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In a 2-year study, the decomposition rates (changes in carbon to nitrogen ratio) of two kinds of sawdust used for blueberry production were determined. The effects of sawdust age and nitrogen application rates on carbon to nitrogen ratio (C:N ratio) of two sawdust types were evaluated. When nitrogen was not applied, the C:N ratio in fresh and aged sawdust decreased 30% and 10% respectively over a 1-year period, indicating fresh sawdust decomposed faster than aged sawdust when used as a surface mulch. However, the C:N ratios between soils amended with aged and fresh sawdust were similar when no nitrogen was added, suggesting the age of sawdust does not affect the decomposition rate once the sawdust is incorporated into the soil. It was found that two nitrogen application rates (150 kg·ha⁻¹ vs. 50 kg·ha⁻¹) had an equal affect on the C:N ratio of both sawdust types. Nitrogen application had no affect on the C:N ratio of both sawdust types when both sawdust were used as soil amendments. Clearly, the decomposition rates of the sawdust were influenced by sawdust age and nitrogen application rates.

Oral Session 22—Propagation

Moderator: Menahem Edelstein

July 19, 2004, 8:30–9:00 AM

San Marcos

Stand Establishment of Grafted Vegetable Transplants in the Mediterranean Basin: An Overview

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Achieving a uniform stand of grafted vegetable transplants in the field is critical to the grower because of the high cost of the grafted transplants. Low and erratic stands can lead to monetary losses even in an otherwise successful crop. Establishing a uniform stand of grafted vegetable transplants in the field depends on several additive parameters prevailing in the nursery and in the field. These include seed quality, grafted-transplant quality, and agrotechniques suitable for the special needs of grafted transplants. Seed quality and seed health should be given special emphasis as compared with non-grafted-transplant production. Grafted transplants spend more time in the nursery, are treated manually more, and are more susceptible to seed-borne pathogens. Field preparation, plastic mulch, irrigation and fertilization are important, especially in warm, mediterranean climates.

Advantages and Limitations of Grafted Vegetable Transplants in Israel

Amnon Koren*¹, Menahem Edelstein²

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Grafting technology for vegetable transplants was introduced to Israel eight years ago by Hishtil Nurseries, Inc. The main goal of grafting was to find a substitute for methyl bromide, the elimination of which was pending. The use of grafted watermelon transplants soon followed. Presently, more than 40% of watermelon transplants are grafted. The chief reason for the success of grafted transplants is their tolerance to soil-borne pathogens, including *Fusarium*, *Monosporascus*, and *Macrophomina*. Yields of grafted transplants are often much higher, and it has been shown possible to grow watermelons with saline water (4.5). A limitation of grafted transplants is that presently, we do not have a good solution for nematodes. A drawback is that in order to get good watermelon taste and flavour, the grower needs the experience

to adjust agrotechniques, especially determining the best harvest date. Grafted tomato transplants were also introduced early on. Grafted tomato transplants can have excellent resistance to fusarium crown rot, corky root, and other soil-borne pathogens. Some rootstocks have been observed to tolerate water salinity of 8 ec and still produce commercially acceptable yields. Limitations to the use of grafted tomato transplants are the lack of compatibility of some of the cultivars with the rootstocks and the breakdown of nematode resistance at high soil temperatures. Melons, eggplants, and cucumbers are grafted under some conditions.

Grafted Melons: The Phytopathological Aspect

Roni Cohen*¹, Yosef Burger², Menahem Edelstein³

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The use of grafted vegetables as one of the alternatives to soil disinfection with methyl bromide is increasing in Israel. Watermelon (*Citrullus lanatus*) and melon (*Cucumis melo*) plants are grafted mainly onto *Cucurbita* rootstocks for lessening losses due to soil-borne pathogens. The contribution of the rootstock to the grafted plant's resistance depends on the nature of the disease. In general, damage caused by non-specific root-rot pathogens such as *Rhizoctonia solani*, *Macrophomina phaseolina*, *Monosporascus cannonballus*, and *Pythium* spp. are effectively reduced by using *Cucurbita* rootstocks. However, these rootstocks provide only partial protection from vascular diseases such as fusarium wilt, in which case better protection can be achieved by grafting susceptible melons onto monogenic fusarium-resistant melon rootstocks. The performance of the grafted plants depends not only on the rootstock but also on the scion response to pathogens and on the effect of the environment on disease development. The response of grafted and non-grafted melons of different cultivars to sudden wilt disease caused by the fungus *Monosporascus cannonballus* was evaluated in field trials conducted in the fall and spring growing seasons. Significant differences in disease incidence were found among cultivars, between grafted and non-grafted plants, and between seasons. Grafting reduced plant mortality in the spring and fall experiments but prevention of yield losses was more effective in the spring. More emphasis should be given to finding suitable rootstocks and adjusting agrotechniques for successful commercial cultivation of grafted melons in the fall.

Response of Grafted and Non-grafted Melon Plants to High Boron and Salinity Levels

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Excess of boron and salinity in soil and irrigation water can limit the production of melons (*Cucumis melo*). A greenhouse study was conducted in order to compare the responses of grafted and non-grafted melon plants to combinations of high levels of boron and salinity. Boron levels were 0.25, 0.8, 2.5, 5.0, 10.0 mg·L⁻¹ and salinity levels were 1.8 and 4.6 dS·m⁻¹. Foliar injury caused by boron was more severe in the non-grafted than in the grafted plants. Likewise, boron accumulation in leaf tissue from non-grafted plants was higher than in grafted plants. High salinity led to decreased boron accumulation in the leaves. Fruit yield was decreased only at a boron concentration of 10 mg·L⁻¹, and the decrease in grafted plants was smaller than that in non-grafted plants. A negative correlation was found between boron accumulation in leaves and fruit yield. The results showed that melon plants grafted on *Cucurbita* rootstock are more tolerant than non-grafted ones to high boron concentrations, and this can probably be explained by the decrease in boron accumulation caused by the rootstock.

Oral Session 23—Marketing and Economics/Human Issues in Horticulture

Moderator: Kerrie Badertscher

July 19, 2004, 8:30–9:45 AM

Trinity A

The Boulder County Jail Project

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The Boulder County Jail Garden was conceived to provide inmates at the jail an opportunity for community service time during their sentence. The jail kitchen needed fresh produce, but costs were rising and variety of choices suffered. In 1994 the Boulder County Jail staff contacted the Colorado Master Gardener™ program (MG), Boulder County, to work on a joint project in tending a 1.1-acre food production garden. Net pounds of produce have increased steadily over succeeding years from 6,300 lbs. in 1997 to 19,100 lbs. in 2003. Market value of 2003 crop is \$22,700.00. Communities must be willing to have a volunteer group that can commit to long-term time investment in working the garden each year. MG's participate as mentors to inmates. Discussion outlines activities and critical components for a successful program.

Do Plant Guarantees Matter?

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Consumers face risks each time they purchase and consume products. Guarantees provide a means of potentially decreasing risk for products that cannot be evaluated until consumption has begun, as with ornamental plants. Despite the potential risk reduction, the effect of guarantees on consumer purchases has been a source of debate for many retailers. Research conducted at Michigan State Univ. examined the effects of guarantees on consumer satisfaction and regret of three horticultural products: hanging baskets, potted roses, and perennials. Over half (56%) of respondents stated the retail outlet provided a guarantee. Twenty-six percent stated the guarantee was a deciding factor in choosing that particular plant while 27% stated it was the deciding factor in shopping at that particular retail location. Results show that guarantees reduce risk for consumers, reducing the incidence of regret but have no effect on customer satisfaction.

Understanding Behavioral Consequences of Dissatisfied and Regretful Customers

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Michigan State Univ. researchers surveyed 777 gardening consumers in an Internet survey on 24 Sept. 2003 to determine consumer perceptions of satisfaction, dissatisfaction, and regret of three horticultural products: hanging baskets, potted roses, and 1 gallon perennials. Consumer satisfaction has been studied in a horticultural context before, however, to our knowledge this is the first time emotion research, specifically regret, has been applied in a horticultural setting. Regret is an emotion experienced from a negative valenced reaction to an event such as a dead or dying plant. Consumer satisfaction/dissatisfaction is a state of being derived from the expectation and performance of a particular product. Based on work from a doctoral dissertation, the objective was to investigate the behavioral consequences associated when gardening consumers experienced dissatisfaction or regret toward these three products. Questions were asked to pinpoint levels of dissatisfaction

and regret and whether they switched from the product based on feelings of dissatisfaction and regret. About 27% (202) of respondents expressed some level of dissatisfaction or regret about the products specified in the survey. Results show regret drives switching behavior and those that experienced regret with their products were more likely to switch. Approximately 10% of gardening consumers switched to another activity outside of gardening because of failure of the plant purchased to perform where as 13.5% switched to another type of plant to remedy the situation. Regret has been shown to strongly influence repurchase behavior based on being an emotion. Results also indicate although dissatisfaction is unfortunate, it does not have the same effect on switching behavior.

Assessing Pennsylvania Consumer's Gardening Experiences and Interests to Develop Marketing Strategies for a State Plant Promotional Program

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Gardeners can provide the best insight to their gardening experiences and interests. In order to identify potential buyers of the state plant promotional program, Pennsylvania Gardener Selects (PGS), an intercept survey with 243 participants was conducted at the Philadelphia Flower Show on 6–7 Mar. 2003. Objectives were to better understand Pennsylvania consumer's: current gardening related shopping habits; where they obtain gardening information; and their motives and limitations for pursuing gardening. Responses were analyzed to identify potential consumer segments who might purchase PGS plants. Participants with an income >\$50,000 (55%) are more likely to gather their gardening information from a university website than those with an income <\$50,000 (39%). Respondents with a college education (59%) reported that time was the limiting factor when gardening as compared to those with only a high school diploma (44%). Survey responses were also analyzed using Cluster Analysis, which generated three distinct consumer segments: "Novice Gardener" (consumers with limited experience in gardening), "Non-Gardener" (consumers who prefer not to garden), and "Avid Gardener" (consumers who spend the majority of their leisure time gardening). "Avid Gardeners" are likely to purchase plants evaluated for Pennsylvania (average response of 6.5; scale 1 to 7) and 73% have purchased Pennsylvania products. They also are more likely to purchase their landscape plant material at local nurseries/garden centers (82%) than the other segments (68%). Based on the results it can be assumed that "Avid Gardener" could be a potential market for PGS plants. A marketing strategy for reaching this audience may consist of promotions at local nurseries/garden centers along side other Pennsylvania-grown products.

Selecting, Training and Evaluating Master Gardeners in the Non-traditional Role of Instructors in the Basic Training Classes of the Program

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In a time of budgetary constraints, reorganization of many extension services and other changes in the educational system, identifying and implementing non-traditional ways to deliver programming is a critical issue if extension is to continue to deliver quality, timely educational programs to clientele. Innovative methods that can be used to efficiently and economically deliver programming would be desirable and beneficial. This presentation will address how Mississippi State Univ. Extension Service, due to the changes listed above, is addressing the lack of extension instructors to teach the basic training curriculum of the Master Gardener (MG) program. In order to continue to meet the public demand for these classes and safeguard the integrity of the instruction, a new process of identifying, training and evaluating "senior" MG volunteers as instructors in the basic training curriculum of the program has been implemented. How this process was initiated and buy-in of

administrators, county extension MG coordinators, volunteers and state specialists was established will be presented. The process of selecting, training, and evaluating of these MG certified educators would also be presented. Difficulties encountered with implementing this new system of program delivery utilizing volunteers in addition to the traditional specialist or agent instructor will be presented as well.

Oral Session 24—Teaching Methods/Computer

Applications in Horticulture

Moderator: James Nienhuis

July 19, 2004, 10:00–11:15 AM

Trinity A

Use of Time-lapse Video to Demonstrate Plant Growth Regulator (PGR) Responses

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Tables, graphs, and photographs can effectively convey detailed results of a PGR experiment. However, we have observed that demonstrating PGR treatment effects by time-lapse video creates a strong impact on both scientists and non-technical audiences. Time-lapse video also provides a method for obtaining a continuous visual record that can be used to establish the precise chronology of a slow process. Recent advances in notebook computers, inexpensive digital cameras (e.g. 3Com HomeConnect™), and time-lapse software (e.g. Picture WorkLive™) allow scientists and teachers to inexpensively prepare time-lapse videos. Important considerations for the production of quality time-lapse videos include: 1. treatment effects should be substantial, consistent, and visible, 2. digital camera images should be clear, 3. lighting should be constant and provide adequate brightness and proper color, 4. camera movement such as those due to vibrations should be minimal, 5. camera placement should simplify composition. Time-lapse videos of PGR treatment effects will be shown, and methods of production will be discussed.

Connecting Fast Plants to Biotechnology

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We have developed a series of instructional materials integrating a proven teaching tool, Wisconsin Fast Plants, with hands-on molecular techniques. Many biotechnology techniques, including genomics, have developed to a point where appropriate modifications can result in classroom accessible instructional materials that will engage students and teachers. Three “kits” have been developed or are in the process of development. Kit 1—PCR and Fast Plants. This kit is designed to provide an introduction to PCR and a link to Wisconsin Fast Plants. This kit uses a specific robust primer, which can amplify a specific sequence in *Brassica rapa* (Fast Plants). This kit serves as a hands-on tool to familiarize students with DNA extraction, PCR, gel electrophoresis, and analysis of PCR products. Kit 2—Genetic Diversity — ‘Veggie interesting’. This kit is based on the development of a specific primer, which is polymorphic between *B. rapa* (Fast Plants) and *B. oleracea* (common vegetables). In this kit, we explore the use of molecular markers and PCR to determine the species classification of various *Brassica* subspecies. This kit can be used to teach students about plant diversity and the use of molecular biology techniques (such as PCR) to determine how plants are related to each other. Kit 3—Genomics. The primary biological component is a simplified DNA chip (microarray) specifically designed for visualization of differential gene expression. This chip contains *Arabidopsis thaliana* genes that have already been

characterized in our laboratory that display differential expression in seedlings grown in light vs. dark. To simplify analysis, the chip contains approximately ten genes rather than the thousands that are typically spotted on research chips.

Developing New Approaches and Tools for Improved Management and Delivery of Online Digital Photos

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More and more of the Department’s academic and outreach communications on the Internet involve the use of digital photos. While enhancing visual appeal and conveying information that cannot be communicated via text is an obvious benefit, it is critical that digital collections be efficiently and effectively managed at the client level (personal workstation) and also the server level. To assist faculty and staff who routinely publish on the web and those who contribute to the Ohio State Univ.’s WebGarden online image database, a new client application was developed to assist in viewing and organizing digital photos on their workstation. Based on FileMaker Pro database software, a standalone program name DPM (Digital Photo Manager) was developed that runs without the user having to have FileMaker software installed on their system. DPM allows the user to scan a folder of digital photos, create thumbnails, add appropriate captions and cataloging information, and even display a full-screen slideshow. When the user is ready to publish on the web, they upload their file into a portion of the department website managed by Gallery software, a free PHP-based application that integrates with various web server programs and handles any number of user-specific digital albums. Following this, a website was developed that allows the user to select a photo from their online album, add 1–3 lines of captioning, and enter their name for a photo credit. The website automatically applies a standard background, creates four different sizes of the image, renames the files into a standard naming convention used for all images on the server, saves each file into a specific folder, and provides the user with the URL address for the digital files.

Using Personal Digital Assistants and Electronic Forms to Collect and Rapidly Summarize Field Data

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The use of handheld computers such as personal digital assistants (PDAs) represents a feasible method of automating the transfer of files to computers for archiving and statistical analysis. Data collected using the PDA can be transferred directly to a database program on a desktop computer, virtually eliminating errors associated with the reentry of manually collected data. These devices are highly portable and can be housed in protective cases, enabling data collection even in inclement environments. The availability of handheld database programs that permit the development of electronic forms further makes the PDA a viable data collection platform for scientific research. These database applications not only allow novice users to develop customized forms that facilitate the recording of alphanumeric data; these applications also synchronize directly with current desktop-based database and spreadsheet applications. We used Microsoft Access database tables, along with Visual CE, a PocketPC database application, to generate electronic forms for collecting data from research trials conducted in 2003. To facilitate comparison with manual data collection, we also recorded observations using “pen and paper” methods. We found no differences between both methods in the length of time required to enter observations. However, the PDA transferred the data to a computer 600% faster relative to the manual reentry method. Using the handheld computer, field data was immediately available for compilation and statistical analysis within minutes of completing the data gathering process, at the same time ensuring the integrity and continuity of the files.

Development of a Web-Accessible GIS Database as a Tool for Sweetpotato Germplasm Collection Activities in East Africa

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Africa represents a unique secondary site of genetic diversity for the sweetpotato [*Ipomoea batatas* (L.) Lam.]. Despite the genetic resources available for sweetpotato breeding and cultivar selection, regional conflicts and adverse weather in the last two decades have accelerated the risk of germplasm loss, particularly in East and Central Africa. A cooperative research project is currently underway to assess genetic diversity as well as help conserve sweetpotato germplasm in East Africa. One of the tools that are currently being used is a web-accessible GIS database that enables access to spatial and temporal data by project investigators and other stakeholders. Although proprietary methods are available for delivering GIS data through web interfaces, these methods often require expensive licensing agreements. The use of ALOV Map, a freely available Java[®] application for publishing vector and raster maps, along with basemaps and other thematic maps downloaded from publicly accessible web sites, helped provide the framework for a web-accessible GIS database. DIVA-GIS, a free desktop based GIS software was used to generate shapefiles as well as preview files prior to uploading. This demonstrates that the availability of publicly available software requiring minimal or flexible licensing costs provide a cost-effective alternative to institutions that are considering access to GIS databases via a web-accessible interface. We describe procedures, software, and other applications that we used to develop a publicly accessible web interface to a GIS database of sweetpotato germplasm collections in Kenya and Tanzania.

Oral Session 25—Organic Horticulture

Moderator: James J. Ferguson

July 19, 2004, 10:30 AM–12:00 PM San Antonio

Evaluation of Organic Herbicides

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Cover crops, cultivation, flaming, soil solarization, and mulching are commonly used for weed control in organic production systems. However, several new herbicides, approved by the Organic Materials Review Institute (OMRI), are recommended as contact, non-selective, post-emergence herbicides for annual grasses and broadleaf weeds. Citric acid (Alldown), clove oil (Matran 2), thyme/clove oil (XPRESS) were compared with glyphosate (Roundup Pro), a systemic broad spectrum herbicide, at three sites in southern and north central Florida during September and October, 2003. Treatments varied at each site but included glyphosate (5% a.i. applied to runoff) organic herbicides at recommended rates (undiluted citrus acid at 61 L·ha⁻¹; 10% clove oil at 76 L·ha⁻¹; 10% clove oil/thyme oil at 76 L·ha⁻¹) and at twice recommended concentrations and application rates. Grasses and broadleaf weed species were different at each site but included Alexander grass, bahia grass, Bermudagrass, carpetweed, crabgrass, hairy indigo, lambs quarters, Florida pusley, goatweed, nutsedge, pigweed, shrubby primrose willow, broadleaf signalgrass, southern sandbur, spurge, torpedograss, and citrus rootstock seedlings. Weed control with the organic herbicides at all three sites at recommended and at higher concentrations and rates was inconsistent, ranging from 10% to 40%, compared with 100% control with glyphosate. Labels for the organic herbicides generally specify application to actively growing weeds less than 10 cm tall, emphasizing their use as early season herbicides. Fall applications to larger weeds, some within the specified maturity and size range and others taller and producing seed, could partially explain poor weed control.

