Effectiveness of MAS and PHE in cucumber breeding is influenced by the traits and populations under selection. These results indicate that both MAS and PHE were effective in improving yield (fruit per plant) and other morphological traits. However, MAS was superior in improving earliness (EAR) and fruit size (FY), while PHE was generally more effective than MAS for greenness (GYN) and earliness (EAR). The population for which MAS was superior, but PHE was generally more effective than MAS for GYN and EAR.

Detection of Genetic Variation in Wild Populations of Three Allium Species using Amplified Fragment Length Polymorphisms (AFLP)

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1Utah State University, Plants, Soils, and Biometeorology, Logan, UT, 84322-4820; 2Utah State University, USDA-ARS Forage and Range Research Lab.

The genus Allium is distributed worldwide and includes about 80 North American species, with at least 13 occurring in Utah. Our study focuses on the population dynamics of three Allium species native to Utah: Allium acuminatum, A. brandegei, and A. passeyi. In conjunction with our studies of life history, growth characteristics, demographies, and habitat, we are interested in determining the levels of genetic variation in these species. This study examines amplified fragment length polymorphism (AFLP) within and among the five Allium acuminatum, four A. brandegei, and three A. passeyi populations native to Utah. These species have contrasting abundance and distribution. The study populations were selected along an elevation gradient to represent within-species habitat differences. About 10–20 plants from each of the 12 populations were genotyped using six AFLP primer combinations, which detect DNA variation within and among all three species. These data will be used to compare levels of genetic variation and isolation among populations and species.

Relationships Among Reducing Sugar, Asparagine, and Chip Color in Wild Solanum Species

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When stored at temperatures less than 10 °C, tubers of all cultivated potatoes exhibit cold-induced sweetening (CIS) during which starch degrades to sucrose, glucose, and fructose. Upon frying at high temperatures, the reducing sugars (Fru, Glu) interact with free amino acids via the non-enzymatic Maillard reaction to form dark-colored chips that are unacceptable to consumers. In addition, scientists recently discovered that the toxic chemical acrylamide is also produced during frying. Although storage at warmer temperatures reverses CIS and circumvents dark chip production, the probability of storage loss due to shrinkage and disease increases. Wild Solanum species form the backbone of many potato-breeding programs. In this study, we evaluated 36 different plant introductions (PI) including 20 different species, grown in Madison and Rhinelander, Wis., to identify germplasm resistant to CIS for genetic analysis. After storage for 2–3 months at 4 °C, tuber sugar and amino acid content were analyzed via HPLC and slices were fried to determine chip color. Sugar and chipping data support previous research indicating CIS resistance in S. okadae, S. raphanifolium, and S. phuhe. Interestingly, some germplasm selections with high reducing sugar content produced light-colored chips, indicating exceptions to the typical correlation between reducing sugar content and chip color. Genetic bases to these exceptions are under evaluation.

Using Prevosti’s Distance Coefficient for Direct Statistical Analysis of Population Differences

Theodore Kisha*, Richard Johnson1, Dan Skinner1, Stephanie Greene2

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Three alfalfa populations were compared using four molecular marker
systems. Population differences were analyzed using Prevosti’s distance coefficient, which is a measurement over all loci of the proportion of unshared alleles. The variance of this sample distance is related to the genetic diversities used in calculating F-statistics and can be easily generated using a spreadsheet. The simplicity of statistical testing using Prevosti’s distance, and its accuracy at small distances compared with other coefficients, are unique and useful characteristics of this measurement.

Genetic Relationships of *Spathiphyllum* Cultivars Analyzed by AFLP Markers

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1University of Florida, Mid-Florida Research and Education Center, Apopka, FL, 32703; 2University of California-Riverside, Department of Botany and Plant Sciences, Riverside, CA, 92521