Organic Cultivation of Radicchio rosso di Chioggia (*Chicorium intybus* var. *silvestre*) in Iowa

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An experiment was carried out at the Iowa State Univ., Neely-Kinyon Research Station (Greenfield, Iowa) to assess the possibility of growing organic radicchio rosso (*Chicorium intybus* var. *silvestre*) in Iowa and to determine the effectiveness of different organic fertilizers. The experiment was a factorial combination of three radicchio cultivars (very early, medium early, and early), three organic fertilizers treatments (non-fertilized control, liquid, and compost based), and two planting dates (11 July and 7 Aug). Treatments were arranged in a split plot design with four replicates. In each sub-plot, plants were transplanted, maintaining 30 cm between plants and 75 cm between rows (4.4 plant per m²). During the growth cycle the crop was managed according to typical production techniques adopted for lettuce. Beginning the first week after transplanting, canopy reflectance measurements were taken every 2 weeks until harvest, using a multispectral radiometer MSR 87 (Cropscan, Inc. Rochester Minn.). At harvest, total and marketable yields were measured and dry matter production was calculated. Yield loss was determined after 15 days of cold storage (4 °C). Cropscan measurement showed no differences among fertilizers treatments, mainly because of the high fertility of the soil (6% organic matter), but different growing patterns among radicchio types. The medium-early type grew quicker than the other types, and showed the lowest percentage of bolted plants (<4%) and the least preharvest weight loss (5%). Moreover, radicchio demonstrated resistance from the hot and dry Iowa summer even without irrigation, representing a useful alternative crop for both organic and conventional farmers.

Reaching Midwest Organic Growers through On-farm Partnerships

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Based on citizen demand, Iowa State Univ. (ISU) established the first organic specialist faculty position at a U.S. Land Grant Univ. in 1997, as a shared appointment in the departments of horticulture and agronomy, with a 70% Extension and 30% Research split. A series of Organic Agriculture Focus Groups was convened in 1998 to help direct the new organic research and Extension program at ISU. Partnerships with the Leopold Center for Sustainable Agriculture and the College of Agriculture facilitated the ISU sustainable agriculture Extension leader and organic specialist's participation in an extensive focus group dialogue with a diverse group of farmers (organic and conventional), agribusiness professionals, bankers and consumers in six agricultural communities across Iowa. Paramount in the needs assessment was the establishment of organic research sites, both on-farm and at research stations across the state, to demonstrate the economic and environmental benefits associated with organic farming practices over the long term. Specific outcomes-based Extension needs were articulated, which led to the development of an annual schedule of organic workshops, field days and conferences. In 2001, in a survey of 300 farmers, 90% of respondents reported an increase in soil quality and 67% reported a 6 to 30% increase in farm income as a result of organic farming practices. The success of Land Grant Univ. organic programs will be dependent upon administrative support, sufficient resources, and community involvement in the decision-making process.

Preliminary Results on the Application of Surround WP on Apple Productivity, and Fruit Quality

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A new biopesticide has been commercially available to apple growers since 2001 in the kaolin clay-based product. This material meets

Federal standards for use in organic crop production as a potential replacement for some insecticides that manage key apple insect pests. Initial research indicated that kaolin might have non-target impacts such a reduction in canopy temperature. However, most of the research on non-target effects, such as impacts on fruit quality, has been conducted in warmer, semi-arid environments. These potential impacts may not be beneficial in cooler orchard environments. The objectives of this 3-year study are to determine potential non-target effects of Surround WP application in the relatively cool and moist climate of the Northeast on 'McIntosh'/M.26 apple tree productivity, and fruit quality. In 2001, preliminary data were collected and are included in these results. Treatments include: (1) Surround beginning at green tip plus fungicides; (2) Surround beginning at green tip without fungicides; (3) Surround beginning at petal fall plus fungicides; (4) IPM; and (5) Nontreated control. In 2001, the control treatment received fungicides. For 2002 and beyond, the protocol was amended to remove fungicides treatments. Data analysis indicate significant differences in treatments for several of the variables measured (fruit weight, percent drop, yield efficiency, starch index, soluble solids, fruit packout, and insect and disease damage). However, some of these differences might be due to the high incidence of scab in the treatments that received no fungicides and not due to the effect of Surround. There were no significant differences in other variables measured such as thinning, fruit color, and spur diameter.

Effect of Surround on Walnut Quality

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The effect of Surround[®] on walnut quality parameters including edible yield, reflected light index, insect damage, off grade, and price per pound were evaluated over a 3-year period in either, or in some years both, 'Vina' and 'Chandler' walnut orchards. Results indicate that edible yield, reflected light index, and price per pound were significantly increased by applications of Surround[®] in some years. Improvements in these parameters were more consistent with the cultivar 'Vina'. Off grade was not significantly reduced by the use of Surround[®]. Insect damage levels were too low to measure in all orchards in all years.

Solid Effluent from Thermophilic Anaerobic Digestion of Poultry Litter as a Potential Fertilizer

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Fertilizer costs and increased awareness of non-point source pollution run-off amplify the pressures on farm economics. Intensive farming operations provided the impetus for our study using effluent from anaerobic thermophilically digested poultry litter as a potential fertilizer. Five fertilizer treatments were used: unfertilized control, pelletized municipal sludge, commercial crop specific products, 1x digested solids and 2x digested solids. All four applications of fertilizer were equalized for nitrogen based on commercial product recommendations. Beds treated with 2x solids accumulated higher percentage of organic matter over the 5-year period. A statistically significant increase in phosphorus was found in the solids beds in 2003. Beds with 2x solids showed statistical significance for Mg, Zn and Cu. Fertilizer trials included blueberries, tomatoes, potatoes, and sweet corn. Potato fresh weight was not significantly different in 2002 or 2003, but was in 2001. Tomato fruit number was not significantly different in 2001 or 2003, but was in 2002. Tomato fresh weight for 2x solids was not significantly different from the commercial or pelletized sludge treatments in 2002

and 2003 suggesting that tomato may discriminate between treatments. Commercial and pelletized sludge fertilizers were statistically better for sweet corn fresh ear weight and number of ears in 2002 and 2003. Blueberry yields were not significantly different between treatments for any year. As this is a perennial crop, it may be several years before a significant difference is observed. While not a total solution, our research shows the effectiveness of digested poultry litter as part of a nutrient management program; making livestock residuals a nutrient resource which offers the potential for organic use.

Oral Session 26—Floriculture 1

Moderator: Art Cameron

July 19, 2004, 10:30–12:15 PM

Pecos

Clerodendrum as Flowering Potted Plants

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The genus *Clerodendrum* is of interest to the floriculture industry as a woody, flowering pot plant because of its variation in type of foliage and flowers, production of many inflorescences on one plant, continuous bloom, fast growing and short production cycle. Plant height, however, needs to be successfully controlled to produce a marketable plant. Paclobutrazol (Bonzi) and ancymidol (A-Rest) have been shown to reduce plant growth and increase the number of flowers of *C. thomsoniae*. The remaining species are relatively new to the floriculture industry and very little information is available on use of growth retardants. Determination of the proper timing, number of applications and rates of growth retardants were studied. Paclobutrazol and ancymidol were applied either as a spray at 0, 100 or 200 ppm, or as a drench at 0, 0.5 or 1.0 a.i. /pot to *C. thomsoniae*, *C. ugandense*, and *C. bungii*. Applications began three weeks after rooted cuttings were potted for three consecutive weeks, with randomized plants treated either in week one, two or three with all treatment rates. As in previous studies, *C. thomsoniae* responded to paclobutrazol and ancymidol by producing a marketable plant, while plant height of *C. ugandense* and *C. bungii* was not affected by treatments.

Specific Surface Versus Particle Diameter of Limestones

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Agricultural limestone is classified based on particle-size distribution, a key factor influencing neutralization capacity. This property is an effective basis for liming recommendations for agronomic purposes which allow for gradual rise in soil pH and residual neutralization for three years. Inconsistencies are prevalent when agricultural limestone is used for horticultural applications which require rapid attainment of target pH and residual neutralization for only four months. Variations in pH among batches of substrate produced with the same limestone rate and pH drift from the same initial pH during crop production infer that factors other than particle diameter also influence limestone neutralization capacity. In this study the relationship between specific surface and diameter of limestone particles was examined. Limestones obtained from twenty North American quarries were wet-sieved into eight particle diameter fractions from 600 to <38 μm (passing 30 through 400-mesh screens). Specific surface (m^2/g) of particles was measured in three replications for each fraction following the BET theory that dinitrogen gas (N_2) condenses in a continuous mono-molecular layer on all particle surfaces. At each particle diameter fraction, specific surface varied significantly (five-fold differences) among quarries. Large specific surface may indicate many reactive interfaces, hence

high neutralization capacity. In containerized production, typical to horticulture, preponderance of root over substrate mass and short crop duration dictate narrower characterization of limestone than is currently used. Specific surface may describe limestone neutralization capacity more finely than does particle diameter.

***Cleome hassleriana* Germination in Minnesota Prairies, Roadsides and Gardens**

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Cleome hassleriana is an ornamental garden plant introduced from South America and naturalized in eastern United States with tendencies to reseed primarily in gardens. The objectives of this research were to determine (1) if *C. hassleriana* cultivars can germinate in Minnesota prairies and roadsides, (2) if germination in cultivated environments reflect germination in non-cultivated environments, and (3) if there are differences among cultivars across environments, with some cultivars germinating well in cultivated habitats and poorly in non-cultivated habitats. In June 2003, 135 seeds from each of four cultivars (Queen Rose, Queen White, Sparkler Rose and Sparkler White) were planted in each of 4 gardens and 8 non-cultivated habitats (4 prairies and 4 roadsides). Germination and survival was recorded once weekly for four weeks. *Cleome* seeds germinated in Minnesota gardens, prairies and roadsides. By day 14, the proportion of germinated seedlings was significantly greater in gardens (30.5%) than in prairies (1.4%) and roadsides (0.9%). Sparklers had significantly greater germination than Queens in the prairies. The best performing cultivar in the garden (Queen White, 29%) was different than the best performing cultivar in the prairies and roadsides (Sparkler Rose, 1.4% and 1.2% respectively), suggesting that germination in non-cultivated habitats may not reflect germination in the field. Cultivars varied in their ability to germinate in cultivated and non-cultivated environments.

Comparative Analysis of Laboratory Freezing Methods to Establish Cold Tolerance of Detached Rhizomes and Intact Crowns in Garden Chrysanthemums

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Since 1924, the Univ. of Minnesota herbaceous perennial breeding program has released $n = 84$ garden chrysanthemums (*Dendranthema grandiflora*). Recent breeding objectives have focused on development of non-destructive phenotypic markers and laboratory freezing tests for continued selection of cold-tolerant *Dendranthema*, *Gaura*, and other herbaceous perennial flowers. Such methods have become critical to flower breeding programs during periods of above-average winter temperatures and minimal snow cover. Two different laboratory freezing tests were evaluated for their effectiveness in determining cold tolerance. Acclimated crowns of $n=6$ hardy and non-hardy garden chrysanthemum genotypes were used in Omega Block (detached, emergent rhizomes) and chamber (intact crowns with emergent/non-emergent rhizomes) freezing test methods. Comparative winter survival in the field was monitored over locations and years. Cold tolerance was assessed at 0 °C to -12 °C with varying ramp and soak time periods. LT_{50} temperatures and number of living emergent rhizomes were determined. Rhizome quality at 1 cm, 3 cm, and 5 cm depths was rated on a 0 (dead) to 5 (undamaged) scale. The chamber freezing method was the most powerful to discern LT_{50} values. Cold tolerant genotypes included 'Duluth' and 98-89-7 ($LT_{50} = -12$ °C). Three genotypes had intermediate cold tolerance ($LT_{50} = -10$ °C) and one genotype was not cold tolerant ($LT_{50} = -6$ °C). Cold-tolerant genotypes also had significantly higher regrowth ratings for rhizomes at 1cm and 3cm depths. Future research will use the chamber freezing method to assay the inheritance of winter hardiness in intact crowns of segregating populations.

Determination of the Alkalinity Toxicity Limits of Selected Greenhouse Ornamental Plants

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Tolerance to alkalinity was evaluated in Rose 'Pink Cupido', Vinca 'Apricot Delight', Chrysanthemum 'Miramar', and Hibiscus 'Bimini Breeze' and 'Mango Breeze'. Plants were potted in a sphagnum peat moss-based growing medium and irrigated with water containing 0, 2.5, 5, 7.5 and 10 mM of Na bicarbonate. In rose, shoot mass was significantly decreased and chlorosis increased at the 5 mM treatment, indicating that the alkalinity toxicity is between 2.5 and 5 mM. In chrysanthemum, the concentration of Na bicarbonate did not significantly affect shoot mass, but caused a significant increase in leaf chlorosis at 5 mM or higher Na bicarbonate. This indicates an alkalinity toxicity level between 2.5 and 5 mM. In Vinca, shoot dry mass was not affected significantly, but leaf chlorosis was significantly increased with 5 mM of Na bicarbonate. This indicates an alkalinity toxicity level between 2.5 and 5 mM. In hibiscus 'Mango Breeze', shoot mass was significantly increased at 2.5 and 5 mM, but was significantly decreased at 7.5 mM and above. Leaf chlorosis was significantly increased with a concentration of 5 mM and above, indicating that in hibiscus 'Mango Breeze' the alkalinity toxicity level is between 5 to 7.5 mM. In hibiscus 'Bimini Breeze', shoot mass was not significantly reduced, but leaf chlorosis exhibited a significant decrease at 7.5 mM. This indicates that in hibiscus 'Bimini Breeze' the alkalinity toxicity level is between 7.5 and 10 mM. Growing medium pH increased with increasing levels of Na bicarbonate. The species showed varying capacity for acidification of the growing medium. All species, except rose and vinca, neutralized the alkalinity effect of 2.5 mM, but none of the species neutralized the effect of 5 mM and higher Na bicarbonate.

Differing Vernalization Responses of *Laurentia axillaris* and *Veronica spicata* 'Red Fox': Evidence for Two Thermometers?

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Many herbaceous perennials require vernalization although effective temperatures (ET) and durations for specific species are largely unknown. To investigate vernalization of *Laurentia axillaris* (Lindl.) E. Wimm. and *Veronica spicata* L. 'Red Fox', vegetative plugs were stored at -2.5, 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, and 20.0 °C for 0 to 15 weeks (Laurentia) or 0 to 8 weeks (Veronica). Following storage, plugs were grown in a 20 °C glass greenhouse with a 16-h photoperiod. Laurentia plugs did not survive storage at -2.5 or 0 °C. Survival varied for plants stored at 2.5 °C, and some plants flowered. ET and the minimum duration for 100% flowering of Laurentia were: 5 weeks at 5 to 10 °C and 10 weeks at 12.5 °C. Time to first visible bud and node number below first visible bud decreased with increasing duration at ET. Veronica plugs survived storage at all temperatures. 100% flowering occurred when plants were vernalized at -2.5 and 0 °C for 4 or more weeks, at 2.5 and 5.0 °C for 6 or more weeks, and at 7.5 °C for 8 weeks. Incomplete vernalization (19 to 93%) occurred at temperatures of 2.5 °C for 4 weeks, 5 °C for 4 or 6 weeks, 7.5 °C for 6 weeks and at 10 °C for 6 or 8 weeks. Vernalization did not occur above 10 °C or following 2 weeks storage at any temperature. The percentage of reproductive lateral shoots increased while node number below the inflorescence remained constant or decreased with increasing storage at ET. The results indicate distinct vernalization optima for the two species; *Laurentia* 5 to 10 °C, and *Veronica* -2.5 to 0 °C. These differences provide evidence that separate "thermometers" may be involved in vernalization perception.

Taste Panel Perception of Sweetness as it Correlates to Refractometer Measurements and HPLC Analysis of Sugar ContentTeri Hale^{*1}, Richard Hassell², Tyron Phillips³¹Clemson Univ., Plant and Environmental Sciences, Charleston, SC 29414; ²Clemson Univ., Plant and Environmental Sciences, Charleston, SC 29414; ³Clemson Univ., Plant and Environmental Sciences, Charleston, SC 29414

Taste panel perception and preference of sweetness in three phenotypes (su, se and sh₂) of sweet corn harvested at three maturities (early, mature and late) were compared to refractometer measurements and HPLC analysis of fructose, sucrose, and glucose. Panelist rating of sweetness and acceptability significantly correlated with HPLC analysis. These correlations were found for sucrose and total sugars present (for sweetness, $r^2 = 0.70$ and 0.61 ; acceptability, $r^2 = 0.64$ and 0.55). Sucrose significantly correlated with the total sugars present ($r^2 = 0.95$). The panelists' perception of flavor also correlated significantly with the amount of sucrose present and total sugars ($r^2 = 0.66$ and 0.59 , respectively). Sucrose content was significantly different between se, sh₂ and su, with sh₂ having the highest level. Taste panels indicated this difference but showed not significant difference between se and sh₂ acceptability. Su was only acceptable to panelists at early maturity. °Brix did not reflect the taste panels scores and HPLC measurements positively. Soluble solids and taste panel scores were negatively correlated in both the panel's perception of sweetness and acceptability ($r^2 = -0.66$ and -0.66 , respectively) which indicates that as panel scores decreased °Brix increased. Comparison of soluble solids to HPLC analysis, indicate that °Brix was negatively correlated to sucrose and total sugar content, and that as soluble solids increased, the sucrose or total sugar concentration remained constant or decreased. Soluble solids measurements have been positively correlated with sucrose levels in other crops; but this was not the case with sweet corn.

CA Induced Internal Browning in 'Pink Lady' ApplesElena De Castro Hernandez^{*1}, Bill Biasi², Elisabeth Mitcham³¹Univ. California Davis, Pomology, Davis, CA 95616; ²Univ. California Davis, Pomology, Davis, CA 95616; ³Univ. California Davis, Pomology, Davis, CA 95616

The internal browning (IB) disorder of 'Pink Lady' apples is the manifestation of some undefined physiological conditions of the fruit at harvest, which predispose them to damage during CA storage. Internal browning problems generally occur intermittently and in unpredictable patterns. This type of disorder has the potential for widespread economic impacts. The optimum storage conditions and underlying physiological factors remain understood. In Fall 2002, 'Pink Lady' apples were harvested in Stockton, Calif., at two maturities, then placed into CA storage. After storage, the percentage of fruit with IB increased with greater CO₂ and with lower O₂ concentrations. The incidence of IB injury was greater in fruit from the second harvest, but there was not a great difference in incidence between 2 and 6 months of storage. In Fall 2003, 'Pink Lady' apples were harvested on the same orchard at three maturities and placed into CA storage. In all three experiments, fruit were stored in either air, 2% O₂ + 1% CO₂, or 2% O₂ + 3% CO₂ at 0.5 °C. In the first experiment, three harvest maturities were placed into storage immediately after harvest. For the second experiment, apples from harvest 2 were treated prior to fruit storage with 1ppm 1-MCP for 24 hours, 2200 ppm DPA, or were untreated. In the third experiment fruit from harvest 3 were placed into CA storage after 0, 2, or 4 weeks in air at 0.5 °C. No IB was observed for any of the three maturities after 0.5 and 1 month storage. After 2 months IB injury was present in 4.8% of the fruit stored in 1% CO₂ and 4.6% stored in 3% CO₂ from harvest one. A lower percentage of IB was observed in harvest two. Harvest three presented 0% and 2.6% of IB in 1% and 3%CO₂ respectively. The effect of 1-MCP,DPA and delayed CA on IB will be discussed.

Radio Frequency Heating of Persimmon and Guava Fruit as an Alternative Quarantine TreatmentMaria Monzon^{*1}, Bill Biasi², Shaojin Wang³, Juming Tang⁴, Guy Hallman⁵, Elisabeth Mitcham⁶¹Univ. of California, Davis, Pomology, Davis, CA 95616; ²Univ. of California, Davis, Pomology, Davis, CA 95616; ³Washington State Univ., Dept. of Biological Systems Engineering, Pullman, WA, 99164; ⁴Washington State Univ., Dept. of Biological Systems Engineering, Pullman, WA, 99164; ⁵USDA, USDA-ARS Crop Quality and Research Laboratory, Weslaco, TX 78596; ⁶Univ. of California, Davis, Pomology, Davis, CA 95616

The Mexican fruit fly infests many tropical and subtropical fruits, consequently fruits must be treated for quarantine security. Although chemical fumigations are the most common quarantine treatments, interest in using cold and heat treatments has increased due to concerns over environment and human health. Recently, shorter heat treatments such as those provided with radio frequency (RF) energy have been studied on walnuts and various fresh fruits as a possible quarantine treatment. Preliminary studies with a heating block system showed that reaching temperatures of 50 °C with a holding period of 2 min. or 48 °C for 6 minutes was required to achieve 100% insect mortality of 600 third instar Mexican fruit flies (the most heat resistant insect stage). Doubling the holding time required to achieve 100% insect mortality would likely be necessary to provide for Probit 9 security. Fresh fruits such as persimmons and guavas are commonly infested by the Mexican fruit fly. Persimmon and guava fruit were treated with RF energy to temperatures ranging from 48 to 52 °C at different holding periods. After treatments fruit were evaluated for external appearance, decay, soluble solids, titratable acidity, internal flesh quality, and ethylene production and respiration rate. Persimmon fruit tolerated the lower temperature, 48 °C for up to 18 min., but temperatures above 50 °C for more than 1 minute caused internal damage. Preliminary studies with guava indicate that fruit may tolerate 50 °C, but fruit quality after storage is still to be evaluated.

Effects of Cooking and Storage on Antioxidant Activity in Potato (*Solanum tuberosum* L.)Tyann Blessington^{*1}, Anna L. Hale², Douglas C. Scheuring³, J. Creighton Miller^{^1}, Jr.⁴¹Texas A&M Univ., Horticultural Sciences, College Station, TX 77843-2133; ²Texas A&M Univ., Horticultural Sciences, College Station, TX 77843-2133; ³Texas A&M Univ., Horticultural Sciences, College Station, TX 77843-2133; ⁴Texas A&M Univ., Horticultural Sciences, College Station, TX 77843-2133

We have demonstrated that potatoes contain significant levels of antioxidants important to human health; however, since potatoes are not consumed raw, it is important to determine the effects of cooking/processing on these levels. Therefore, the changes in phenolic and carotenoid content and total antioxidant activity in potatoes were investigated using combinations of storage and cooking methods. Fresh and stored tubers (110 days at 4 °C) of 17 potato cultivars, both raw and cooked (microwaved, boiled, baked, fried), were analyzed for antioxidant activity using the DPPH method. In addition, carotenoid levels were determined for each treatment based on the absorbance of the methanol extraction (oxygenated phenolics and carotenoids) at 445 nm and the hexane extraction (non-oxygenated carotenoids) at 450 nm. Total antioxidant activity as well as carotenoid levels were significantly affected by both genotype and cooking method. Across extraction methods, the microwave and fry cooking treatments were generally highest in antioxidant activity, while boiling was the lowest. Oxygenated carotenoids were significantly affected by storage, while the non-oxygenated carotenoids were unaffected.

Preserving Color in 'Michigan Purple' PotatoesElzette van Rooyen^{*1}, Randolph Beaudry²¹Michigan State Univ., Horticulture, East Lansing, MI 48824; ²Michigan State Univ., Horticulture, East Lansing, MI 48824

The objective of this study was to evaluate preharvest fertilizer application and postharvest storage temperature and duration as they affect the intensity and stability of color in red and purple potato cultivars during storage. 'Michigan Purple', 'Dakota Rose', and 'Chieftain' were stored

at 4 °C and hue angle (h°) was measured weekly. The initial 'Michigan Purple' h° of 1.1° changed to 23.2° after 18 weeks of storage (a shift in h° from 350° to 30° changes from purple to red) while the initial hue angle of 18.5° and 34.1° for red-skinned cultivars, 'Dakota Rose' and 'Chieftain', changed to 27.2° and 43.2°, respectively. Hence, the degree of color shift was greater in 'Michigan Purple' although all the cultivars in this experiment underwent significant color change during storage. Hue angle of 'Michigan Purple' tubers stored at 4°, 10°, and 20 °C for 8 weeks changed 19.4°, 12°, and 14.2° toward the redder h°, respectively. Thus, the color of 'Michigan Purple' tubers changed the least at 10°C. Hue angle of 'Michigan Purple' tubers fertilized with 180 lbs/acre slow-releasing nitrogen, 180 lbs/acre nitrogen, 270 lbs/acre nitrogen, and 2.5 lbs/acre poultry manure was measured after 5 weeks at 4 °C. Hue angles were 0.92°, 11.65°, 3.99°, and 1.34°, respectively. The hue of the first three treatments differed significantly from one another, but the hue of the potatoes treated with 180 lbs/acre slow-releasing nitrogen and 2.5 lbs/acre poultry manure did not differ. Preharvest factors like plant nutrition can influence tuber color in storage and 'Michigan Purple' tuber color is particularly sensitive to storage temperature.

Effects of Storage Methods on Ripening of *Uapaca kirkiana* Fruit¹

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Postharvest biology of *Uapaca kirkiana*, a native tree fruit to the miombo woodlands of some parts of Southern Africa, is little understood. Experiments have been carried out to determine the influence of pre-ripening storage treatments on subsequent fruit ripening characteristics. Mature but unripe fruit, collected from Dedza District in Malawi, were either held under ambient conditions, incubated in clay pots for 3 d or at 4 °C for 11 d. Fruit were removed from clay pots and cold storage, held under ambient conditions, and quality assessed daily. Color changed from green-yellow and/or brown-yellow in the unripe fruit to brown in ripe fruit. Low initial fruit compression was associated with hard and unripe fruit at harvest. Compared with both ambient and cold storage, incubating the fruits in clay pots resulted in advanced fruit softening as reflected by the high compression levels even on the day of removal from the clay pots. By day six after removal, compression had increased to a mean of 81 mm in the clay pot fruits while maximum levels were 56 and 38 mm for ambient and cold storage, respectively. Storing fruit at cold temperature delayed softening and deterioration compared with ambient and clay pot storage treatments. There was a general decrease in the total soluble solids content of the fruit during ripening, and was not influenced by the pre-ripening storage treatments. Decay increased during ripening for all the three treatments. Deterioration of the pulp in fruit, indicated by the development of a brown color and/or disintegration of the pulp, was observed with increasing time from removal. These results will be discussed in relation to the potential for improving storage of *U. kirkiana*.

Canopy Separation and Defoliation for Dry-on-the-vine (DOV) Raisins on Traditional Trellises

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Pruning efficiency, fruitfulness, and yield and quality of raisins of 'Thompson Seedless' (*Vitis vinifera* L.) grapevines subjected to several canopy separation and defoliation treatments for DOV raisin production were evaluated. Canopy separation treatments, tested in vineyards at Easton, and at the Kearney Agricultural Center (KAC), Parlier, Calif., were as follows; horizontal canopy separation with vine sections of fruiting or renewal zones (Peacock), horizontal canopy separation with vine sections of fruiting zones of one vine adjacent to renewal shoots of the next vine (wave), or non-separated (control). Defoliation treatments included burning or blowing leaves (Easton), application of concentrated solutions of calcium ammonium nitrate or Etherel to leaves (KAC),

or no defoliation (both vineyards). Canopy separation treatments did not affect berry size, soluble solids, or raisin yield. Vines subjected to Peacock training had more cluster layers than vines subjected to wave training, at Easton, and more cluster layers than vines subjected to control training at KAC. Canopy separation reduced harvest pruning time by 20% at Easton, but not at KAC. No treatments affected raisin moisture at Easton but, at KAC, raisins of vines trained in the Peacock style had 10% higher moisture contents at harvest than raisins of wave or control vines. Vines subjected to conventional training and leaf blowing had about 40% higher "B and better" raisin grades than vines with separated canopies that were not defoliated, and about 30% higher grades than vines with conventional training and leaf burning. However, raisins of vines subjected to blowing had about 60% more mold than raisins of non-defoliated vines. Defoliation treatments at KAC did not affect any variables measured.

Oral Session 28—Vegetable Breeding

Moderator: Rebeca Grube

July 19, 2004, 3:00–4:45 PM

San Antonio

Developing and Successfully Implementing a Strategy for Breeding Frost-hardy Carrots

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Freezing stress resistance is composed of several components namely tolerance, avoidance and acclimation ability. These three components of freezing stress are heritable traits. We have demonstrated that progress in the improvement of freezing stress resistance can be made by individually selecting for various components of this resistance and then recombining them to get the desired plan. Freeze-thaw injury in carrots is manifested as damage to the foliage, cracks on the roots (especially on the crown), and crown root rot. We found that foliage damage following freeze-thaw stress was related to the tolerance of the foliage to ice formation. The formation of cracks in the crown and root tissue was related to formation of ice itself. The carrot breeding lines we tested varied considerably for the crown position in relation to soil surface. The carrot crowns and roots below the soil surface will be better in avoiding ice in the tissue, thus avoiding cracks. The freeze-thaw injury observed on the foliage in the field was highly correlated to the freeze-thaw tolerance of leaf tissue (measured as ion leakage from the leaf tissue) determined by controlled freeze-thaw test in the laboratory. Based on this work we developed a breeding strategy to improve frost hardness in carrots by combining the characteristics that avoid ice in the crown and root tissues (e.g., crown position underground) with the characteristics that reduce foliage and root injury by ice (freezing tolerance of foliage). By using this strategy we were able to successfully obtain the desired plant. Two hardy carrot hybrids (Eskimo, Artico) were released by Vilmorin and their hardy characteristics have been confirmed under field conditions.

Toward Introgression of Ornamental *Cucurbita* Germplasm: Generation of *C. maxima* x *pepo* hybrids

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Cucurbita maxima and *C. pepo* are difficult to hybridize, and it was our objective to generate F₁ hybrids between ornamental cultivars of the two species. *C. maxima* 'Lakota' and *C. pepo* 'Jack O'Lantern'; and 'OZ'; were selected as parents. 'Lakota' (L) is an heirloom, hubbard-type cultivar producing pear-shaped, red-orange fruit with dark green mottling, 'Jack O'Lantern'; (J) is an open-pollinated Halloween-type pumpkin cultivar and 'OZ' is a Halloween-type hybrid. Sixteen plants of each cultivar were greenhouse-grown in a CRB design during

the period July–Sept. 2003. Interspecific crosses were made in both directions, with intraspecific crosses (J × O) and selfs (L) serving as controls. Fruits were harvested about 20 d after pollination. Embryos were excised under aseptic conditions and grown on either full strength Murashige and Skoog (MS) media with 6% sucrose (S6), full strength MS media with 6% maltose (M6), or half strength MS media with 3% sucrose (S3). Fruit set was generally greater in the intraspecific crosses (33%) and selfs (67%) than in the interspecific crosses (15 %), with the notable exception of the interspecific combination L × J (85% fruit set). Embryos of interspecific and control crosses were about 1.5mm and >1cm long, respectively. Hypocotyl and root growth 10 d after plating was better on S3 (3.2 and 1.7 cm) than on S6 (1.6 and 0.25 cm) or M6 (0.35 and 0 cm), and a greater number of functional hybrids were obtained from embryos grown on S3 (6 plants) than on S6 (2 plants) or M6 (2 plants). The interspecific plants were backcrossed to one of the parents and novel combinations of shape, color and variegation in hybrid fruit were observed.

Variance Component Analysis of Parthenocarpic Character in a Processing Cucumber (*Cucumis sativus* L.) population

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The incorporation of genes for parthenocarpy (production of fruit without fertilization) has potential for increasing yield in pickling cucumber (*Cucumis sativus* L.). The inheritance of parthenocarpy in cucumber is not well understood, and thus a genetic analysis was performed on F3 cross-progeny resulting from a mating between the processing cucumber inbred line 2A (P1, gynoeious, parthenocarpic, indeterminate, normal leaf) and Gy8 (P2, gynoeious, non-parthenocarpic, indeterminate, normal leaf). A variance component analysis was performed to fruit yield data collected at two locations (designated E-block and G-block) at Hancock, WI in 2000. The relative importance of additive genetic variance compared to dominance genetic variance changed across environments. The additive genetic variance was 0.5 and 4.3 times of dominance genetic variance in E-block and G-block, respectively. The estimated environmental variance accounted for ≈90% of the total phenotypic variance on an individual plant basis in both locations. Narrow-sense heritability estimated on an individual plant basis ranged from 0.04 (E-block) to 0.12 (G-block). Broad-sense heritability estimated on an individual plant basis ranged from 0.12 (E-block) to 0.15 (G-block). The minimum number of effective factors controlling parthenocarpy was estimated to range between 5 (G-block) to 13 (E-block). These results suggest that the response to direct selection of individual plants for improving parthenocarpy character will likely be slow and difficult. Experiment procedures that minimize the effect of environment on the expression of parthenocarpy will likely maximize the likelihood of gain from selection.

Relationship Between Plant Morphological Traits and Resistance to *Sclerotinia minor* in Lettuce

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A low to moderate incidence of lettuce drop caused by *Sclerotinia minor* is commonly observed in commercial lettuce fields of all types of lettuce (e.g. crisphead, romaine, leaf, butter) and although partial resistance has been reported, no sources of immunity have been described. We sought to determine whether there was variability between different types of lettuce and among cultivars within types. Replicated experiments were conducted in an infested field using established inoculation procedures. Significant variation in susceptibility to *S. minor* was detected among cultivars within as well as between major lettuce types. Correlations between lettuce drop susceptibility and plant canopy size, seedling vigor, and additional morphological traits were determined. Variability between different field experiments was also evaluated for several traits and a subset of cultivars. Our results suggest that cultivated germplasm

may provide genes that are as useful or more useful than those found in genotypes with more primitive growth habits in developing cultivars with tolerance to lettuce drop.

Introgression of Big Vein Tolerance from *Lactuca virosa* L. into Cultivated Lettuce (*Lactuca sativa* L.)

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Big vein (BV) disease of lettuce is caused by soil borne fungal vectored viruses, and reduces marketability through head deformation. Tolerant cultivars reduce BV frequency, but no resistant cultivars exist. *L. virosa* L. is highly resistance. The objectives were to 1) determine if *L. virosa* P.I.s exhibit variation for resistance, and 2) determine if resistance is transferable to lettuce. Seedlings were inoculated with root macerate of BV infected plants, transplanted to BV infested soil, and greenhouse grown for 3 months. Twelve plants in each of 1,2, or 3 reps of Great Lakes 65 (GL65-susceptible), Pavane (Pav-tolerant), *L. virosa* (11 accessions), and BC₁F₂ through F₅ families of lettuce cultivars × *L. virosa* accession IVT280 were tested. The percentage of BV afflicted plants was recorded. In hybrid families, BV free plants from tolerant families were selected and advanced. No BV was found in *L. virosa*. Variation for tolerance was observed in BC₁F₂ and F₃ families; 33% had greater tolerance than Pav (17% afflicted). Additional tests identified 11 BC₁F₃ families (14%) with greater tolerance than Pav (42% afflicted). Subsequent BC₁F₄ and F₅ generations however, were more susceptible than Pav. *Lactuca virosa* is highly resistant, but resistance did not transfer to hybrid progeny. Variation for tolerance was observed in BC₁F₂ and F₃ families, but later generations were susceptible. Interactions or linkage of genes for developmental processes and BV resistance may hinder introgression. Introgression will continue using congruity backcrossing and a greater diversity of *L. virosa*.

Changes of Endogenous Hormones and Polyamines in Cytoplasmic Male Sterile Non-heading Chinese Cabbage During Anther Development

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It studies the changes of endogenous hormones and polyamines in cytoplasmic male sterile non-heading Chinese cabbage (*Brassica campestris* L. ssp. *chinensis* Makino var. *communis* Tsen et Lee). Results showed that the microspore was prone to being sterile when there were lack of IAA, GA and polyamines, especially Put and abundant with ZRs and ABA in the anther. The imbalance of IAA/ZRs also easily caused the anther sterile.

Research and Development on Genetic Resources in Non-heading Chinese Cabbage

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It reviewed the research and development on genetic resources in non-heading Chinese cabbage (*Brassica campestris* L. ssp. *chinensis* Makino var. *communis* Tsen et Lee) achieved during the past 50 years. Researches were carried out on the methodology and classification of horticultural crops, investigation and collection of the genetic resources and development of new cultivars. Further studies were conducted on the morphological and biological characteristics, identification and analysis of disease resistance and genetic model of main economic characteristics. On these bases, 13 new cultivars were selected and spread to 800,000 hm².

Greenhouse and Nursery Media Analysis Proficiency TestingSteven E. Newman^{*1}, Robert O. Miller²¹Colorado State Univ., Horticulture and Landscape Architecture, Fort Collins, CO, 80523-1173; ²Colorado State Univ., Soil and Crop Sciences, Fort Collins, CO, 80523

Greenhouse and nursery managers rely on testing laboratories with the expectations of accuracy and consistency. The Greenhouse and Nursery Media Analysis Proficiency (GNMAP) Testing program was initiated to provide laboratories servicing greenhouses and nurseries with inter-laboratory quality control. The GNMAP program operational guidelines are based on those outlined under ISO 9000, ISO/IEC Guide 43 and Draft ISO/IEC Guide 24, which describe the requirements for proficiency testing. Nine laboratories enrolled in the program in 2003 and submitted results for root zone media and fertilizer solutions. Data analysis provided the minimum, maximum and median values; median absolute deviation (MAD); overall reproducibility (Rd); individual reported lab values; repeatability (Rp) of lab value (CV for the individual lab); and mean lab value reported. The Rd was calculated from the median of all lab Rp values and is a measure of intra-lab variance. A measure of inter-lab variance was determined by calculating the relative median deviations (RMD = MAD/Median × 100). For one of the media distributed, results for the saturated media extract included median pH values from 4.3 to 6.9 with MAD values averaging 0.1 across the three samples. The electrical conductivity (EC) median values ranged from 0.36 to 4.57 dS/m with RMD averaging 31% of the median. The main variability between laboratories for the majority of the macro cations was closely aligned with measured EC. Cations (K, Ca and Mg) concentrations ranged from 17 to 502 mg/L with Ca typically in the greatest concentration. Cation inter-lab precision, based on the RMD ranged from 9-32% across the three substrate samples. The greatest RMD was 31.8% for Ca and 9.2% for K. The Rd values for the cations averaged 5%.

Eradication of Common Liverwort from a Soilless Growing MediumRobert H. Stamps^{*1}, Annette L. Chandler²¹Univ. of Florida, IFAS, MREC, Environmental Hort. Dept., Apopka, FL 32703-8504;²Univ. of Florida, IFAS, MREC, Environmental Hort. Dept.

Common liverwort (*Marchantia polymorpha* L.) is an increasingly troublesome weed in containerized plant production. Postemergence applications were made to try to eradicate established stands of liverwort. Treatments consisted of sprays of quinclamine at 1× and 2× rates and oxadiazon at the highest label rate, broadcast applications of sodium carbonate peroxyhydrate at 1× and 3× rates and four granular herbicides (flumioxazin, oxadiazon, oxyfluorfen + pendimethalin, and prodiamine) applied at label rates. The granular herbicides were applied both alone and with the sodium carbonate peroxyhydrate treatments. Herbicides were applied to common liverwort growing on an 80% aged pine bark: 20% *Sphagnum* peat-based soilless growing medium contained in 10-cm diameter plastic pots located in a double-poly covered greenhouse. At 2 weeks after treatment (WAT), control was best (93% to 100%) for both quinclamine and the 3× peroxyhydrate treatments, intermediate (68% to 83%) for the 1× peroxyhydrate treatments, and not significant for any of the preemergence herbicides used alone. At 4 WAT, slight regrowth was evident in plots in which the treatments had an initial effect and the 1× peroxyhydrate + flumioxazin was as effective as the 3× peroxyhydrate and the 2× quinclamine treatments. At 6 WAT, control was excellent in the 3× peroxyhydrate and 1× peroxyhydrate + flumioxazin treatments. Control was less, but still evident, in the quinclamine and other 1× peroxyhydrate treated plots. While none of the treatments had completely eradicated common liverwort in all replications at 10 WAT, control was still excellent to good in many of the peroxyhydrate + preemergence herbicide-treated plots.