Peace lily (*Spathiphyllum Schott*) is one of the most popular tropical ornamental foliage plants and is used worldwide for interiorscaping. However, little information is available on the genetic relationships of cultivars. Using amplified fragment length polymorphism (AFLP) markers with near-infrared fluorescence-labeled primers, this study analyzed genetic relatedness of 63 commercial cultivars and breeding lines. Forty-eight EcoRI + 2/Msel + 3 primer set combinations were initially screened, from which six primer sets were selected and used in this investigation. All cultivars were clearly differentiated by their AFLP fingerprints, and the relationships were analyzed using the unweighted pair-group method of arithmetic average cluster analysis (UPGMA). The 63 cultivars were divided into four clusters. All commercial cultivars or breeding lines resulted from crosses of some of the cultivars, a total of 45, were positioned in cluster I with Jaccard’s similarity coefficients between 0.61 and 0.88. There was only one cultivar in cluster II. Cluster III contained 16 cultivars; they are either species or breeding lines generated from interspecific hybridization. Cluster IV had one unknown species. This study provides genetic evidence as to why cultivars from cluster I and III are not readily crossable because the Jaccard’s similarity coefficient between the two clusters was only 0.35. Results also indicate that commercial cultivars are genetically close. Strategies for increasing genetic diversity of cultivated peace lily should be sought for future breeding efforts.

Oral Session 2—
Consumer Horticulture & Master Gardeners

27 July 2006, 2:00–3:30 p.m.  Nottoway

Moderator: Richard Durham

Introduction to Landscape Design as Continuing Education for Master Gardeners

Kerrie B. Badertscher*

University of Nevada, Reno, Cooperative Extension, Reno, NV, 89502

Colorado currently has no licensure program for landscaping and many people applying to the Colorado Master Gardener program have indicated a desire to seek entry-level training in order to determine if a second career in horticulture is feasible. Alternatively, some each year who complete this basic training go on into the Green Industry either in basic design and/or maintenance. Colorado State University Cooperative Extension came together with Associated Landscape Contractors of Colorado and the Colorado Nursery Association (now CNGA) to create the Rocky Mountain Landscape Design Guide. The purpose of this publication was to inform the general consumer about the landscape design process. A review will be given using this publication with concurrent laboratory activities to Master Gardeners as a continuing education piece.

Innovative Teaching of Botany to Master Gardener Trainees

Linda McMahan*

Oregon State University, Department of Horticulture, OSU Extension, Yamhill County, McMinnville, OR, 97128

The science of botany is often daunting to people who are training to become Master Gardener volunteers. However, the range of natural diversity of plants as well as practical information about plant anatomy are essential foundations for other parts of Master Gardener training. I will present a botany module that I have developed over the past 5 years. The module focuses on relevance to the trainee and builds on basic information to examine more complex aspects of botany, all in the space of the 3–6 hours often allotted for basic botany training. It begins with a “tour” of the plant kingdom and plant relatives like algae and fungi, mosses, liverworts, and ferns. I follow this with basic morphology of stems, roots, and leaves; this basic morphology is used to answer the question of how water and minerals move from the soil into and throughout plants, even reaching the height of the tallest tree. A short segment on mycorrhizae reinforces water and mineral transport, while providing a link to the plant kingdom tour. The mycorrhizal section also reinforces or complements training on soils, which is often presented in another portion of the training schedule. Finally, a segment on flowers introduces basic terminology and winds up a discussion of how to recognize monocotyledons and dicotyledons. Several optional hands-on activities help active learners assimilate the information and provide needed reflective time for more traditional learners. The module has been adopted as the official OSU Extension Master Gardener™ Program botany module in Oregon.

Revamping a Master Gardener Curriculum for Use in Prison Job Readiness Programs

Angela M. O’Callaghan*, M.L. Robinson

University of Nevada Cooperative Extension, Las Vegas, NV, 89146

University of Nevada Cooperative Extension (UNCE) faculty members have taught horticulture to inmates of correctional facilities for over 8 years. The training material used was the Master Gardener curriculum. Because inmates in Nevada have few opportunities to meet requirements for certification as Master Gardeners, this program was described simply as a horticulture class. Over the past 3 years, we have redirected it toward job readiness to assist inmates after release. The curriculum was first expanded to do intensive teaching on such topics as irrigation, landscape plant selection and maintenance, and problem solving. Even with these changes, horticulture jobs generally limited to low-paying, entry level ones. To improve employment opportunities, UNCE obtained the involvement of the Nevada Department of Agriculture. After inmates have passed the horticulture program, they may take the state pesticide applicator training and examination. This year, a mini course in “Developing a Business Model” will be added to the initial curriculum. To date, 36 inmates have received PAT certification. Conversations with potential employers indicate that this significantly enhances their likelihood of employment at a higher-than-entry level.