Seasonal Flowering of *Heliconia xraulianiana*Richard A. Criley^{*1}¹Univ. of Hawaii, Tropical Plant & Soil Sciences, Honolulu, HI 96822

As part of a research study on growth and flower production of 20 commercial heliconia cultivars, plants were established at the Waimanalo Research Farm (Oahu) of the Univ. of Hawaii in July 1999. This report focuses on *Heliconia xraulianiana*. Five plants in 7.6 L pots were planted at spacings of 2.5 M in row, with between row spacings of 3 M. Beginning a month later, newly emerged shoots were tagged every four weeks. At flowering, the shoots were harvested and leaf counts made. The information derived from the data include time frame from shoot emergence to flower, rate of shoot production, percentage of shoots from each tag date that flowered and the periodicity of flowering in a two year period. The range of times from shoot emergence to harvest was 208 to 450 days. In the first 12 months following planting, the average cumulative new shoot production since planting was 77 shoots per plant, while more than 58 inflorescences per plant were produced from the tagged stems for a 75% productivity rating. *H. Xraulianiana* evidenced periodic flowering behavior, with peak flowering in the April to June period, that suggested it is a short-day plant for flower initiation.

Temperature Effects on Flower Induction of Two *Phalaenopsis* Orchid HybridsMatthew G. Blanchard^{*1}, Erik Runkle²¹Michigan State Univ., Horticulture, East Lansing, MI 48824; ²Michigan State Univ., Horticulture, East Lansing, MI 48824

The commercial production of potted flowering orchids has increased tremendously in the past decade, and is now the second most valuable potted flowering crop in the United States. *Phalaenopsis* spp. comprise a large percentage (75% to 85%) of the potted orchid sales in the U.S. due to their long flower life and ease of scheduling to meet specific market dates. Constant air temperatures above ~26 °C inhibit flowering of most *Phalaenopsis* hybrids, and a 25/20 °C day/night temperature regimen is used commercially to induce flowering. However, the relative promotion of flowering by constant versus fluctuating day/night cool temperatures (<25 °C) has not been well described. *Phalaenopsis* Miva Smartissimo × Canbera '450' and Brother Goldsmith '720' were grown at constant temperatures of 14, 17, 20, 23, 26, and 29 °C, and day/night temperatures of 20/14, 23/17, 26/14, 26/20, 29/23, and 29/17 °C. Plants were grown in glass greenhouses with a constant photoperiod of 12 h, and shading was provided so that the maximum instantaneous irradiance was ≤150 μmol·m⁻²·s⁻¹. After 6 weeks at the various temperature setpoints, ≥80% of plants of both cultivars had VI when grown at a constant 17, 20, or 23 °C, and at the 23/17 °C day/night regimen. None of the plants were reproductive within 6 weeks when grown at a constant 26 or 29 °C, or at the 26/14, 26/20, 29/17, or 29/23 °C day/night temperature setpoints. Therefore, temperature during the day and night both influence flowering of these two *Phalaenopsis* orchid hybrids.

Cold and Hot Rhizome Storage Affects Growth and Flowering of Ornamental GingersMaria P. Paz^{*1}, Jeff S. Kuehny², Richard Criley³¹Univ. of Florida, Dept. of Environmental Horticulture, Gainesville, FL 32611-0670;²Louisiana State Univ., Dept. of Horticulture, Baton Rouge, LA 70803; ³Univ. of Hawaii at Manoa, Dept. of Tropical Plants and Soil Sciences, Honolulu, HI 96822

Ornamental gingers are popular cut flowers and have been promoted as a promising potted flower crop because of unique foliage, long-lasting colorful bracts, and few pest problems. Rhizomes are the primary means of propagation in late spring followed by shoot growth and flowering, and plants enter dormancy under short days in the fall. Termination of dormancy is important for greenhouse forcing and extending the growing season. Dormancy of storage organs can be terminated prematurely by temperature. Rhizomes of three ginger species (*Curcuma alismatifolia* Gagnep., *C. cordata* L., and *Glozza winittii* C.H. Wright) were stored for 0, 1, or 2 weeks at 10 or 15 °C

followed by 0,1, or 2 weeks at 25, 30, or 35 °C to determine the effect on growth and flowering. Upon completion of treatment application, rhizomes were planted in a peat moss : bark : perlite mix and placed in a greenhouse with 25 °C day/21 °C night temperatures with 40% shade. Rhizome cold storage in combination with hot storage affected growth and development of ornamental ginger. Days to emergence (DTE) and days to flower (DTF) for *Globba* were hastened when rhizomes were stored for 3 weeks at 15 °C followed by 3 weeks at 30 °C. For *C. alismatifolia*, DTE and DTF were hastened when rhizomes were stored for 3 weeks at 10 °C followed by 3 weeks at 30 °C. For *C. cordata*, DTE and DTF were hastened with rhizome storage of 2 weeks at 10 °C followed by 3 weeks at 35 °C.

Effect of Far-red Light on Inhibiting Anthocyanin Formation in the Leaves of *Hanabusaya asiatica*

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Hanabusaya asiatica has beautiful flowers as ornamental pot plant. It's a famous Korean endemic perennial plant in Korea. Recently many research items has been studying for developing cultivation technology of *H. asiatica* as a new commercial pot plant. Many endemic plants have much problems associated with maintaining quality for commercial plant. In *H. asiatica*, as a result of accumulation of anthocyanin in the leaves at reproductive stage, the leaf veins turn to brownish black and whole leaves become to necrosis and dry after all. This study was carried out to find out the suitable method for preventing the accumulation of anthocyanin in leaves by light quality. *H. asiatica* was treated three light quality, blue, far-red + blue, far-red and control on the middle stage of vegetative growth. Light quality sources were made by diodes. Light quality treatments were done in growth chamber. The photoperiod was 16 hours. Light quality treatments were done for 4 hours as daylight extension after 12 hours lighting by fluorescent lamps. Far-red lighting treatment was very effective to prohibit the formation of anthocyanin in the leaves. Blue lighting treatment was increased the anthocyanin accumulation but blue lighting treatment with far-red showed preventing the formation of anthocyanin. In these results, far-red lighting was very effective for preventing the action of cryptochrome by blue lighting on the anthocyanin formation in the leaves of *Hanabusaya asiatica*.

Oral Session 30—Ornamentals/Landscape and Turf/

Nursery Crops

Moderator: Albert Sutherland

July 20, 2004, 8:00–10:00 AM

San Marcos

Photosynthesis, Growth, and Water-use Efficiency of Carolina Buckthorn: Comparisons to the Invasive Common Buckthorn

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Some buckthorn species from other continents have proven invasive in North American landscapes. Carolina buckthorn (*Rhamnus caroliniana* Walt.) is an attractive, native species that would merit increased use in horticultural landscapes if concerns about its potential invasiveness are allayed. Invasiveness often is associated with efficient use of water and other resources. We tested for differences between Carolina buckthorn and common buckthorn (*Rhamnus cathartica* L.) in photosynthesis, aboveground dry matter accumulation, and water-use efficiency. Seedlings were grown in columns of field soil within insulated pots

outdoors for 98 days. Net photosynthesis of Carolina buckthorn was 17% to 39% greater than that of common buckthorn through day 22. This difference between species was reversed through the end of the treatment period with a concomitant increase in leaf temperature of Carolina buckthorn. Final dry weight of aboveground tissues was similar for the two species, but a greater proportion of dry matter was partitioned to stems for common buckthorn compared to Carolina buckthorn. Although common buckthorn initially had higher water-use efficiency (110 mg·g⁻¹ per day) than did Carolina buckthorn (60 mg·g⁻¹ per day), the water-use efficiency of both species decreased to similar values for the remainder of the treatment period. We conclude that young plants of common buckthorn do not use water more efficiently than do young Carolina buckthorn under field conditions in central Iowa. Considering the possible species differences in the relationship between temperature and photosynthesis, comparative water-use efficiency should be tested further in other environments where Carolina buckthorn might be used for landscaping.

Soil Water in Amended Landscape Soils

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This study determined the effect of soil amendments on plant available water (PAW) and readily available water (RAW). Intact soil cores were collected from a Cecil sandy clay loam soil landscape planting beds that had been amended annually for 5 years with 5 cm (25% by volume) of pine bark and broiler litter. Soil cores were also collected from a landscape bed that had been amended once in April 2000 with 5 cm (25% by volume) of Permatill (expanded slate). The results of this study indicated that amending soil with pine bark or broiler litter compost increased soil porosity, drainage, aeration and PAW. The volumetric RAW (cm³·cm⁻³) did not differ among treatments, but amending the soil with pine bark or broiler litter did increase the gravimetric RAW (g·g⁻¹). Permatill increased drainage and aeration, but did not increase available water to plants.

Improving Species and Cultivar Specific Estimates of Transpiration by Using Physiologically Based Approaches

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A process-based whole-tree simulation model was used to simulate crown transpiration in several species and cultivars of nursery crops. To validate estimates, we measured transpiration in cultivars of red maple (*Acer rubrum* L.) to determine if there were differences in intraspecific variation that could affect estimates of whole tree water use. We used a combination of field and published data to parameterize additional species and cultivar differences in response to environment and/or management. The different water use estimates of the species and cultivars were related to their genetic variability in leaf biochemical limitations, where the relationship between stomatal conductance and photosynthetic rate may be so closely matched that stomatal conductance appears to adjust itself to the photosynthetic capacity of the species or cultivar. Model predictions indicated that species and cultivars that had higher biochemical limitation regulated transpiration by down regulation of the rate of carboxylation (V_{cmax}) and coupled photosynthetic electron transport (J_{max}), whereas the reverse occurred as V_{cmax} and J_{max} increased. Our model simulations show significant variation in transpiration due to both inter and intraspecific variation in biochemical limitations. These results suggest that models that do not account for inter and intraspecific variation, to reflect genetic variation in physiology, may over or under estimate transpiration. Therefore, physiology-based species and cultivar variation should be part of process-based simulations that assess nursery water use. Results also suggest that effects of leaf dark respiration adaptation interactions can concurrently reduce variation in water use estimates.

Refining Ornamental Heat Zone Categories with Evapotranspiration

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The American Horticulture Society (AHS) Heat Zone categories have been developed to categorize ornamental plant adaptability to different air temperature climates. These zones, like the Plant Hardiness map showing plant cold hardiness zones within the United States, are primarily north to south zones. Within the Great Plains region of the United States, the AHS Heat Zone categories provide a basic level of plant adaptability to air temperature, but do not account for plant reaction to variations in wind, relative humidity or sunlight. Daily reference evapotranspiration provides a single number that responds to variations in air temperature, wind, relative humidity and sunlight. In Oklahoma, the Oklahoma Mesonet provides a uniform statewide network of weather monitor towers that can be used to accurately calculate both short and tall American Society of Civil Engineers (ASCE) reference evapotranspiration (ref ET) across the entire state. Accumulated daily ref ET values can be used to provide further refinement in categorizing ornamental plant adaptability.

Effects of Transplant Season and Container Size on Landscape Establishment of *Kalmia latifolia* L.

Anne-Marie Hanson¹, J. Roger Harris*², Robert Wright³

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Mountain laurel (*Kalmia latifolia* L.) is a common native shrub in the Eastern United States; however, this species can be difficult to establish in landscapes. Two experiments were conducted to test the effects of transplant season and container size on landscape establishment of *Kalmia latifolia* L. 'Olympic Wedding'. In experiment one, 7.6-L (2-gal.) and 19-L (5-gal.) container-grown plants were planted into a simulated landscape (Blacksburg, Va., USDA plant hardiness zone 6A) in early Fall 2000 and in late Spring 2001. 19-L (5-gal.) plants had the lowest leaf xylem potential (more stressed) near the end of the first post-transplant growing season, and leaf dry weight and area were higher for spring transplants than for fall transplants. For spring transplants, 7.6-L (2-gal.) plants had the highest visual ratings, but 19-L (5-gal.) plants had the highest visual ratings for fall transplants three growing seasons after transplanting. 7.6-L (2-gal.) plants had the highest % canopy volume increase after three post-transplant growing seasons. In experiment two, 19-L (5-gal.) plants were transplanted into above-ground root observation chambers (rhizotrons) in early Fall 2000 and late Spring 2001. Roots of fall transplants grew further into the backfill than spring transplants at the end of one post-transplant growing season. Overall, our data suggest that smaller plants will be less stressed the first season after transplanting and will likely stand a better chance for successful establishment in a hot and dry environment. Fall is the preferred time to transplant since capacity for maximum root extension into the backfill will be greater than for spring transplants.

Seasonal Effects of Transplanting on Growth and Pre-bud Break Root System Regeneration of Northern Red Oak and Willow Oak

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Seasonal effects on transplant establishment of balled-and-burlapped (B&B) shade trees are not well documented. Early post-transplant root growth and above-ground growth over 3 years were therefore documented for November- and March-transplanted northern red oak (*Quercus rubra* L.) and willow oak (*Q. phellos* L.). Survival of red oak was 100% for both treatments. Survival of November- and March-transplanted willow oak was 67% and 83%, respectively. No new root growth was observed outside or within the root balls of either species upon excavation in January. However, new root growth was evident

when subsamples were excavated the following April for November-transplanted trees of both species, indicating that root system regeneration of November-transplanted trees occurs in late winter and/or early spring, not late fall and/or early winter. November-transplanted red oak, but not willow oak, had grown more roots by spring bud break than March-transplanted trees. While height growth of willow oak was nearly identical between treatments after 3 years, November-transplants exhibited greater trunk diameter increase for all 3 years. Overall, season of transplant had little effect on height and trunk diameter increase of red oak, even though November-transplanted trees grew more roots prior to the first bud break following transplant. Among the willow oaks that survived, season of transplanting had little effect on height growth, but November transplanting resulted in greater trunk diameter increase. However, considering the mortality rate of November-transplanted willow oak, March may be a better time to transplant willow oak in climates similar to southwest Virginia.

Mulch Thickness and Planting Depths Can Interact to Reduce Growth and Survival of Green Ash and Goldenrain Tree

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Most available information on the effects of planting depths for trees need not and/or testing of interactions with other important cultural practices implemented during landscape establishment is lacking. Green ash (*Fraxinus pensylvanica* H. Marshall, hypoxia tolerant species) and bougainvillea goldenrain tree (*Koeleruteria bipinnata* Franchet, hypoxia intolerant species) were grown from seed in 2.3-L containers which were transplanted to 9.3-L black plastic and grown to a marketable size. Root-collars of the plants were maintained level with the surface of the substrate. Green ash (1 May 2001) and bougainvillea goldenrain tree (27 Apr. 2001) were transplanted to clay soil field plots with the root-collars at a 7.6 cm above soil grade, at grade, or 7.6 cm below grade. Planting depths for each species were in factorial combinations with 0, 8, 15, or 23 cm of pine bark mulch covering 2.4 m² of soil beneath each tree. After 2 years, survival of bougainvillea goldenrain trees planted below grade was one third that of those planted at or above grade. Planting below grade reduced survival of green ash by 25% after 3 years. Even the thinnest layer of mulch reduced bougainvillea goldenrain tree height and trunk diameters. Height and trunk diameter responses interacted with planting depth for green ash. Mean soil moisture levels were slightly less negative with 8 cm of mulch (-5.8 kPa) compared to bare soil (-9.1 kPa), but increasing mulch thickness to 23 cm (-16.2 kPa) inhibited penetration of irrigation water/rainfall. This data suggests that planting with the root-collar at or above grade greatly enhances survival and growth potential of green ash and bougainvillea goldenrain tree and that mulch application should be only at thin layers to inhibit weeds.

Effects of Paclobutrazol on Production and Landscape Performance of Texas Maroon Bluebonnet

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Texas maroon bluebonnets (*Lupinus texensis* Hook. 'Texas Maroon') grown for fall planting may be germinated as early as September. Plant growth regulators are commonly applied to control excessive stem elongation during production, but may potentially result in adverse responses in the landscape due to residual effects. In October 2003, an experiment was initiated to observe potential landscape residual effects of paclobutrazol (formulated as Bonzi) applied during the production phase to retard internode elongation. Seedlings were received in six-pack cell units. On 30 Oct. 2003, while still in six-packs, bluebon-

nets were sprayed with paclobutrazol. Paclobutrazol was applied at concentrations of 0, 5, 10, and 15 mg·L⁻¹ a.i. at a coverage rate of 10 mL per 0.93 m². After treatment, half of the plants were transplanted from six-packs to 0.73 L pots and the other half remained in six-packs. Plants were grown in a nursery until they reached a marketable stage (13 Nov. 2003 for six-packs, 20 Nov. 2003 for 0.73-L pots). At the end of nursery production, one half of the plants (both container sizes) were then planted to landscape plots (0.3 m centers) at either College Station, Texas or Dallas, Texas. During the production phase, bluebonnets grown in 0.73-L pots had slightly larger growth indices than those produced in six-packs. As application rates of paclobutrazol increased, growth indices decreased. Possible residual effects on growth and flowering will also be discussed.

Oral Session 31—Citrus Crops

Moderator: TBA

July 20, 2004, 8:00–10:00 AM

Wedgewood

Optimizing Continuous Canopy Shakers for Late Season 'Valencia' Harvest

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Continuous canopy shakers (CCS) were developed in the late 90's and have been used to commercially harvest citrus in Florida. A viable mechanical harvester in Florida must be able to selectively remove mature 'Valencia' fruit. A study was conducted to evaluate the effect of operating conditions on mature and immature fruit removal during the 2003 harvest season. The study was conducted in the southern flat woods and northern ridge areas. The study treatments were completely random and replicated four times. The CCS treatments were 145, 215, 230, and 245 cycles per minute (cpm) and a hand picked control. The harvest occurred on 17 and 19 June at the southern and northern sites, respectively. Mature fruit removal linearly increased from 95.7% to 97.9% between 145 and 245 cpm, respectively. Varying the operating ranges significantly influenced mature fruit removal in the southern flat woods site. The trees at the southern site were taller (>4m), and had a larger crop load. At the northern ridge site where trees were smaller, varying the CCS operating ranges did not significantly influence mature fruit removal. Immature fruit removal was influenced by the operating ranges. Immature fruit removal was increased at least 22% over hand picked controls. The results were interpreted to indicate the frequency of CCS is dependent on tree size. The initial selectivity of the CCS was not equal to hand picking.

Fruit Removal and Recovery during Citrus Harvesting are Improved when Abscission Agent Applications are Used with Mechanical Harvesters

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A study was initiated in 'Hamlin' orange to determine if a selective citrus abscission material, 5-chloro-3-methyl-4-nitro-1H-pyrazole (CMNP), could improve mature fruit removal and recovery when used with mechanical harvesters. A trunk shaker and continuous-moving canopy shaker equipped with catch-frames were used at the flatwoods and ridge growing regions in Florida. Both trials were conducted during the first 2 weeks of Dec. 2003. Plots were constructed as randomized complete blocks containing four replicates for each treatment. Each replicate contained five trees at the ridge site or four trees at the flatwoods site. CMNP was applied using a commercial airblast sprayer at 0, 125, 250 and 500 mg·L⁻¹ at a rate of 2,800 L·ha⁻¹ 4 days before scheduled harvest. The trunk shaker was operated for either 7

seconds or 2 seconds/tree, whereas the canopy shaker was operated at either 260 cpm or 140 cpm/tree. The data show that the correct time was selected for harvest. Over a 50% reduction in FDF was achieved with the 250 and 500 mg·L⁻¹ treatments, while post-application fruit drop was less than 1.5%. The greatest benefit of abscission agent use was seen when the mechanical harvesters were operated at the least aggressive setting (2 seconds or 140 cpm), where increases in % fruit removal and recovery were over 20% higher than the controls. At the most aggressive settings, numeric increases in % fruit removal and recoveries were measured, but these changes were not statistically significant. The results demonstrated that statistically similar % fruit removal and recoveries could be achieved using less aggressive harvester settings with abscission agent use when compared with most aggressive settings using no abscission agent.

Physiological Effects of Mechanical Harvesting in Citrus Trees

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Mechanical harvesting of citrus trees by trunk or canopy shakers can cause leaf and twig removal, bark injury and root exposure. Such problems have restricted the adoption of mechanical harvesting in Florida citrus. We assessed physiological responses of citrus trees that were mechanically harvested with a linear-type trunk shaker, operating at 4 Hz, 70.8 kg mass weight, and 6.5 cm displacement, for 10 or 20 seconds. We measured fruit recovery efficiency, leaf and shoot removal, mid-day stem water potential, leaf gas exchange, and leaf fluorescence emission of mature 'Hamlin' and 'Valencia' orange trees under restricted or normal irrigation. Shaking treatments effectively removed 90% to 94% of fruit without bark damage. Compared to harvesting by hand, trunk shaking removed 10% more leaf area and twigs, and caused some visible exposure of fibrous roots at the soil surface. There were no significant treatment differences on mid-day stem water potential, leaf gas exchange, and leaf photosystem efficiency. Excessively shaken trees for 20-30 seconds can temporary induce stress symptoms resembling that in trees without irrigation. Trees may have benefited from the low levels of leaf and twig loss after trunk shaking that compensated for any root loss. Long-term effects of trunk shaking will be assessed by tree growth, return bloom, subsequent yield, and carbohydrate reserves.

Topping and Pruning Effects on Yield and Fruit Size of Navel Orange

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Yield, fruit quality parameters and pruning costs were compared among differentially-pruned, mature navel orange trees planted at a density of 222 trees per hectare (90 trees per acre) in 2000, 2001 and 2002. The experiment was designed as a replicated, split block with topping height as the main plot split by three levels of interior pruning as subplots. A tree was reduced in height by mechanical topping to 4.3 m, 4.9 m or left untopped and hand pruned according to one of the three following options: 1. scaffold removal in March of 2000 followed by dead-brushing in 2001, and 2002; 2. dead-brushing only in 2000, 2001, and 2002; or 3. no topping or dead-brushing. Scaffold removal resulted in removal of approximately 50% of the tree canopy. Data were collected from experimental trees surrounded by similarly topped and interiorly pruned border trees. A highly significant positive-linear correlation ($r^2 = 0.95$) was found between the total numbers of fruit produced annually per hectare versus the total number of fruit sized 72 to 88 mm in diameter (i.e. fruit sized such that 88 to 48 may be packed in a standard 17-kg packing carton). This functional relationship existed whether reductions in fruit numbers were the result of severe pruning in March or from, apparently, weather-related year to year variability in fruit set. These results suggest that anything in this orchard that reduces fruit numbers below approximately 250,000 fruit per hectare at harvest (100,000 per acre) will result in a mathematically predictable decrease in the total number of harvested fruit sized 72

to 88 mm in diameter. Trees that were not topped and which had no interior pruning produced the largest number of valuable fruit without additional pruning costs.

Copper Fungicide Spray Timings for Melanose Control in Grapefruit: Comparison of Computer Modelling of Copper Residues vs. Calendar Sprays

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Grapefruit are susceptible to melanose from initial set until fruit diam. is 6–7 cm, which can span 3 months. Common Indian River melanose-control practice has been application of Cu fungicides at petal fall, with reapplication every three wks. through the infection period. Research data were previously used to develop a computer model to estimate Cu levels on fruit and indicate when reapplication is needed to prevent potential infection. The purpose of this study was to compare melanose control using spray timings suggested by the computer model vs. standard 3 week intervals vs. non-sprayed checks and was conducted over 3 years in mature grapefruit groves near Ft. Pierce, Fla. All applications were made using airblast at 1180 L/ha⁻¹. Melanose and melanose-like Cu injury could not be distinguished and were combined in a melanose/Cu marking (MCM) score for each fruit. Separate fruit samples from the interior and exterior of tree canopies were randomly selected from each tree. In no year was there a significant difference in interior fruit MCM from computer model vs. calendar spray timings when treated with standard rates of Cu fungicide. However, rainfall never occurred when calendar-sprayed fruit were projected to be at low Cu levels. In 2 of 3 yrs. exterior fruit in the non-sprayed checks had less MCM than those from trees treated with Cu, indicating that Cu injury predominated over melanose on exterior fruit. In these fruit, MCM increased linearly with maximum fruit Cu concentration, which was lower on trees managed using the computer model. The computer model appears to be a sound approach to managing melanose, but economic benefit over calendar-based spray timing may only become apparent when practiced over numerous groves and seasons.

Current Status of Citrus Gummosis in Kenya

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Citrus is one of the most important fruits in Kenya because of its nutritional value. It is ranked as the highest source of income from tree crops in Kwale district of the coastal region. The average farmer has 0.25 to 4 acres of citrus and earns between 1 to 2 U.S. cents per fruit based on quality. Citrus gummosis (*P. citrophthora* and *P. nicotianae*) is of economic importance on citrus in Kenya. *P. citrophthora* prefers cooler conditions in the highlands and *P. nicotianae* favours the warm conditions of coastal areas. Several IPM options are being used to control this disease in Kenya. Research to select suitable rootstocks, determine the period when disease development is greatest and the distribution of infected trees in Kwale districts is currently being conducted. Gummosis has also been reported to occur in farmers fields around Marigat (Perkerra) and surrounding areas however the data is scanty and a detailed survey is underway. Gummosis disease incidence in Marigat was first reported in 1989/1990. Since then symptomatic trees have been treated with fungicides e.g. Ridomil. A citrus mother block consisting of 241 trees, established at Perkerra in 1984 now only supports 112 trees or 47% of the original trees. From the 112 trees, only 21 trees are classified as healthy trees. More extensive research needs to be conducted to show the impact of this disease on the small scale farmer and develop better methods of control.

Effects of Reduced Fall and Winter Irrigation on Citrus Fruit Quality

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Earlier work has shown that moderate water deficits imposed on citrus trees can increase fruit Brix without adversely affecting yield. Increased water restrictions have been imposed on citrus growers as Florida's population continues to increase. The objectives of this study were to determine: 1) the effects of no irrigation in the fall and winter on orange fruit quality parameters in Florida; and 2) amount of potential irrigation water savings. Trees were irrigated identically in the spring and summer. A non-irrigation treatment was started on Hamlin and Valencia oranges in September and October, respectively, while controls continued to be irrigated following established irrigation practices. An additional non-irrigated treatment was started at the same time on the Valencias that consisted of a soil covering with a water barrier (Tyvek) to exclude rainfall. Stem water potential was monitored during the fall and winter to estimate differences in water stress among the treatments. Brix and organic acids increased in fruit from non-irrigated treatments when compared to fruit from irrigated trees. Results also demonstrate that reduced irrigation did not affect yield greatly. Amount of irrigation savings was determined for both cultivars that differ in maturity dates.

Oral Session 32—Crop Physiology

Moderator: Douglas Archbold

July 20, 2004, 10:15 AM–12:00 PM

Wedgewood

Crop Load and Canopy Temperature Affect Leaf Characteristics and Net Gas Exchange of 'Spring' Navel Orange Trees

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Six-year-old 'Spring' navel [*Citrus sinensis* (L.) Osb.] orange trees were either totally defruited, 50% defruited or left fully cropped to study effects of fruit load on growth net gas exchange characteristics of mature leaves on seven selected clear days from Nov. 2001 through July 2002. Near harvest time, defruited trees had more shoot flushes, greater leaf dry wt per area (LDW/A) but lower net assimilation of CO₂ (Ac) and stomatal conductance (gs) at midday than leaves on trees with fruit. Defruited trees had a higher ratio of internal to ambient CO₂ (Ci/Ca) concentration in leaves implying internal limitations were dominant over stomatal limitation on Ac. Removal of half the crop increased individual fruit mass but reduced fruit color development. Half the trees were also shaded for four months prior to harvest with reflective 50% shade cloth to determine effects of lower leaf temperature (Tl) and leaf-to-air vapor pressure difference (D) on leaf responses. On selected clear days throughout the season, shade increased midday Ac and gs but decreased Ci/Ca compared to trees in the open implying that high mesophyll temperatures in sunlit leaves were more important than gs in limiting Ac. There were no effects of the shade treatment on canopy volume, yield or fruit size. Shaded fruit developed better external color but lower Brix than sun-exposed fruit. Thus, the presence of mature fruit maintained higher Ac than in leaves on defruited trees but high leaf temperatures and D reduced gs and Ac on warm days throughout the season.

CO₂ Assimilation, Carbohydrate Metabolism, Xanthophyll Cycle, and the Antioxidant System of 'Honeycrisp' Apple Leaves with Zonal Chlorosis

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To determine the cause of zonal chlorosis of 'Honeycrisp' apple leaves, we compared CO₂ assimilation, carbohydrate metabolism, xanthophyll cycle and the antioxidant system between chlorotic leaves and normal leaves. Chlorotic leaves accumulated higher levels of non-structural carbohydrates, particularly starch, sorbitol, sucrose, and fructose at both dusk and predawn, and no difference was found in total non-structural

carbohydrates between predawn and dusk. CO₂ assimilation and the key enzymes in the Calvin cycle, ribulose 1,5-bisphosphate carboxylase/oxygenase, NADP-glyceraldehyde-3-phosphate dehydrogenase, phosphoribulokinase, stromal fructose-1,6-bisphosphatase, and enzymes in starch and sorbitol synthesis, ADP-glucose pyrophosphorylase, cytosolic fructose-1,6-bisphosphatase, and aldose 6-phosphate reductase were significantly lower in chlorotic leaves than in normal leaves. However, sucrose phosphate synthase activity was higher in chlorotic leaves. Thermal dissipation of excitation energy was enhanced in chlorotic leaves under full sun, lowering the efficiency of excitation energy transfer to PSII reaction centers. This was accompanied by a corresponding increase in both xanthophyll cycle pool size (on a chlorophyll basis) and conversion of violaxanthin to antheraxanthin and zeaxanthin. The antioxidant system was up-regulated in chlorotic leaves in response to the increased generation of reactive oxygen species. These findings support the hypothesis that phloem loading and/or transport is partially or completely blocked in chlorotic leaves, and that excessive accumulation of non-structural carbohydrates may cause feedback suppression of CO₂ assimilation via direct interference with chloroplast function and/or indirect repression of photosynthetic enzymes.

Exposure of the Shaded Side of Apple Fruit to Full Sun Leads to Up-regulation of Both the Xanthophyll Cycle and the Ascorbate-glutathione Cycle

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About 80 days after full bloom, well-exposed fruit on the south part of the canopy of mature Liberty/M.9 apple trees were randomly assigned to one of the following two treatments. Some fruit were turned about 180 degrees to expose the original shaded side to full sun whereas the rest served as untreated controls. On day 0, 1, 2, 4, 7, and 10 after treatment, fruit peel samples were taken from the original shaded side of the treated fruit and both the sun-exposed side and the shaded side of the control fruit at midday to determine photosynthetic pigments and enzymatic and non-enzymatic antioxidants. Maximum photosystem II efficiency of the original shaded side decreased sharply after 1 day exposure to full sun, and then gradually recovered to a similar value of the sun-exposed side of the control fruit by day 10. The shaded side of the control fruit had much lower xanthophyll cycle pool size and conversion and antioxidant enzymes and soluble antioxidants of the ascorbate-glutathione cycle than the sun-exposed side. In response to full sun exposure, xanthophyll cycle pool size of the original shaded side increased, reaching a similar value of the sun-exposed side by day 10. Ascorbate peroxidase, monodehydroascorbate reductase, dehydroascorbate reductase, and glutathione reductase and total pool size and reduction state of both ascorbate and glutathione of the original shaded side all increased to the corresponding values found in the sun-exposed side of the control fruit over a 10-day period. It is concluded that both xanthophyll cycle and the ascorbate-glutathione cycle in the original shaded side are up-regulated in response to full-sun exposure to minimize photo-oxidative damage and contributes to its re-acclimation to full sun.

Patterns of Sorbitol Metabolism and Availability during Apple Fruit Set

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Acquiring sufficient carbohydrate is essential for successful apple fruit set. Sorbitol may be the dominant carbohydrate imported by growing fruit, and the rate of sorbitol accumulation may be a function of NAD-dependent sorbitol dehydrogenase (SDH; EC 1.1.1.14) activity. Prior work indicated that SDH activity from whole fruit (seeds plus cortex) increased for 2 or 3 weeks after initiation of fruit growth and then declined through 5 weeks. Using SDH activity assays, an SDH-specific antibody, and SDH-specific probes in Northern analyses, it is evident that SDH is expressed and is active in both apple seed and cortex tissue during the first few weeks of fruit growth. On a per unit

protein basis, SDH activity in seeds increased by the pattern described above while that in fruit was generally lower and constant. During this same period of time, the sorbitol content of the expressed sap of apple shoots was analyzed. The sorbitol concentration was 50- to 100-fold higher than the sucrose concentration. The concentrations of both carbohydrates changed in parallel to the change in SDH activity of whole fruit and seeds. The lowest SDH activity and sap sorbitol levels preceded and/or coincided with the beginning of the natural fruit drop (or June drop) period.

¹³C-Partitioning in Sweet Cherry (*Prunus avium* L) During Early Spring

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In deciduous fruit trees, some storage reserves accumulate during fall and are used for early spring growth. In sweet cherry (*Prunus avium* L), stored reserves are critical for early growth and there is a transition phase during which current photoassimilates become the primary source for support of reproductive and vegetative sinks. As little is known about this transition, an experiment using 4-year-old 'Regina' sweet cherry on the semidwarfing rootstock, Gisela 6, was established. Using whole canopy exposure chambers, five trees were pulsed with high levels of ¹³CO₂ on three different dates during fall (Sept.–Oct). At leaf drop, leaves, buds, wood, bark and roots were sampled for GCMS analysis of pre-winter storage reserves. The major storage organs (those which had the highest change in isotopic ratios) were roots and wood in the trunk and branches. During spring, newly developing organs (flowers, fruits and young leaves) were sampled weekly from bloom to stage III of fruit development for additional GCMS analysis. The stored ¹³C was mobilized and partitioned to flowers, fruits and young leaves from early spring until one week after fruit set. The highest ¹³C levels in growing sinks were observed between bloom and fruit set. The isotopic composition of new organs did not differ initially (3 May). During the three next sampling dates (10–24 May) reproductive organs had higher ¹³C levels compared to vegetative growth. The role of storage reserves, as a source of assimilates for early spring growth and their implications for crop development, will be discussed.

Translocation of the Mango Florigenic Promoter

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Floral induction of mango is determined by interaction of a short-lived, florigenic promoter that is up-regulated in leaves during exposure to cool temperatures and an age-dependent vegetative promoter at the time that initiation of shoot growth occurs. Research conducted during the past flowering season demonstrated that 1/4 of a leaf per stem was sufficient to stimulate flowering in 100% of the tested stems. Three or more leaves on a donor stem of an isolated branch also bearing five defoliated stems induced flowering on all six stems. One leaf on the donor stem was sufficient to induce flowering in all of the donor stems and most of the five defoliated stems, and 1/2 leaf on the donor stem stimulated flowering in that stem and in less than 1/2 of the defoliated stems. Stems that did not flower initiated vegetative shoots instead. Flowering occurred on those stems that were inserted into main branches in the same phylotaxic position as the leaf. Evidence suggests that leaves are capable of producing far greater amounts of florigenic promoter during floral inductive conditions than needed for induction of buds and that the promoter can move great distances in phloem aligned in the same phylotaxic position as the source leaf.

Antisense Inhibition of Sorbitol Synthesis Leads to Changes in the Activity of the Antioxidant System in Apple Leaves

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Sorbitol is the primary photosynthetic end product in the leaves of many tree fruit species in the Rosaceae family, but its physiological role remains unclear. In this study, we determined the effect of decreased sorbitol synthesis on the antioxidant system that scavenges reactive oxygen species (ROS) in apple leaves. Sorbitol synthesis was decreased in apple leaves by antisense inhibition of aldose-6-phosphate reductase activity. Dehydroascorbate reductase (DHAR), glutathione reductase, and catalase (CAT) activities increased in the leaves of the transgenic plants with decreased sorbitol synthesis, whereas superoxide dismutase, ascorbate peroxidase, NADH dependent and NADPH dependent monodehydroascorbate reductase activity did not show significant changes. Ascorbate and glutathione concentrations were higher in leaves of the transgenic plants compared with the control. The effect of decreased sorbitol synthesis on the antioxidant enzyme activity was dependent on leaf developmental stages. Larger changes in the enzyme activities of CAT, DHAR, and GR were observed in the old leaves than in the young leaves. These results suggest that sorbitol may play a role in ROS scavenging in apple leaves.

Oral Session 33—Genetics and Germplasm/Plant

Biotechnology

Moderator: Sara Patterson

July 19, 2004, 3:00–4:45 PM

San Antonio

Analysis of Genetic Relationships of *Calathea* Species and Cultivars by AFLP Markers

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Calathea, the largest genus in the family Marantaceae, is composed of 100 species native to tropical America in moist or swampy forest habitats. Because of their brilliant patterns of leaf color and different textures plus ability to tolerate low light levels, calatheas have been widely produced as ornamental foliage plants for interior landscaping. Thus far, genetic relationships among its species and cultivars have not been documented. This study analyzed the relationships of 34 cultivars across 14 species using amplified fragment length polymorphism (AFLP) markers. Six EcoRI + 2/MseI + 3 primer set combinations were used in this investigation. Each selected primer set generated 105 to 136 scorable fragments. A total of 733 AFLP fragments were detected of which 497 were polymorphic (68%). A dendrogram was constructed using the unweighted pair-group method of arithmetic averages (UP-GMA) technique and a principal coordinated analysis (PCOA) was used to analyze the relationships. The 34 cultivars were divided into four clusters. Cluster I had 19 cultivars derived from *C. roseo-picta* and *C. loesnerii* with Jaccard's similarity coefficients from 0.74 to 0.97, of which six are somaclonal variants or sports and two cultivars are genetic identical. Only *C. kennedae* 'Helen' is positioned in cluster II. Cluster III had 10 cultivars across seven species; Jaccard's similarity coefficients among them varied from 0.41 to 0.63. Four species were situated in cluster IV with Jaccard's similarity between 0.27 to 0.41. Results from this study indicate that broadening of genetic diversity is needed for cultivars in cluster I as they are the most commonly grown calatheas but genetically are very close.

Genetic Relationship of Ornamental Peach Using Amplified Fragments Length Polymorphism (AFLPs) Fingerprints

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Ornamental peach (*Prunus persica* (L.) Batsch) is native to China. The

ornamental value of peach is gaining popularity for its use in urban landscape and everyday gardens. However, the genetic relationship among ornamental peach cultivars is not clear, which limits the further studies of its molecular systematic. A sample of 51 cultivars of ornamental peach, originated from *P. persica* and *Prunus davidiana*, had been studied by using AFLPs. All samples were collected from China, Japan, and the US. A total of 275 useful markers between 75 to 500 base pairs were generated from 6 EcoRI/MseI AFLP primer combinations. Among them, 93% of bands were polymorphic markers. Total markers for each cultivar ranged from 90 to 140, and the average number of markers for each cultivar was 120. Two distinguished clad generated from PAUP-UPGMA tree. *P. davidiana*, as a species, was apparently an out-group to *P. persica*, which implied that *P. davidiana* was far away genetically from ornamental peach (*P. persica*). Within *P. persica* clad, 15 out of 17 upright ornamental peach cultivars in this study were grouped to one clad, which indicated cultivars that with upright growth habit had close genetic relationship. Five dwarf cultivars were grouped to one clad, with 81% bootstrap supported. The genetic relationships between these five dwarfs were much closer than any other cultivars, and showed that they probably derived from the similar gene pool. The results demonstrated that AFLP are powerful markers for revealing genetic relationships in ornamental peach. The genetic relationships among ornamental cultivars established in this study could help future ornamental peach germplasm identification, conservation, and new cultivars development.

Continuous Darkness and Silver Nitrate Promote Anther-derived Callus in *Rosa hybrida* L.

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Haploid (2x) roses derived from modern tetraploid breeding lines would allow for crosses to diploid species at the diploid level. In addition, inheritance studies are easier at the diploid level, using diploids derived from tetraploids possessing economically important traits. Haploidization of 4x roses through anther culture has not been successful due to challenges in callus induction and shoot regeneration. This study investigates rose anther responses to recently reported methods that optimize in vitro adventitious shoot regeneration in rose leaves. Anthers of three cultivars (Akito, Grand Gala, and Orlando) were put in a two-step callus induction (CI) and shoot regeneration procedure with varying CI factors. Experiment one (E1) compared continuous light/dark and silver nitrate (0, 30, 60 mg·L⁻¹) and experiment two (E2) used the optimal E1 treatment comparing two and four weeks on CI media. Twenty-five anthers per treatment per cultivar were used in E1 and n = 100 for E2. Although no adventitious shoots were generated, callus formed on anther tissue and frequency of formation was variable across treatments. Continuous light resulted in 100% lethality. Darkness and silver nitrate (30 or 60 µM) favored callus generation and significant differences for callus generation were found among cultivars. Darkness and 30 µM silver nitrate were used in E2. Two and four weeks on initiation media were not significantly different for generation of anther-derived callus. Identification of factors which optimize callus formation on rose anthers is a positive step toward reliably generating rose haploids.