The Impact of the Louisiana Master Gardener Program on the Perceived and Actual Horticultural Knowledge of Program Participants

Bobby H. Fletcher, Jr.*, Michael F. Burnett1, Krisanna L. Machtimes2, Jeff S. Kuehny3

1Louisiana State University Agricultural Center, Louisiana Cooperative Extension Service, Thibodaux, LA, 70301; 2Louisiana State University, School of Human Resource Education and Workforce Development, Baton Rouge, LA, 70803; 3Louisiana State University, Department of Horticulture, Baton Rouge, LA, 70803

The primary purpose of this study was to determine the impact of participation in the Master Gardener program on horticultural knowledge and practice. In 1972, the “Master Gardener” concept was initiated in Washington State due to the high demand to answer consumer horticultural questions. The main objective of this program is to increase
horticultural knowledge of program participants so they can transfer this information to consumer horticultural clientele. The program quickly spread throughout the United States. It reached Louisiana in 1994 and was expanded throughout most metropolitan areas by 1997. No formal evaluation has been conducted to determine the horticultural knowledge impacts of this program. All 257 participants in the 2004 Louisiana Master Gardener (LMG) program were surveyed before and after participation in this program. The survey used was a researcher-developed instrument designed to measure self-perceived knowledge, tested knowledge, and Best Management Practices (BMPs) used. Data were collected by master gardener coordinators and submitted to the researcher after each phase of data collection (pre and post). Results of the study revealed that the LMG participants were highly educated, mostly Caucasian, and mostly female. Significant improvements were identified in all of the knowledge and practice measurements included in the study. These included self-perceived improvements were identified in all of the knowledge and practice measurements included in the study. These included self-perceived knowledge, tested knowledge, and use of BMPs. It was concluded that the 2004 Louisiana Master Gardener program was effective in increasing the self-perceived horticultural knowledge and tested horticultural knowledge of program participants. In addition, the study concluded that the 2004 Louisiana Master Gardener program improved the use of BMPs among the participants.

The Relationship of Knowledge, Attitudes, and Perceptions Regarding Non-native Texas Invasive Plant Species

Sharon Frey*, Carolyn Robinson
Sam Houston State University, Agricultural Sciences, Huntsville, TX, 77340

Plants have been introduced into the United States intentionally as well as unintentionally as seeds and weeds. Technological advances, a mobile society, and our curiosity and desire to improve our landscapes have led to an ever-increasing invasive movement. These alien plants can jeopardize native populations, alter ecosystems, alter fire and water regimes, change the nutrient status, modify habitats, and cause significant economic harm. Today’s public is unaware of the danger some non-native plants species pose to natural areas, thereby contributing to the lack of control for non-native invasive plants. This study looked at the knowledge and attitudes of Texas Master Gardeners as related to invasive species commonly used in landscaping. A web survey was made available to all Texas Master Gardeners that included pictures of plants along with their common and scientific names. Participants were asked to identify which they thought were invasive and contribute information regarding their knowledge of non-native invasive plants. Each of the invasive plants shown is on both the federal and the Texas Invasive Plant lists. Inquires were made concerning the occurrence of these plants in the participants’ personal landscape and communities and their perceptions of each plant as an invasive threat. The purpose of the study is to determine if a relationship exists between knowledge, attitudes and perceptions of the participant and the occurrence of non-native invasive plants in the landscape. The results of this study will help determine factors that contribute to the lack of control for non-native invasive plants.

The eXtension Consumer Horticulture Community of Practice

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A Community of Practice (CoP) for consumer horticulture has been formed as part of the eXtension system. The CoP was organized at the National Consumer Horticulture Forum held Nov. 2005 at the Minnesota Landscape Arboretum. The meeting was attended by representatives of 24 states from all four Extension geographical regions. The attendees discussed project priorities and began to build a framework for working together across state lines on eXtension-sponsored activities and other efforts. Initial plans from the meeting include constructing a National Consumer Horticulture FAQ database, developing online learning modules that can be used for Master Gardener training, and developing marketing tools to better identify consumer horticulture resources available through local as well as national Extension activities. This presentation will provide additional details regarding the Consumer Horticulture Forum, an update regarding consumer horticulture activities within eXtension, and an opportunity for members of ASHS to learn how they can get involved in eXtension. Information regarding eXtension CoPs (including Consumer Horticulture) is continually being updated on the eXtension CoP Web site (cop.extension.org) and information regarding the Consumer Horticulture Forum has been posted on the Consumer Horticulture CoP Community Home page (cop.extension.org/wiki/Consumer_Horticulture_Community).