Genetic Linkage Mapping and QTL Analysis of Economic Traits in Papaya (*Carica papaya* L.)

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QTL mapping gives an insight into the number, position and effect of loci controlling quantitative traits. Although a few linkage maps already exist for papaya, not many economically important traits have been studied. An investigation was undertaken to map two qualitative traits: 1) fruit flesh color and 2) an isozyme locus, phosphoglucose mutase (PGM); as well as two quantitative traits: 1) number of nodes to

first flowering and 2) stamen carpellody. An F_2 population consisting of 281 plants derived from the parents Kapoho X Saipan Red was used for this study. Field observations suggested that there may be a linkage between PGM locus and one of the major QTLs controlling number of nodes to first flowering. Also, phenotypic data suggested that there may be a linkage between flesh color and carpellody. Marker genotyping was performed on a subset of 84 plants chosen from the phenotypic extremes of the population for node number and carpellody. Using AFLP (Amplified fragment length polymorphism) method, 510 markers were generated with 161 primer pairs. Although papaya has a haploid chromosome number of 9, at LOD score 5.0 and a maximum recombination frequency of 0.25, 25 linkage groups with number of markers ranging from 2 to 109 were generated using the software Mapmaker/EXP. Linkage and QTL maps are being constructed to reveal the molecular markers linked with the traits of interest and the nature of QTLs controlling the quantitative traits.

Use of RAPD Markers to Assess Genetic Diversity of American Ginseng (*Panax quinquefolium* L.) Among Wild Populations from the Catskill Mountains of New York State and Other States

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The Catskill Mountains of New York are an important source of wild-collected American ginseng (*Panax quinquefolium*), and increasingly, of woods-cultivated ginseng. The objective of this study was to assess genetic diversity among eight different wild ginseng populations from the Catskill Mountains and to compare Catskill populations to five wild populations from other states including Kentucky, Tennessee, North Carolina, Pennsylvania, Virginia, and one cultivated population from Wisconsin. Randomly amplified polymorphic DNA markers were used to estimate the genetic difference among the 14 populations using PCR amplified nuclear DNA. Fifteen random primers were selected from a total of 64 random decamer primers by screening bulked DNA samples from the eight Catskill populations. These 15 primers were then used to compare 10 plants each from the eight Catskill populations and three to four plants each from the non-Catskill populations. The 15 primers produced 124 polymorphic bands. The genetic distance within and among populations was estimated using the ratio of discordant bands to total bands. Multidimensional scaling of the relation matrix showed separation of Catskill and non-Catskill population clusters. Significant differences between these groups was confirmed using pooled chi-square tests for fragment homogeneity. Although the eight Catskill populations differed from the non Catskill populations, there were no significant differences among the Catskill populations. This study shows that presence and absence of bands can be used as population specific markers for American ginseng. Although these results do not rule out the possibility that there may be some level of genetic differences among Catskill populations, 10 plants per population was not sufficient to establish such differences.

Expression and Cellular Localization of *dab 5-1*, a Delayed Abscission Mutant, in *Arabidopsis thaliana*

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Abscission, an active process resulting in the removal of an organ from the main body of a plant, occurs naturally in response to pathogens, disease, or when the plant part is no longer needed. Several delayed abscission mutants have been identified from the Univ. of Wisconsin T-DNA tagged mutant populations in *Arabidopsis thaliana*. One of the identified mutants, *dab 5-1*, is characterized by a delay in abscission causing the floral organs to remain attached past position ten; however, all other plant functions are normal. *dab 5-1* has been thought to be involved in the secretory pathway. The present study was conducted to further characterize *dab 5-1* expression at the cellular, tissue, and

organelle levels using reporter gene constructs, light microscopy, scanning electron microscopy, and RT-PCR. *dab 5-1* expression was found in the roots, root tips, cotyledons, meristem, abscission zone, and anthers. Early abscission can lead to loss in yield and quality and we believe that understanding genes such as *DAB5* will ultimately lead to crop improvement.

Inactivation of DFR (Dihydroflavonol 4-reductase) Gene Transcription Results in Blockage of Anthocyanin Production in Yellow Onions (*Allium cepa*)

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Anthocyanin, one of the flavonoids, is a primary determinant of red color in onions. Inheritance studies indicate that a single gene determines the color difference between yellow and red onions. In order to establish which gene might be responsible for this color difference, full-length cDNAs of five structural genes: chalcone synthase (CHS), flavanone 3-hydroxylase (F3H), dihydroflavonol 4-reductase (DFR), anthocyanidin synthase (ANS), and flavonol synthase (FLS) were cloned using degenerate PCR and RACE (Rapid Amplification of cDNA Ends). RT-PCR was carried out for these five genes to examine differential expression between yellow and red colored bulbs. Accumulation of the DFR gene transcript only occurred in red onions. In F_3 populations which originated from the cross between yellow and red parents, DFR transcript was detected only in red F_3 lines, not in yellow F_3 lines. To design molecular markers for selection of yellow and red DFR alleles, the DFR gene was sequenced from genomic DNA isolated from both types of onions. The genomic DNA sequence revealed the DFR gene consists of six exons and five introns. A PCR-RFLP marker was designed based on 2% polymorphic nucleotide sequence of the DFR gene between yellow and red onions. The co-segregation of markers and red color were observed in F_2 segregating populations, supporting the conclusion that color difference in red and yellow onions is likely to be due to the lack of an active DFR gene.

Evaluation of Strawberry Genotypes for Tolerance to Black Root Rot

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Black root rot is a serious disease of strawberry (*Fragaria x ananassa* Duch.) that causes the death of feeder roots, the degradation and blackening of structural roots, and an overall decrease in plant vigor and productivity. The causal organisms of black root rot are *Rhizoctonia fragariae*, *Pythium* sp. and *Pratylenchus penetrans* (the root lesion nematode). Each organism alone can cause extensive damage to strawberry roots, but studies have shown that black root rot may be more severe when all organisms are present, indicating there is an interaction between the fungal organisms and the nematode. The current method of control for black root rot is methyl-bromide fumigation; however, methyl bromide is to be phased out by 2005, and it is not very effective in perennial matted-row systems. The objectives of the study are to measure levels of tolerance to black root rot in 21 strawberry genotypes. The genotypes were planted in four blocks each of methyl-bromide fumigated and non-fumigated soil, and were evaluated for crown, runner, and inflorescence number; yield; average berry weight; and root health. 'Cavendish', 'Kent', 'Midway' and 'Winona' showed the highest degree of tolerance, while 'Jewel', 'Mesabi', and LH50-4 (a *F. virginiana* genotype) were the poorest performers.

Propagation of Two Native Shrubs, *Rhamnus alnifolia* and *Rhamnus lanceolata*Jyotsna Sharma^{*1}, William R. Graves²¹Univ. of Florida, Environmental Horticulture, Quincy, FL 32303; ²Iowa State Univ., Horticulture, Ames, IA 50011

Rhamnus alnifolia and *Rhamnus lanceolata* are shrubs of modest size with lustrous foliage. We evaluated seed germination of both species and propagated *R. alnifolia* by using softwood cuttings collected in early June. For *R. alnifolia*, cold stratification for up to 90 d resulted in 48% germination and a germination value of 1.9, whereas only 7% germination occurred among seeds stratified for 120 d. Seeds of *R. alnifolia* did not germinate if they were untreated or if scarified and stratified. *Rhamnus lanceolata* required 120 d of stratification to germinate, but percentages were low (≤ 5). Survival of germinants of both species was 90 to 100% regardless of prior seed treatment. Seedlings grew uniformly and had a mean leaf count of 11 and a mean height of 20 cm after 102 d. Application of 3000 and 8000 mg/L indole-3-butyric acid (IBA) in talc led to 85% rooting of *R. alnifolia*, whereas rooting was $\leq 15\%$ after use of solutions with those IBA concentrations. While 75% of untreated cuttings rooted, fewer roots formed without IBA. More roots developed in 100% vermiculite than in 1 vermiculite : 1 perlite (by volume), which also diminished the number and apparent health of leaves on cuttings during the rooting period. We conclude that talc-based IBA and vermiculite should be used to root softwood cuttings of *R. alnifolia*, and that both species can be propagated from stratified seeds. *Rhamnus lanceolata* is more recalcitrant than is *R. alnifolia* and merits further study to optimize germination success.

Trench Layering as a Method of Clonally Propagating Pawpaw (*Asimina triloba*)Sheri B. Crabtree^{*1}, Kirk W. Pomper², Robert L. Geneve³¹Kentucky State Univ., Land Grant Program, Frankfort, KY 40601; ²Kentucky State Univ., Land Grant Program, Frankfort, KY 40601; ³Univ. of Kentucky, Dept. of Horticulture, Lexington, KY 40517

The pawpaw (*Asimina triloba*) is the largest fruit native to the U.S. and has potential as a new fruit crop. Few methods are available to clonally propagate pawpaw, with grafting or budding onto a seedling rootstock being the only currently feasible method. Developing new options for clonal propagation of pawpaw could help advance this growing industry. Layering has been used to clonally propagate other difficult to root tree species. The objective of this study was to examine trench layering as a method to clonally propagate pawpaw. A randomized factorial experiment was implemented to examine the roles of plant juvenility and auxin concentration on rooting in a greenhouse trench layering system. Seedlings were defoliated, tipped, and transplanted into trench layering beds at 3, 6, and 12 weeks after emergence. Shoots were etiolated, then girdled and treated with three levels of IBA (0, 5000, and 10,000 ppm). The main effects of age and IBA concentration significantly affected the percentage of shoots producing roots. Juvenility enhanced rooting, with 15% of the shoots of the 3-week-old pawpaw seedlings producing roots, compared to only about 5% of the 12-week-old seedlings rooting. Auxin application to shoots also promoted rooting, with 16% of IBA-treated shoots producing roots, compared to the untreated control, with only 2% of shoots producing roots. There was no significant difference in rooting percentage between the two concentrations of IBA. The treatment combination most successful at promoting root initiation was 10,000 ppm IBA applied to shoots of 3-week-old seedlings, with 31% of shoots rooting.

The Influence of Location of Main Stem Segment Origin on Forcing and Rooting of Softwood Shoots of *Betula nigra* L.Laurie J. George^{*1}, John E. Preece²¹Southern Illinois Univ., Dept. of Plant, Soil and Agricultural Systems, Carbondale, IL 62901; ²Southern Illinois Univ., Dept. of Plant, Soil and Agricultural Systems, Carbondale, IL 62901

The objective of this study was to investigate the effects of the position on the main stem that large stem segments were harvested from on forcing and subsequent rooting of *Betula nigra* L. (river birch) softwood shoots. The main trunks of eight adult-phase native trees (four trees per run of the experiment) were cut into 50-cm long segments from the ground up. The segments placed in horizontally in 52 × 25 × 6.5 cm (l × w × h) flats containing perlite and were positioned so the bottom one-third of the stem was within the medium. Shoots were forced under natural photoperiod and intermittent mist. This experiment was conducted twice. Data were collected weekly for fourteen weeks on the number of softwood shoots each segment produced, shoot length, number of rootable shoots (>6 cm long), the length of time that the stem segments produced rootable shoots, and the rootability of these shoots treated with 3000 ppm IBA in talc. The number of harvested shoots was greater in Run 1, with the basal segments producing the most harvestable shoots. However, the upper segments in Run 2 produced the most harvestable shoots. Softwood shoots that rooted were placed under intermittent mist. Out of the 540 harvested shoots for both runs, 82.4% rooted, with the majority of those from Run 1. Shoots harvested from this run began producing roots about 6 weeks after harvest, and continued until the end of the experiment. Run 2 shoots began root initiation about 3 weeks after harvest and ended about 2 weeks before the end of the experiment. Run 1 had an mean of 8.3 roots per shoot and Run 2 had an mean of 6.2 roots. The relationship between juvenility and shoot forcing and subsequent rooting will be discussed.

Mist, Vapor Pressure Deficit, and Cutting Water Potential Influence Rooting of Stem Cuttings of Loblolly PineAnthony V. LeBude^{*1}, Barry Goldfarb², Frank A. Blazich³¹NC State Univ., Horticultural Science, Raleigh, NC 27695-7609; ²NC State Univ., Forestry, Raleigh, NC 27695-8002; ³NC State Univ., Horticultural Science, Raleigh, NC 27695-7609

Producing high quality rooted stem cuttings on a large scale requires precise management of the rooting environment. This study was conducted to investigate the effect of the rooting environment on adventitious root formation of stem cuttings of loblolly pine (*Pinus taeda* L.). Hardwood stem cuttings of loblolly pine were collected in Feb. 2002 from hedged stock plants and stored at 4 °C until setting in Apr. 2002. One hundred stem cuttings per plot in each of two replications received 45, 61, 73, 102, 147, or 310 mL·m⁻² of mist delivered intermittently by a traveling gantry (boom) system. Mist frequency was similar for all treatments and was related inversely to relative humidity (RH) within the polyethylene covered greenhouse. Rooting tubs in each plot were filled with a substrate of fine silica sand, and substrate water potential was held constant using soil tensiometers that activated a subirrigation system. Cutting water potential was measured destructively on two cuttings per plot beginning at 0500 HR every 3 hh until 2300 HR (seven measurements) 7, 14, 21, or 28 days after setting. During rooting, leaf temperature and RH were recorded in each plot to calculate vapor pressure deficit (VPD). Cutting water potential and VPD were strongly related to mist application. Cutting water potential was also related to VPD. Rooting percentage had a linear and quadratic relationship with mean cutting water potential and VPD averaged between 1000 and 1800 HR. Eighty percent rooting occurred within a range of values for VPD. Data suggest that VPD can be used to manage the water deficit of stem cuttings of loblolly pine to increase rooting percentage. These results may be applicable to other species and to other rooting environments.

Growth and Development of Lingonberry Cultivars as Affected by In Vitro and Ex Vitro Culture Methods and Source Propagule

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The morphological development of lingonberry (*Vaccinium vitis-idaea* L.) plants propagated either by conventional softwood cuttings or by in vitro shoot proliferation from nodal explants or by shoot regeneration from excised leaves of micropropagated shoots, was studied in cultivars 'Regal', 'Splendor', and 'Erntedank'. Significant differences were observed between the treatments. In vitro-derived plants produced more shoots branches and rhizomes in contrast to conventional cuttings which rarely produced rhizomes. Plants propagated from cuttings had a lower number but vigorous shoots and thicker rhizomes than in vitro-derived plants. Source propagule had significant effect on multiplication rate. Another experiment evaluated the effect of indole-3-butyric acid (IBA) application to softwood cuttings on subsequent rooting, shoot development, and rhizome production. Treating cuttings with IBA did not significantly improve rhizome formation and elongation. In vitro culture on nutrient medium apparently induces the juvenile branching characteristics that favored rhizome production. The advantage of rhizome production of in vitro-derived plants over stem cuttings varied among genotypes.

Comparative In Vitro Growth and Development of Easy- and Difficult-to-Acclimatize Sea Oats (*Uniola paniculata* L.) Genotypes

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A sea oats (*Uniola paniculata* L.) micropropagation protocol was previously developed for 28 genotypes that favored multiplication and rooting of shoots in vitro. However, microcutting size, morphology, and acclimatization ex vitro varied considerably among genotypes. In the present study we evaluated the effect of Stage III duration on in vitro morphology, biomass production, and ex vitro survivability of easy- (EK 16-3) and difficult-to-acclimatize (EK 11-1) sea oats genotypes. After 3, 6, and 9 weeks at Stage III, survivability of microcuttings was 85%, 96% and 98% for EK 16-3, and 2%, 27% and 40% for EK 11-1, respectively. After 9 weeks Stage III, EK 16-3 microcuttings had higher shoot dry weights but lower root dry weights than in EK 11-1. Moreover, roots in EK 11-1 were fewer but longer than in EK 16-3. Leaf production was similar in both genotypes. However, leaf elongation was significantly inhibited in EK 11-1, in which 95% of the leaves were ≤ 15 mm long in contrast with EK 16-3, with 50% leaves ≥ 16 mm long after 9 weeks Stage III. Light microscopy examinations showed anatomical similarities between EK 16-3 in vitro leaves and mature ex vitro leaves. Conversely, short in vitro leaves of EK 11-1 exhibited mesophyll disruption and reduced cuticle development. Conceivably, the short leaves had limited photosynthetic competency, thereby reducing ex vitro survival of rooted EK 11-1 microcuttings.

Seed Production of Field- and Greenhouse-Grown Herbaceous Ornamental Plants: Flowering and Pollinator Effects

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Seeds of herbaceous ornamental accessions conserved by the USDA National Plant Germplasm System (NPGS) are traditionally produced in summer field cages with honey bees (*Apis mellifera*) when pollinators are required. Efficient methods to produce high-quality seed in greenhouses may allow for year-round seed production. Flower quantities and effects of pollinators on number and weight of seed produced were studied in field cages and greenhouses at the Ornamental Plant

Germplasm Center in 2003 in a randomized complete-block experiment. Honey bees, bumblebees (*Bombus impatiens*), or blue bottle flies (*Diptera calliphoridae*) were used as pollinators. Field cages and greenhouse compartments with no pollinator were controls. Cultivars used were *Antirrhinum majus* 'Gum Drop', *Coreopsis tinctoria* 'Plains Bicolor', *Dianthus chinensis* 'Carnation' (NPGS accession NSL 15527), *Rudbeckia hirta* 'Indian Summer', and *Tagetes patula* 'Jaguar'. Seeds were harvested, cleaned, weighed, and 100-seed weights calculated. On average *Antirrhinum*, *Dianthus*, *Rudbeckia* and *Tagetes* produced more flowers in greenhouses, *Coreopsis* produced more flowers in the field. *Coreopsis* and *Rudbeckia* produced more seed per flower on average with field pollination by honey bees, *Antirrhinum* and *Dianthus* produced most with bumblebees in the field, and *Tagetes* produced most with blue bottle flies in the greenhouse. Each genus had similar 100-seed weights on average in all treatments. Results show pollinators other than honey bees are useful for herbaceous ornamental seed production and that seed production in greenhouses may be an alternative method for seed production of herbaceous ornamentals.

Amylase and Endo- β -mannanase Related to the Germination of Eggplant Seeds

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Germination of 'Fond May' eggplant seeds at 25°C could be increased by after-ripening fruit or fresh seed treated with KNO₃ or GA₃ or priming. There were high amount of starch and low amount of soluble sugar in after-ripening seed or primed seed. The amount of soluble sugar in after-ripening seed was higher than that in control seed before the radicle protrusion at 25 °C and 25/30 °C. Starch amount in after-ripening seed imbibed at 25/30 °C was significantly high. Soluble sugar in un-after-ripening seed imbibed at 25 °C for 2–3 days had higher amount and the high activity of β -amylase was appeared in the second days. Activity of amylase in primed seed imbibed at 25 and 25/30 °C for 3 days increased. The activity of endo- β -mannanase was high in after-ripening or priming or GA₃ treated seed at 25 °C.