Oral Session 3—Floriculture

27 July 2006, 2:00–3:15 p.m. Oak Alley
Moderator: Jonathan Frantz

Light, Fertilizer, and CO₂ Interact in Petunia ×hybrida Nutrient Uptake and Partitioning

Jonathan Frantz*, Peter Ling

Bedding plant petunia (Petunia ×hybrida) is often produced with high nutrient concentrations as a cool-season crop. How a plant uses the nutrients supplied will depend in large part on the environmental factors influencing growth rate, such as light and CO₂. Since more growers are considering using supplemental CO₂ to improve energy efficiency for plant production, it is important to understand light and fertilizer levels needed for efficient production of high-quality plants. Using a multi-chamber controlled environment system, petunia plants were grown from seed for 6–8 weeks after transplanting into different light and CO₂ environments and fed with either a low (7.1 mM N) or high (21.3 mM N) fertilizer regime. Plants were evaluated for appearance, harvested periodically, and separated into flower, stem, and leaf biomass. Biomass was then dried and analyzed with ICP-OES for essential macro- and micronutrients. Low-fertilizer-grown plants had consistently earlier and more flowers, but showed symptoms of nutrient deficiencies in the final few weeks of production at all light and CO₂ levels. There were significant interactions between light and fertilizer treatments for different nutrients. Calcium uptake was greatly influenced by light level, Fe, P, and K were influenced by the fertilizer supply, and Mg and B were inversely influenced by fertilizer supply at high light. These data suggest new management strategies are needed to improve fertilizer use efficiency in different environments.

Using SPAD-meter in Nitrogen Fertilization of Rosa chinensis Jacq. var. mutabilis

Giampaolo Zanin*, Paolo Sambo

Rosa chinensis Jacq. var. mutabilis plants were grown in a greenhouse to determine whether a hand-held chlorophyll meter (SPAD-meter) is suitable for the plant N status assessment. Therefore, plants were fertilized with increasing levels of N, applied through urea form as top dressing. The doses were: 0, 0.15, 0.3, 0.45, 0.6, and 0.75 g of N per liter of substrate. Periodically during the growing season, plant height and width, fresh and dry weight of different plant organs at 10, 20, and 30 weeks after planting, and their total N, plant P, and K were measured. Furthermore, six times along the growing cycle, the amount of chlorophyll in leaves was estimated using a SPAD-meter and analytically measured by chlorophyll extraction with ethanol and reading through a spectrophotometer. In the same leaves, N concentration was also determined. Treatments with 0.45–0.6 g of N per liter of substrate gave the tallest and widest plant. Plant weight and flower production were also the highest with these doses. The concentration of organic N in plant organs increased along with the N availability in
the substrate, which suggests that a "luxury consumption" took place. The SPAD values showed high correlation among chlorophyll and N concentrations. Values that ranged between 35–40 seemed to mean good nutrient status. A high correlation was also found among SPAD values and some of the productive characteristics, which indicates that a SPAD-meter is a suitable tool in the dynamic fertilization of rose.

**Counter-anions Influence Greenhouse Rose (Rosa ×hybrida) Responses to Sodium-based Salinity**
Alina R. Solís-Pérez*, Raul I. Cabrera
Texas A&M University, Horticultural Sciences, Dallas, TX, 75252

Greenhouse rose plants, ‘Bull’s Eye’, budded on the rootstocks Rosa manetti and R. × ‘Natal Briar’, were grown in containers filled with a peat-based growing medium. The plants were irrigated with a 0.5× Hoagland solution salinized with a fixed 12-mM Na solution made up of seven ratios of NaCl, Na₂SO₄, and NaNO₃ (100:0.0, 50:50:0, 0:100:0, 0:50:50, 0:0:100, 50:0:50, and 33:33:33). The results after four flushes of growth and flowering showed higher dry weight productivity in R. manetti plants. Salt composition (i.e., counter-anion ratios) significantly affected the dry weight yield of ‘Natal Briar’ plants, with those irrigated with 100% Na₂SO₄ and NaNO₃ having the highest and lowest values, respectively. While the plants budded on R. manetti did not show significant responses to salt composition, there was a strong tendency for higher dry weight yields in binary salt (anion) compositions. Leachate collected throughout the study showed similar pH (7.5) and electrical conductivities (4.7 dS/m) for all salt treatments. Leachate Cl- concentrations were linearly correlated with Cl-application, whereas leachate Na⁺ concentrations remained similar among treatments. Plants on R. manetti accumulated less leaf Na⁺ and Cl- than in R. × ‘Natal Briar’ plants, with lower values observed, in general, in plants irrigated with solutions containing Na₂SO₄.

**Impact of Low Iron and Phosphorus Stresses on Acidification of Nutrient Solution by Geranium**
Matthew D. Taylor*, Paul V. Nelson1, Jonathan M. Frantz2
1North Carolina State University, Department of Horticulture Science, Raleigh, NC, 27607; USDA-ARS, Toledo, OH, 43606

The cause of sudden substrate pH decline by geranium is unknown. Low Fe and low P have been shown to cause many plant species to acidify the substrate. Research was done to determine if low Fe or P stresses caused four geranium (Pelargonium ×hortorum Bailey) cultivars to acidify nutrient solution. Two cultivars were susceptible and two resistant to substrate acidification based on a grower survey. Rooted geranium cuttings were transplanted to 4-L containers containing modified Hoagland’s solution with N supplied as 15% NH₄ and 85% NO₃. The plants were grown in a greenhouse for 44 days. Treatments consisted of a complete nutrient solution and two similar solutions devoid of either Fe or P. Solutions pH was set at 5.8, changed weekly, and tested 3 and 6 days after each change. Because all cultivars showed similar responses, results were combined. Twenty days after transplanting (DAT), plants in all treatments, including control, caused solution pH to fall below 5. At 37 DAT, the solution pH levels for control, minus Fe, and minus P treatments were 4.1, 3.7, and 3.6, respectively. Results indicated that geranium is an acidifying plant when N is supplied as 15% NH₄ and 85% NO₃. Additionally, low Fe and low P stresses increase the acidification rate. Total dry weights of minus-P plants were about half that of minus-Fe plants. This indicated that plants under P stress had a higher specific rate of acidification than plants under Fe stress.

**Impact of Flower Removal and Light and Temperature Stresses on Acidification of Nutrient Solution by Geranium**
Matthew D. Taylor1, Paul V. Nelson*, Jonathan M. Frantz2
1North Carolina State University, Department of Horticulture Science, USDA, ARS, Toledo, OH, 43606

The cause of sudden substrate pH decline by geranium (Pelargonium ×hortorum Bailey) is unknown. Published reports indicate that this response can be influenced in other plants by temperature and light extremes. The first of five experiments compared plants with all flowers removed to plants that were allowed to flower. Experiment 2 compared plants grown at four light levels (105, 210, 450 and 1020 µmol·m⁻²·s⁻¹). Experiment 3 compared plants grown at four temperatures (14/10, 18/14, 22/18 and 26/22 °C day/night). Experiment 4 was a repeat of Experiment 1 and Experiment 5 was a factorial combining the three highest light levels and the three highest temperature levels. Plants allowed to form flowers had a final substrate pH of 5.7 compared to 6.3 for plants where flowers were removed. With increasing increments of temperature, substrate pH declined from 6.8 to 4.6 and with increasing light intensity from 6.1 to 4.8. There was no effect of flower removal in Experiment 4. Light and temperature had no consistent effects in Experiment 5 throughout 46 days after planting, with most pH values remaining in the acceptable range of 5.6–6.1. By 50 days, temperature treatments began to segregate, with pH being highest in the low-temperature treatments and lowest, down to 5.5, in the highest-temperature treatments. High temperature stimulated geranium acidification in both experiments, with the effect more severe in the first experiment. The flowering and high light effects were not duplicated in the second trial. This indicates that an additional factor is involved in expression of the light, temperature, and flowering control of acidification.