Oral Session 35—Nursery Crops

Moderator: William R. Graves

July 20, 2004, 10:30 AM–12:00 PM

San Marcos

Isotopic and Nonisotopic Estimation of Nitrogen Fertilizer Uptake in Container-grown Woody Ornamentals

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Accurate methods for determining the fate and recovery of nitrogen (N) fertilizer applied to container-grown nursery crops are essential to comply with regulations and develop innovative fertilizer programs. The objectives of this study were (i) to use ¹⁵N techniques to determine the fate of fertilizer N, (ii) to compare nonisotopic and isotopic methods of determining N recovery, and (iii) to determine the relative importance of fertilizer and non-fertilizer N at rates of 25, 50, 100, 200, and 300 mg·L⁻¹ in container-grown *Euonymus alatus* (Thunb.) Sieb., *Cornus sericea* L., and *Weigela florida* (Bunge) A. DC. In all species, root and shoot N increased with N rate, and at each rate more N was stored in the roots than in the shoots. Estimation of N recovery determined by the total N method (Kjeldahl N/applied N) was significantly higher for all species and at each N rate than estimation of N recovery determined by the labeled fertilizer N method (labeled N/total applied N). Increasing fertilizer rates up to 100 mg·L⁻¹ resulted in increased uptake of N derived from other sources (NDFO). NDFO at low N concentrations was a significant portion of the total N in the plant. As a result, the difference in estimation of percent N recovery between each method was larger at lower N concentrations for all

species. The nonisotopic total N method produces higher fertilizer N uptake estimates, as much as three to four times the isotopic based estimates, in container-grown plants at N concentrations of 25 mg·L⁻¹. Actual fertilizer N loss increases dramatically from 25 to 300 mg·L⁻¹ (due to dramatic increases in N applied), despite small gains in fertilizer N recovery efficiency.

Mouse Ear Disorder on River Birch Caused by Nickel Deficiency

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Mouse ear (leaf curl, little leaf, squirrel ear) has been a problem for growers of container-grown river birch (*Betula nigra* L.) since the early 1990's. Mouse ear has been noticed in several southeastern States as well as Minnesota, Ohio, Oregon, and Wisconsin, making it a national problem. The disorder is easy to detect in nurseries as the plants appear stunted. The leaves are small, wrinkled, often darker green in color, commonly cupped, and have necrotic margins. New growth has shortened internodes which gives plants a witches-broom appearance. Plants growing in native soil rarely express the disorder. Several common micronutrients have been evaluated with no results. A trial was initiated in June, 2003 to determine if nickel deficiency was the cause of mouse-ear. Symptomatic river birch trees growing in a pine bark substrate in containers were treated with foliar applications of nickel sulfate and a substrate drench. Topdress applications of superphosphate (0-46-0) and Miloroganite, products known to contain nickel, were also applied. At 16 days after treatment (DAT), up to 5 cm of new growth occurred on plants sprayed with nickel sulfate and foliar concentrations of nickel in the new growth increased five fold compared to control plants. At 30 DAT, shoot length increased 60%, leaf area increased 83%, and leaf dry mass increased 81% for trees receiving a foliar application compared to non-treated control plants. Treating trees with a substrate drench alleviated symptoms, whereas treatment with superphosphate and Miloroganite did not. Trees receiving a foliar or drench application had normal growth for the remainder of the growing season. Additional studies are underway to refine methods of application, rates, and sources of nickel suitable for use.

Crape Myrtle (*Lagerstroemia* sp.) Growth and Quality as Affected by Cultivar and Salt Stress

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Rooted liners of the crape myrtle cultivars 'Pink Lace', 'Natchez' and 'Basham's Party Pink' ('BPP') were grown in 20-L containers filled with a 2 peat : 1 pine bark : 1 sand (v/v) medium and irrigated for 15 weeks with irrigation water containing 0, 3, 6, 12, and 24 mM NaCl. Cultivar selection and salinity significantly affected plant growth and quality. Regardless of salinity level, 'Natchez' plants had higher leaf area, total and shoot (top) dry weights and growth indices, whereas 'Pink Lace' had the lowest. 'BPP' had the highest average root dry weights across salt treatments. The vigorous shoot (top) growth of 'Natchez' was also evident with an average shoot to root ratio of 4.1, compared to 2.7 and 2.4 for 'BPP' and 'Pink Lace', respectively. Salinity significantly decreased plant growth and quality in the three cultivars, but the rate at which these parameters were reduced with increases in salinity differed among the cultivars. The rate of reduction in plant growth parameters was lower in 'Pink Lace' plants compared to 'Natchez' and 'BPP'. However, foliage burn symptoms due to salt stress increased at significantly higher rate for 'Pink Lace' plants compared to the other two cultivars. 'BPP' plants had in general the lowest salt burn ratings at each salinity level. Leaf concentrations of Na and Cl increased with salt stress in all cultivars, but significantly lower concentrations were found in 'BPP' plants. 'Pink Lace' plants had better correlations with the recorded salt burn symptoms as compared to the other two cultivars.

Long- and Short-term Effects of Nitrogen on Formation and Function of Root Nodules on *Alnus maritima*

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Symbiotic associations between *Alnus maritima* (Marsh.) Muhl. ex Nutt. (seaside alder) and the actinomycete *Frankia* result in root nodules in which atmospheric nitrogen (N) is fixed. This has led to interest in producing seaside alders with minimal N fertilizer and in using the species on low-N soils. Our objectives were to determine how applied N influences nodulation and to characterize how short-term changes in root-zone N affect the function of established nodules. Seaside alders native to the Delmarva Peninsula (*Alnus maritima* subsp. *maritima*) were grown in perlite inoculated with soil from roots of indigenous plants. Plants were treated with N-free Hoagland solution supplemented with ammonium nitrate at 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 2, 4, and 8 mM for 10 weeks. Nodulation decreased as applied N increased. While plants treated with ammonium nitrate at 4 and 8 mM formed nearly no nodules, 0.5 mM resulted in vigorous, healthy plants that formed, on average, 70 nodules. In a second experiment, a nodulated population of seaside alders was established by treating seedlings with 0.5-mM ammonium nitrate in otherwise N-free Hoagland solution for 6 weeks. Plants then were provided ammonium nitrate at 0.5, 2, or 4 mM for two weeks. Acetylene-reduction assays showed that ammonium nitrate at 4 mM suppressed nodule activity. Daily irrigation with N-free solution subsequently led to a rapid depletion of root-zone N and a concomitant resurgence of nodule activity among plants previously provided 2- and 4-mM ammonium nitrate. These results provide useful information on how to manage fertility to optimize nodulation and show suppression of nodule activity caused by N fertilization can be temporary if excess N is leached from the root zone.

Adaptations of *Alnus maritima* Nodules to Low Oxygen in the Root Zone

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Alnus maritima (Marsh.) Muhl. ex Nutt. is unique among alders in its degree of preference for low-oxygen soils of wetlands. An actinorhizal species with promise for use in sustainable horticulture, *A. maritima* develops a root-nodule symbiosis with nitrogen-fixing *Frankia*. Nodules of other actinorhizal species that are obligate wetland natives are adapted to low oxygen, and expression of hemoglobin is common to these taxa. Our objectives were to determine the range of oxygen tension under which *Alnus maritima* subsp. *maritima* fixes nitrogen and to investigate a potential role for hemoglobin in adaptation of nodules to low oxygen. Roots of plants, cultured aeroponically, were subjected to eight oxygen tensions from 0 to 32 kPa. After four weeks, plant dry weight, nodule fresh weight, nitrogenase activity, and photosynthetic rate were measured. In addition, nodules were assayed spectrophotometrically for the presence of hemoglobin. A quadratic function best described the influence of oxygen on plant dry weight, nodule fresh weight, nitrogenase activity, and photosynthetic rate with maximal values above 20 kPa. *Alnus serrulata* (Ait.) Willd. is sympatric with *A. maritima* subsp. *maritima* but is not an obligate inhabitant of wetlands. In a separate experiment, we found higher nitrogenase activity in *A. maritima* subsp. *maritima* than in *A. serrulata* (0.74 vs. 0.26 µmol/h per plant) at hypoxic oxygen tensions. Further, optical absorption spectra of nodule extracts confirmed hemoglobin within nodules of *A. maritima* subsp. *maritima*. Our data suggest that hemoglobin contributes to oxygen regulation in nodules of *A. maritima* subsp. *maritima*.

Growth and Physiological Response of Nursery-grown Landscape Trees to Fertigation

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Thirteen species of shade trees including four oak and three maple spe-

cies were planted from bare root whips in Spring 2001 at the Michigan State Univ. horticulture station near Benton Harbor, Mich. Forty trees of each species were planted and placed under a randomized complete block design consisting of four fertigation treatments in a 2 × 2 factorial (with and without irrigation; with and without nitrogen fertilization). Fertilized trees received 168 kg per hectare of ammonium nitrate annually via the drip system. We measured tree height, stem diameter, and stem volume index (D²H) at the end of each growing season. We also measured photosynthetic gas exchange with a portable photosynthesis system. After three growing seasons irrigation increased stem volume and height growth. Fertilization has not increased stem volume and height growth, yet there is an interaction between irrigation and fertilization meaning that among irrigated trees fertilizer produced significantly more growth. Species effect on growth was significant ($P < 0.001$); honey locust trees have grown the most with an average height increase of 1.28 meters in 2003. ‘Crimson King’ Norway maple and goldenchain trees grew the least averaging less than 305 meters of height growth per year. There is no interaction between species and fertigation responses meaning that all species had similar responses to the treatments. From light response curves obtained with a portable photosynthesis system Amax (maximum rate of CO₂ assimilation) varied significantly by species and treatment, but showed no interaction between species and treatment effects. Implications for the nursery industry along with further photosynthetic responses will be discussed.

Chilling Duration, Container Size and Photoperiod Influence Flowering of *Aruncus* ‘Misty Lace’

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Aruncus ‘Misty Lace’ is a new hybrid selection between *Aruncus dioicus* and *A. aethusifolius*. The plants outstanding characteristics include heat tolerance, dwarf stature, and delicate, plume-like flowers. The objectives of this study were to evaluate the effect of different production parameters (chilling duration, container size, and photoperiod) on flowering in this new genotype Tissue cultured plantlets of *Aruncus* ‘Misty Lace’ were transplanted to 72- or 36-cell trays and to 10-cm pots. Transplanted materials remained on the greenhouse bench until roots were visible in the soil plug, then placed in a cooler at 2–4 °C for 0 (control), 4, 6, 8, 10 and 12 weeks of chilling. Upon removal, plants were placed in a greenhouse in 10-cm containers under long or short day photoperiods until flowering, or until the experiment was terminated. Plants required less time on the bench to flower as cooling time increased, regardless of container size. Plants flowered earlier under long days than short days, but photoperiod was less of a factor in the control of flowering than cooling duration. Death of plants was greatest in the 72-plug cells and least in 10-cm pots. Plants without well established root growth sustained significant losses, regardless of container size.

Oral Session 36—Floriculture 3

Moderator: William B. Miller

July 20, 2004, 1:30 –2:45 PM

San Antonio

Production System Impacts Quality of Cut Poinsettia Stems

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The development of the Renaissance series of cut poinsettias, *Euphorbia pulcherrima*, presents unique opportunities and challenges to cut flower producers. This series has curled bracts, long stem length, excellent vase life and is highly marketable. Literature indicates that this crop is suited for pot or bed production, but does not compare methods. This study assessed the impact of production system on final

stem quality. Uniform rooted cuttings of ‘Renaissance Red’ obtained from a commercial supplier were transplanted into 30.5-cm pots or a 1.2- × 2.4-m bed containing a soilless media to obtain 2 plants per 0.9 m². A total of 56 cuttings were used for each production system and grown using standard production techniques. Transplanting occurred on 11 Aug. 11 2003 with plants reaching market stage, two cyathia shedding pollen, about 17 weeks later. To minimize border effects, plants in the outside rows of each production system were discarded. Thus, stem length, stem diameter, bract diameter, floral development, and number of axillary shoots were determined for 30 interior plants in each system. The production systems differentially impacted stem length and number of axillary shoots. Mean stem length in the bed system (89.7 cm) was greater than that observed in the pot system (71.4 cm). Plants in the bed system had significantly fewer axillary branches per plant (0.5) than plants in the pots (2.0). Stem diameters were similar for both systems (11.5 mm and 10.9 mm for bench and pot, respectively) as were bract diameters (14.3 cm and 13.4 cm for pot and bench, respectively). Both systems produced marketable stems; however, stems produced in the bed system had longer stems, fewer axillary branches, and were more uniform than those in the pot system.

Variation in *Fusarium*-induced Ethylene Synthesis Among Tulip Cultivars

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Ethylene evolution is a consequence of *Fusarium* infection of tulip bulbs, yet little is known about the bulb-pathogen interactions involved in the induction or time course of ethylene synthesis. The resulting ethylene can affect adjacent, non-infected bulbs, and results in a variety of disorders, most notably flower abortion. Earlier work indicates that cultivars vary in their sensitivity to ethylene, but there are few data on ethylene production by cultivar. In this experiment, we assessed *Fusarium*-induced ethylene production in 36 tulip cultivars. Bulbs were wounded, inoculated with a liquid *Fusarium* suspension (isolated from infected bulbs) and held at 25 °C. Control bulbs were wounded, but not inoculated. Ethylene production was monitored by headspace analysis and gas chromatography. Ethylene increased rapidly after a lag phase of at least 8 days, but there were large differences in ethylene production among cultivars. Of the cultivars tested, ‘Furand’ evolved more than 340 μL/kg/fwt/hr (≈250 μL/L/bulb/day) on the 11th day after infection, a rate ≈440-fold greater than in non-inoculated bulbs. Inoculated cultivars producing ethylene at rates exceeding 50 μL/kg/hr included ‘Mary Belle’, ‘Libretto’, ‘Nashville’, ‘Yonina’, ‘Friso’, and ‘Prominence’. About 25% of the cultivars produced ethylene at rates >10 μL/kg/hr, and ≈40% of cultivars produced less than this rate on day 11. High-ethylene producing tulips could be stored separately from other cultivars, or be given increased ventilation during storage or transportation. Knowledge of cultivar variation might also be useful in breeding programs. Further questions concerning the specific tissue responsible for ethylene synthesis (bulb, fungus, or both?) also arise.

Nitrogen Toning and Thidiazuron (TDZ) Improve Pot Plant Quality of *Bracteantha bracteata* Cultivars

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Bracteantha bracteata (Vent.) Anderb. & Haegi (*bracteantha*) is a vegetative annual produced as a 12.7-cm potted plant in 6 weeks of greenhouse production. A dense leaf canopy produced with a conventional constant-feed fertilization regime (300 mg·L⁻¹ 20N–4.4P–16.6K) caused increased disease pressure and lower leaf chlorosis during greenhouse production. During shelf life, lower leaves of plants con-

tinued to become chlorotic. The objective was to decrease leaf area and prevent lower leaf chlorosis without affecting harvest time, plant quality or shelf life of two cultivars of three series of bracteantha. The first experiment was to reduce the rate of fertilizer two weeks prior to harvest. Treatments were no fertility reduction (300 mg/liter), 50% reduction (150 mg/liter), and 100% reduction (0 mg·L⁻¹). At harvest, plants were evaluated for shelf life in a growth room at 21.1 ± 1.3 °C and 6 μmol·m⁻²·s⁻¹ PPF. Five cultivars in the 100% fertility reduction treatment had decreased height and/or width index at harvest and three cultivars maintained higher postharvest quality ratings compared to the other treatments. Separately, the effect of the duration of fertilization was evaluated by terminating fertilization at weekly intervals (0–6 weeks) throughout production. Ceasing fertilization two to three weeks prior to harvest produced plants with lower leaf area without affecting flower number. In another experiment, thidiazuron (TDZ) as a foliar spray at 0, 0.1, 0.5, and 1.0 mg·L⁻¹ was applied to decrease lower leaf yellowing. SPAD-502 chlorophyll meter readings of lower leaves were increased with 0.1 mg·L⁻¹ TDZ treatment compared to the control. Phytotoxic symptoms occurred on plants receiving higher TDZ rates.

Sorting the Heated Mess: Screening Tulip Cultivars for Sensitivity to Heat

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Tulip bulbs are produced in the Netherlands and are shipped to United States during the months of July and August in temperature-controlled shipping containers. Each shipment is often composed of a mixture of many cultivars. Mechanical failure of temperature controls may result in high temperatures that ultimately may reduce forcing quality of the bulbs. When such accidents occur, an immediate decision must be made about whether to invest more time and money on these *potentially* damaged bulbs. Such a decision is not easy because symptoms of heat damage are often delayed until months later. Research on a single cultivar, ‘Apeldoorn’, has shown that heat stress can cause flower abortion and other abnormalities. However, cultivars undoubtedly vary in their response to heat stress. Thus in the 2002 and 2004 forcing seasons, ≈45 cultivars were screened for response to a standard heat stress of 4 days at 35 °C. Prior to the heat stress, bulbs were held at 17 °C or 9 °C for 4 weeks, mimicking conditions used for late and early forced bulbs, respectively. Flower and leaf height, percent flower abortion, and flowering date were evaluated. Heat stress caused flower abortion and reduced plant height in sensitive cultivars. Across all cultivars, cold storage prior to the heat stress significantly increased bulb’s sensitivity to heat stress. Using percent flower abortion, cultivars were grouped into three categories: resistant, moderate, and susceptible. With this information, we hope that damage assessment may become easier and fewer bulbs wasted.

Time to Flowering and Survival of Two Herbaceous Perennials is Affected by Day/Night Temperature Difference

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Research by the authors has demonstrated the effect of day/night temperature difference (Tdiff) on plant growth is as substantive as the effect of daily average temperature (DAT). Dependence of plant primary productivity on temperature cannot be assessed with fewer than two data per 24 hours. Thus, the same experimental approach was applied to time to anthesis in *Delphinium cultorum* Voss ‘Magic Fountains’ and *Stokesia laevis* L. ‘White Parasols’, and to survival in *D. cultorum*. Two hundred and seventy seedlings of *D. cultorum* and 72 plantlets of *S. laevis* were grown for 56 days in growth chambers under eighteen 12 hour day/12 hour night combinations of six day and six night temperatures (10, 15, 20, 25, 30, or 35 °C). Ninety plants of *D. cultorum* were harvested after 13, 34, or 56 days, and 36 plants of *S. laevis* after 34 or 56 days. For each event of interest (anthesis or death), one datum per plant was recorded, consisting of time elapsed

when either the event occurred, or the plant was harvested, whichever came first. Each datum was paired with an indicator of whether the plant was harvested prior to the event being observed. Data were analyzed using time — to — event data analysis procedures. Several parametric distributions fitted the data equally well, and both day and night temperature had strong effects on time to anthesis and survival time. However, in contrast with biomass production, DAT was quite sufficient to account for timing of these developmental events in relation to temperature. Addition of Tdiff contributed marginally to the fit to the data, but the magnitude of the effect was considerably smaller. Within the range of temperatures likely to be encountered in cultivation, the effect was negligible.

Oral Session 37—Ornamentals/Landscape/Turf

Moderator: TBA

July 20, 2004, 1:30 –3:00 PM

Trinity B

Evaluation of Hardy Shrub Roses for the Upper Midwest

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A hardy shrub rose evaluation trial was planted at three locations in Wisconsin representing U.S.D.A. cold hardiness zones 3, 4, and 5. There were nine replications of each of the 20 different, new or underused rose cultivars located at each location. The roses were then evaluated monthly (May–Nov.) for three years. Monthly data were taken and parameters included: plant height, width, flowers (color, size, amount, duration), insect injury, disease susceptibility, hips (production, size, and color in fall), and amount of winter dieback in spring. Pesticides and winter protection were not used in the trial to properly evaluate for pest resistance and cold hardiness. Pest resistance for roses varied among the cultivars. ‘Marie-Victorin’ was the most severely infected rose by insects. Blackspot and anthracnose were severe (>60% of plant infected) on ‘Robusta’, Red Fairy™, Kaleidoscope™, Cambridge™, and Madison™. Flower amount and continuous bloom occurred on Carefree Delight™, Cambridge™, Madison™, Knockout™, Fire Meidiland™, Mystic Meidiland™, and Red Fairy™. Hip production occurred on many of the cultivars, however, only Carefree Beauty™, ‘Marie-Victorin’, and Mystic Meidiland™ produced colorful orange-red hips. Winter hardiness also varied between the cultivars.

Screening Landscape Roses for Salinity Tolerance

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Given the regularity of periods of drought in the southwestern U.S., concern over an ample supply of high quality water is always an issue. With a diminishing water supply, higher quality water will likely be diverted to higher priority uses; therefore, concern arises over the availability and quality of water for landscape use. This project was designed to screen representative cultivars from several of the major garden rose categories (China, Tea, Polyantha, Hybrid Tea, and Found Roses) for tolerance to saline irrigation water. Roses were placed in a completely randomized design with four replications in a container holding area. Salinity treatments were designed to be a 2:1 molar ratio of NaCl:CaCl₂. The treatments consisted of 0, 6.25, 12.5, 25, and 50 mmol NaCl. The volume of solution applied to each treatment was adjusted at every irrigation event to meet ET and produce a 30% leaching-fraction. At the conclusion of the study, the China rose retained the best foliage while one of the hybrid tea roses maintained flowering throughout the study at all treatment levels. It appears that the roses with the smallest leaflets were able to tolerate salinity better than those with larger leaflets. Results of the tissue sample, leachate, spad and media analyses will also be presented.

Characterization of Floral Initiation and Development in *Hydrangea macrophylla* Cultivars Varying in Re-blooming Capacity

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Recently, the release of *Hydrangea* cultivars with the capacity to produce a second flush of blooms has created a great expectation in the ornamental industry. However, the lack of fundamental information on flower development of big leaf *Hydrangea* does not allow a descriptive explanation of why re-blooming capacity occurs. The objectives of this study were to characterize the timing and location of flower initiation and development in several *H. macrophylla* cultivars throughout an annual cycle. Four cultivars were evaluated: 2 exhibiting re-flowering capacity (Penny Mac-PM and Endless Summer-ES) and 2 without (Madame Emile Mouillere-MEM and Nikko Blue-NB). Plants were managed under outdoor nursery conditions and harvested at each of four different time periods. These periods represented key developmental stages: 1) Pre-induction: late summer, after completion of shoot expansion; 2) Post-induction: late fall, following short day and cold temperature exposure; 3) Dormancy: winter, post leaf abscission; and 4) Post-dormancy: early spring, just prior to bud break. At each sampling time, bud location (terminal or lateral) and stem origin (basal, lateral, terminal, or secondary) were established. All buds >2 mm were dissected under a stereomicroscope and the degree of floral induction was determined. Floral primordial were initiated not only in the terminal buds but also within axillary buds. The degree of induction and development varied according to the stem origin, bud location and cultivar. Cultivars with re-blooming capacity had floral primordial initiated within buds at the first sampling period prior to receiving inductive conditions. This suggests they may have minimal or no photoperiodic/temp requirements for flowering.

The Effect of Leaf Wax Extracts from the Leaves of Eight Azalea Genotypes (*Rhododendron* spp.) on Feeding and Oviposition by Azalea Lace Bug [*Stephanitis pyrioides* (Scott)]

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Azalea Lace Bug (ALB) is a significant pest on azalea species. ALB feeding injury causes a stippled appearance on the leaves of susceptible genotypes from late spring until leaf drop. To determine whether leaf surface lipids are a factor in determining resistance or susceptibility to ALB, epicuticular leaf wax was extracted from the leaves of eight azalea genotypes, half with resistance and half susceptible to ALB. Leaf wax from each genotype was extracted and re-suspended in an 2 ethanol : 1 water solution for application to all entries in a full diallel manner, including a control of solution only. Each treatment included three replications. The leaf wax solution was applied to each replication (single leaf) by painting the solution on one side of the midrib, on both abaxial and adaxial surfaces. By applying solution to one side of the leaf, the untreated leaf surface served as a control. Each leaf and two female ALB were placed in separate 50-mL sealed tubes at 24 °C and 12-hour daylength for 48 hours, at which time the number of live adults, frass spots, and eggs were counted. Frass and egg data were recorded separately for treated and untreated sides of each leaf. The application of leaf wax solution had an impact on the level of frass and egg deposition by ALB in all genotypes. The effect was most pronounced when solution of resistant genotypes was placed on susceptible genotypes, resulting in lower numbers of frass spots and eggs. The solution alone had little effect on frass or egg numbers. This research acknowledges that a major constituent of an azalea's resistance or susceptibility to ALB is via epicuticular wax components.

Results from a Multi-year Evaluation Study of *Epimedium* Taxa

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The Chicago Botanic Garden (USDA Hardiness Zone 5b, AHS Plant

Heat Zone 5) conducted an evaluation study of 40 taxa of *Epimedium* from 1995 to 2001. The goal of this project was to select superior taxa based on winter hardiness, ornamental merit, pest and disease resistance, and cultural adaptability. Three plants of each taxon were grown in a site that features a variety of light levels and diverse microclimates. Of the 40 taxa that began this trial, 33 survived to receive final ratings that ranged from excellent to poor. Although a wide variety of data was collected for each taxon, overall ratings were based on four criteria: flower coverage, health quality, overall habit quality and winter hardiness. Among the rated plants, three varieties stood apart from the others: *Epimedium* 'Crimson', *E. grandiflorum* 'Sonoyzki' and *E. × versicolor* 'Neosulphureum'. One of the most significant characteristics that separated the best performers from the mediocre and poor performers was winter hardiness. Five taxa lost all three plants in the first winter of the trial and were not retested. Several other taxa had their overall ratings severely impacted by winter losses. In addition to winter hardiness, data on frost damage, nutrient limitation and rabbit damage were also collected. *Epimedium* habits varied from clumped to widespread groundcovers. Of the 33 barrenwort taxa to receive final ratings, nine were determined to have significant potential use as groundcovers. Also, 12 taxa displayed highly ornamental, early-season foliage colors in shades of burgundy, bronze and red.

New Golden Leaf Cultivar of *Celtis julianae* ('Golden Phoenix') and Its Primary Research

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As well as investigating physiological characteristics of the new yellow cultivar of *Celtis julianae* — 'Golden Phoenix' (Julian hackberry, which originally distributed in south of China, is important environmental plant, because there are numerous hairs on surfaces of the leaf, which can absorb dust and clean the air. Julian hackberry is deciduous big tree, more than 25 meters in high, with deep green leaf, red flower and orange fruit, blossoming in April.), differences in leaf color between the new cultivar and the normal *Celtis julianae* were evaluated. The new cultivar is a natural seed mutant from some cultivated seedlings of *Celtis julianae* found in 2001. It has golden yellow leaf, average color is Yellow-Green150A mensurating by English Color Card, is significantly more different than those of the normal. It can normally growing but slowly, with smaller plant-size and shorter internode than common plant. The new cultivar's leaf contains less chlorophyll than the normal, but same carotenoid. Its net photosynthetic rate is lower than that of Julian hackberry common cultivates in full sunlight. Shading of leaf to 50% sunlight decreases chlorophyll content and photosynthetic rate compared with full sunlight and sharper in photosynthetic, resulting in deepen green color. Leaves of the new cultivar show higher values of lightness and yellow-green as compared with other normal. Shoot multiplication frequency was highest on woody plant medium containing 1.5 mg 6-BA(benzyladenine)/ml, producing 6 shoots from a single explant, but these are some troubles to root.

Selecting the Best Citrus Rootstock for Young 'Valencia' Orange Trees Under Soil Salinity Stress Conditions

A.M. Akl*¹

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This study was conducted during 2002 and 2003 seasons to select the best citrus rootstocks for young 'Valencia' orange trees grown under soil salinity stress. Six citrus rootstocks namely Volkamer lemon, Cleopatra mandarin, Troyer citrange, Rough lemon, Egyptian lime, and Sour orange were tested. Four soil salinity levels, namely, 0.0%, 0.1%, 0.2%, and 0.4% were examined. Results showed that growth criteria, plant pigments and percentages of N, P, and K in the leaves of 'Valencia' orange onto all citrus rootstocks tended to reduce with raising soil salinity. The harmful effects imposed by soil salinity was 'Valencia' orange on Volkamer lemon, Cleopatra mandarin Troyer citrange, Rough lemon, Egyptian lime, and Sour orange, in ascending order. Results

proved the superiority of Volkamer lemon, Cleopatra mandarin, and Trouyer citrange rootstocks for 'Valencia' orange transplants grown under salinity conditions as compared to the other rootstocks. 'Valencia' orange on such promising rootstocks could tolerate soil salinity until 0.20‰ without adverse effects on growth of transplants. Sour orange rootstock seems to be the lowest suitable stock for 'Valencia' orange transplants grown under soil salinity conditions.

Oral Session 38—Environmental Stress Physiology 2

Moderator: Chieri Kubota

July 20, 2004, 1:30–3:30 PM

Wedgewood

Radish (*Raphanus sativus*) as a Model System for the Study of Soil Moisture Effects on the Glucosinolate-myrosinase Complex

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Clarifying the influence of abiotic environmental factors on the glucosinolate-myrosinase complex in vegetables of the *Brassicaceae* is an important step in understanding physiological processes that affect crop quality. Previous related work in this lab has shown that irrigation timing in the field may influence physical-, chemical- and sensory-based indicators of cabbage quality. The objective of this study was to record glucosinolate concentrations and myrosinase activity in crop tissues from plants subjected to varying soil moisture levels, employing radish as a model. Plants of cv. Belle Glade were grown in a controlled environment system designed at the Ohio Agricultural Research and Development Center in Wooster, Ohio for maintenance of target soil moisture levels. Pots were maintained at three soil moisture ranges, 40% to 60% (A), 20% to 30% (B) and 10% to 20% (C) volumetric soil moisture content at 30 °C. Preliminary observations revealed that treatments A, B and C corresponded to soil tensions which were not stressful, moderately stressful, and severely stressful to plants, respectively. Pot evapotranspiration, leaf stomatal conductance and plant size followed the order A>B>C, while canopy temperatures followed the order C>B>A. In leaves, glucosinolate concentrations and myrosinase activity were about 15% greater in treatments B and C than in A, while glucosinolate levels and myrosinase activity were 28 and 50% lower in hypocotyls and roots, respectively, in C than in A. It is hypothesized that changes in enzyme and substrate synthesis and translocation within the plant in response to sub-optimal soil moisture levels may explain the differential response of tissue glucosinolate concentrations and myrosinase activity to soil moisture treatments.

Photosynthesis, Respiration, and Water Relations of Vinca and Salvia Subjected to Moisture Stress

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Subjecting bedding plants to non-lethal moisture stress is an established irrigation practice for bedding plants; however information on physiological responses of bedding plants to moisture stress is limited. We examined the CO₂ exchange rates (CER) and water relations of salvia (*Salvia splendens*) and vinca (*Catharanthus roseus*) during moisture stress. Seedlings of both species were grown from seed in 7-L trays containing a soilless growing medium. After plants completely covered the trays, they were irrigated and shifted into whole-plant gas exchange chambers (27 °C and daily light integral of 7.5 mol/m²) arranged inside a growth chamber. Inside the gas exchange chambers, the growing medium was allowed to dry and plants were re-watered after wilting. Results from this study indicate that the growth rate (moles of CO₂ gained by plants in a day) of salvia was higher than vinca before experiencing moisture stress; however the volumetric moisture content of the growing

medium at which plant growth decreased was higher for salvia than for vinca. During moisture stress, the decrease in growth rate of salvia was gradual and that of vinca was rapid. After re-watering the plants, leaf water potential (Ψ_L) and growth rate of vinca revived completely, and Ψ_L of salvia remained low (more negative), whereas its growth rate revived completely. This study shows that bedding plant species respond differently to moisture stress, particularly with respect to the critical substrate moisture level for initiating moisture stress and the rate of development of moisture stress.

Optimization of Long Distance Transportation Conditions for High Quality Tomato Seedlings: Effects of Air Temperature and Light inside Trailers

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Increasing numbers of vegetable growers purchase their transplants from specialized transplant producers. Possible deterioration of transplants during transportation limits the market size as well as the potential sources of high quality transplants. To determine best conditions for transportation of seedlings, tomato (*Lycopersicon esculentum*; 'Durinta') seedlings with visible flower buds were placed for 4 days under varied air temperature (6, 12, or the conventional transportation temperature of 18 °C) and light intensity 0 (conventional darkness) or dim light at 12 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ PAR). Plants were evaluated for visual quality, photosynthetic capacity, growth and ultimately fruit yield. Lower temperatures and illumination significantly maintained visual quality of the seedlings. Lower temperature maintained high photosynthetic capacity of the seedlings during transportation. Growth and development of the seedlings were significantly affected by higher temperature resulting in significantly delayed growth and development. Number of fruits set on the first truss was significantly reduced when seedlings were at 18 °C during transportation. Overall, simulated transport at 6 °C under light showed the best transportability without experiencing negative impact for the 4-day simulated transportation. Seedlings at 6 °C in darkness and at 12 °C under light and in darkness also showed satisfactory transportability. Seedlings at 18 °C exhibited serious quality deterioration of seedlings, delay in early growth and development, loss of flower buds on the first truss and yield reduction, which agrees with the fact that conventional transportation is currently able to be no longer than 3 days in duration.

Phytotoxicity of Copper in Greenhouse Crops

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Copper is one of the essential micro-nutrient elements for plants, but when in excess, is toxic to plants and other living organisms. Electrolytically generated copper and cupric sulphate are increasingly used by the greenhouse industry to control diseases and algae in hydroponic systems. However, there is little information regarding appropriate strategies for employing copper in greenhouse crop production. We investigated the physiological responses, growth and production of several ornamental crops (miniature rose, chrysanthemum and geranium) and greenhouse vegetable crops (pepper, cucumber, and tomato) with respect to Cu₂₊ concentration in the root zone. Tests were conducted using plants grown in nutrient solution, Promix and rockwool. Results showed that phytotoxic levels of Cu₂₊ were dependent on the crop species and growing substrate. Plants grown in nutrient solution exhibited symptoms of phytotoxicity at lower Cu₂₊ concentrations than those on the solid substrates. The ability of copper to control *Pythium aphanidermatum* and green algae was evaluated under both laboratory and greenhouse conditions. Copper was effective in suppressing green algae in nutrient solution, but did not control *Pythium* effectively. This presentation is a

comprehensive summary of the research conducted over the last three years by our group on copper application in greenhouse systems.

Trinexapac-ethyl and Paclobutrazol Protect against Drought in Hot Pepper Plants

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Compounds that modulate the synthesis of gibberellin (GA) can also enhance resistance to abiotic stress in treated plants. Seed treatments of 600 ppm trinexapac-ethyl (TE), which inhibits GA synthesis by blocking the transformation of GA₂₀ to GA₁ and foliar applications of 15 ppm paclobutrazol (Paclo), which inhibits the oxidation of ent-kaurene to kaurenoic acid, were applied separately or together to three varieties of hot pepper (*Capsicum annuum* L.) that are popular in Thailand. Greenhouse-grown plants were subjected to 7–10 days of drought, and then rewatered before transfer to a screenhouse. Khee Noo (an upright “bird type” pepper) was most sensitive to drought, compared to Bang Chang and Hot (“cayenne type”). In all varieties, both Paclo and TE treatments reduced the height of irrigated plants, but led to the retention of both plant size and pepper yield in droughted plants, compared to either irrigated plants or to untreated droughted plants. Treatment with Paclo provided the greatest retention of leaf relative water content (RWC) under drought conditions, with no advantage to the combination Paclo+TE treatment. Only Paclo treatment increased leaf thickness in Bang Chan and Hot, whereas both Paclo and TE had similar effects on increasing leaf thickness in Khee Noo. Khee Noo was the variety most responsive to Paclo or TE treatments, with increases in leaf thickness, epicuticular wax, and leaf pigments, all of which may better allow the plants to survive stress by storing leaf moisture, enhancing photosynthesis (chlorophyll), and preventing oxidative injury (carotenoids). Electrolyte leakage, indicative of membrane permeability and thus of susceptibility to stress, was diminished by 25% to 33% in leaves from plants treated with Paclo or TE.

Assessment of *Leitneria floridana* in Disjunct Native Habitats: Implications for Horticulture and Conservation

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Tolerance of shade, flooding, drought, and nutrient-poor substrate is desirable among ornamental plants installed in managed landscapes. Many attractive native taxa have not been evaluated for their resistance to environmental stressors. We assessed Florida corkwood (*Leitneria floridana* Chapman) in its natural habitat in four disjunct populations in the United States and tested the physical and chemical properties of the soil at the study sites. Measures at all sites were made within two weeks in late June, 2003. Leaf area, plant height, length of new shoots, and the rate of photosynthesis were higher among plants receiving more than 600 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ of photosynthetically active radiation (PAR) compared to plants that occurred where maximum PAR was lower. Soil texture ranged from clay loam to fine sand, and soil pH across sites was 4.5 to 6.6. Concentration of nitrate-nitrogen, phosphorus, and potassium ranged from 3 to 75 $\text{mg}\cdot\text{L}^{-1}$, 7 to 11 $\text{mg}\cdot\text{L}^{-1}$, and 3 to 64 $\text{mg}\cdot\text{L}^{-1}$, respectively. Bases of plants in Florida were submersed in water, while soil moisture percentages in Missouri and Texas were 6 to 30. The apparent tolerance of *L. floridana* to shade, low and high soil moisture, and nutrient-poor soil in native habitats indicates that it could be used in a wide range of managed landscapes. Its capacity to adapt to shade may permit the use of *L. floridana* as an understory species in managed landscapes, but stewards of natural areas may need to maintain open sites within its native habitat to allow expansion of populations. Because this assessment of *L. floridana* included

native populations across the natural range of the species, our results are uniquely suited for both horticultural and ecological interpretation and application.

True Firs (*Abies* sp.): New Conifers for the Midwestern Landscape

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The genus *Abies* is a member of the family Pinaceae and consists of approximately 55 species found mainly in upper latitudes or higher elevations in the northern hemisphere. Firs generally prefer cool, well-drained sites with acidic soil. Fir trees are occasionally used as landscape trees but are more commonly grown as Christmas trees. Recently, the Michigan State Univ. Forestry Dept. and the Michigan Christmas tree industry initiated a field test of exotic firs (*Abies* sp.) for potential use as Christmas trees. In the present study we expanded the evaluation of these exotic fir species to include their suitability as landscape trees and to characterize their tolerance to various environmental stresses. We compared foliar nutrition, gas exchange, chlorophyll fluorescence, and shoot morphology of 23 *Abies* species and hybrids planted at three horticultural research stations in Michigan. Foliar nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), sulfur (S), boron (B), zinc (Zn), and copper (Cu) were correlated ($P < 0.05$) with soil pH. Species and hybrids varied ($P < 0.05$) in maximum photosynthetic rate, water use efficiency, chlorophyll fluorescence, and the ratio of total needle area to projected needle area. We will discuss the significance of these traits in relation to selecting trees adapted for use in the Midwestern landscape.

Effects of Salinity and Drought stresses on *Petunia* Transformed for α -Galactosidase Expression

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Salinity, drought and temperature frequently limit crop productivity. Transgenic *Petunia \times hybrida* cv. Mitchell with altered endogenous raffinose family oligosaccharides (RFO) due to over-expression (sense) or under-expression (antisense) of the tomato α -galactosidase gene show that antisense increases in RFO are associated with greater tolerance to freezing stress (Pennycooke et al., 2003). Because vegetative propagules of these antisense lines rooted and established more quickly than their sense counterparts, we hypothesized that antisense lines would also respond to salinity and wilting stress. Salinity treatment plants were exposed to 50–200 mM NaCl graduated 25 mM every 3 days and held at 200 mM for 13 days. Dry-down treatments were watered to pot capacity, then not watered until the onset of wilting. This was repeated in cycles for 26 days. Data were collected on plant growth, root/shoot ratios, and leaf water potential. Fresh and dry weights in four of the six antisense lines exceeded the wild type and sense lines. Osmotic potential for salinity and dry-down plants was 160% to 220% higher than control plants. Pearson correlations revealed that higher osmotic potential was partially associated with higher fresh weight ($r = 0.7214$, $P = 0.02$) and root/shoot ratios ($r = -0.7414$, $P = 0.02$) in salinity stressed plants. In the dry-down drought stressed plants, osmotic potential was not associated with fresh weight ($r = 0.3364$, ns) nor root/shoot ratio ($r = -0.0431$, ns). Salinity stress reduced root mass compared to control and dry down plants. Sense plants grew slowly and were highly variable.