**Oral Session 4—**

**Water Utilization/Management & Pest Management**
27 July 2006, 2:00–4:00 p.m.
Southdown
Moderator: Michael Compton

**Potential of Anaerobic Digestion-derived Biosolids as an Organic Addendum in Horticultural Growing Media**
Michael Compton*, Timothy Zauche2
1University of Wisconsin–Platteville, School of Agriculture, Platteville, WI, 53818; 2University of Wisconsin–Platteville, Department of Chemistry and Engineering Physics, Platteville, WI, 53818

Soilless horticultural growing media are composed of organic matter, coarse aggregates, nutrients, and a wetting agent. Sphagnum peat has been the standard organic addendum to soils growing media. However, recent shortages, escalating costs, and its acidity make sphagnum peat a sometimes less-than-desirable material. Alternatives such as composted bark dust, coconut coir, composted manure, and crop by-products have been proposed as substitutes for sphagnum peat, but none are a suitable general alternative. Anaerobic digestion-derived biosolids (ADB) has the potential to become a complete or partial substitute for sphagnum peat. ADB is a cellulosic product similar in appearance to sphagnum peat. It has been proposed as a substitute for sphagnum peat, but none are a suitable general alternative. Anaerobic digestion-derived biosolids (ADB) has the potential to become a complete or partial substitute for sphagnum peat. ADB is a cellulosic product similar in appearance to sphagnum peat and is a product from the anaerobic digestion of cattle manure for 14 to 25 days at temperatures between 104 °F and 140 °F. Bacteria from the animal’s rumen, present in the manure prior to anaerobic digestion, are used to breakdown excessive nutrients present in the manure. Following anaerobic digestion, the nutrient-rich liquid phase is removed to yield an odorless cellulosic fiber that is sterile, free of weeds, pests, and pathogens, as well as uniform and reproducible. The potential application of ADB to the horticulture industry, most specifically as an organic addendum to soilless media, is immense and will be discussed. Use of anaerobic digester-derived biosolids in horticultural growing media is a protected intellectual property and available for license through the WiSys Technology Foundation.

**Roots Affect the Accuracy of Dual-probe Heat-pulse Method for Measuring Water Content in Plant Growth Media**
Susan L. Steinberg*, Gerard J. Kluitenberg, Sohini Tanzeema

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Little attention has been paid to how the presence of roots influences water content measurements obtained with water content sensors. This issue is especially important if sensors are deployed in densely rooted soil or growth media. This work addresses the impact of roots on water content measurements obtained with dual-probe heat-pulse (DPHP) sensors. In the DPHP method, the maximum temperature rise in response to heating ($T_{\text{max}}$) is used to calculate volumetric heat capacity, which in turn is used to calculate volumetric water content. The accuracy of DPHP sensors was evaluated in unrooted and rooted 0.25–1 mm baked ceramic aggregate. For both restricted and unrestricted volumes of aggregate the presence of roots caused DPHP sensors to consistently overestimate water content by 0.05–0.09 cm$^3$ cm$^{-3}$. Measured values of $T_{\text{max}}$ were lower in the presence of roots, which resulted in overestimation of volumetric heat capacity that was attributed to the high specific heat of water contained in roots in addition to that contained within the aggregate. Differences in water content and aggregate heating between unrooted and rooted aggregate equilibrated to the same matrix potential were less distinct in unrestricted volumes, where the decrease in bulk density has the offsetting effect of lowering the heat capacity. Error in water content caused by the presence of roots and changes in bulk density was estimated by developing a theoretical mixing model for volumetric heat capacity that accounted for the heat capacity of all constituents, including aggregate, water, root water, and root tissue. Predicted errors in volumetric water content due to changes in bulk density or changes in heat capacity due to roots agreed well with direct measurement.

**Non-irrigation in Fall and Winter Improves Florida Citrus Fruit Quality**

Larry Parsons*, Ed Etcheberria

1University of Florida, IFAS, Citrus Research & Education Center, Lake Alfred, FL, 33850

Moderate water stress applied to citrus trees can increase fruit °Brix. Florida citrus growers have been required to use less irrigation as competition for water increases. The goal of this study was to see if irrigation could be eliminated in the fall and winter with few negative consequences. Water stress was imposed over a 3-year period on ‘Hamlin’ and ‘Valencia’ oranges (an early and late variety, respectively) by stopping irrigation in late October and restarting it in March. ‘Hamlin’ fruit was harvested after 2 months of stress and ‘Valencia’ fruit was harvested after 4 to 5 months of stress. In most years, °Brix was increased by water stress. Over a 3-year period, ‘Hamlin’ yield was not affected by the water stress, but ‘Valencia’ yield decreased slightly in the 3rd year. The increase in °Brix is beneficial economically, and, over 3 cm of irrigation water per year can be saved.

**Crop Simulation and Crop Evapotranspiration for Irrigation Management of Spinach**

Giovanni Piccinni1, Thomas Gerik1, Evelyn Steglich2, Daniel Leskovar3, Jonghan Ko2, Thomas Marek2, Terry Howell4

1Texas A&M University, Soil and Crop Sciences–TAES, Uvalde, TX, 78801; 2Texas A&M University, Texas Agricultural Experiment Station; 3Texas A&M University, Horticulture–TAES; 4USDA–ARS, Conservation and Production Research Laboratory

Improving irrigation water management for crop production is becoming increasingly important in South Texas as the water supplies shrink and competition with urban centers in the region grows. Crop simulators and crop evapotranspiration (ET) are appealing methods for estimating crop water use and irrigation requirements because of the low investment in time and dollars required by on-site (in-field) measurement of soil and/or crop water status. We compared the effectiveness of the Crop,man/EPIC crop simulator and Crop-ET approaches estimating the crop water use for irrigation scheduling of spinach. In-ground weighing lysimeters were used to measure real-time spinach water use during the growing season. We related the water use of the spinach crop to a well-watered reference grass crop to determine crop coefficients ($K_c$) to assist in predicting accurate crop needs using available meteorological data. In addition, we ran several simulations of CropMan to evaluate the best management for growing spinach under limited water availability. Results show the possibility of saving about 61 to 74 million m$^3$ of water per year in the 36,500 ha of irrigated farms of the Edwards aquifer region if proper irrigation management techniques are implemented in conjunction with the newly developed decision support systems. We discuss the implications of the use of these technologies for improving the effectiveness of irrigation and for reducing irrigation water requirements in South Texas.

**Pre-emergence Weed Control in No-tillage Pumpkin Production**

S. Alan Walters*, Bryan G. Young1, Ronald F. Krausz2

1Southern Illinois University, Plant, Soil, and Ag. Systems, Carbondale, IL, 62901–4415; 2Southern Illinois University, Plant, Soil, and Ag. Systems, SIUC Belleville Research Center, Belleville, IL, 62221–8615

A field study was conducted in 2002, 2003, and 2004 to evaluate various pre-emergence herbicides (ethalfluralin & clomazone, ethalfluralin & clomazone + halosulfuron, and ethalfluralin & clomazone + imazamox) with or without a winter rye (Secale cereale L.) cover crop in tillage and no-tillage ‘Appalachian’ pumpkin (Cucurbita pepo L.) production. All herbicides were applied within two days of seeding, and no injury was observed with any of the herbicides evaluated at any time during the three growing seasons. Early- and late-season control of all weed species [giant foxtail (Setaria faberi Herrm.), common cocklebur (Xanthium strumarium L.), redroot pigweed (Amaranthus retroflexus L.), and common waterhemp (Amaranthus rudis Sauer)] were highly correlated (0.47 ≤ r ≤ 0.86, P ≤ 0.01) with pumpkin yield and fruit size. The winter rye + no-tillage system provided greater weed control compared to the tillage systems and the no cover crop + no-tillage production system. Although winter rye alone had little influence on pumpkin yield, the no-tillage system improved pumpkin yield and fruit size compared to the tillage system. The two herbicide combinations (ethalfluralin & clomazone + halosulfuron and ethalfluralin & clomazone + imazamox) improved weed control and pumpkin yields compared to only ethalfluralin & clomazone. Although this study indicated that the use of a high-residue winter rye cover crop in no-tillage pumpkin production will provide some weed control, the choice of pre-emergence herbicides is critical to maximize pumpkin productivity. No-tillage pumpkin production is feasible with proper herbicide use and timing, although current herbicide options will not provide optimal weed control.

**Early Season Broadleaf Weed Control in Onion**

Harlene M. Hatterman-Valenti*, Carrie E. Schumacher1, Collin P. Auwarter1, Paul E. Hendrickson2

1North Dakota State University, Plant Sciences; 2North Dakota State University, Carrington Research/Extension Center

Field studies were conducted at Absaraka, Carrington, and Oakes, N.D., in 2005 to evaluate early season broadleaf weed control and onion (Allium cepa L.) injury with herbicides applied preemergence to the crop. DCPA is a common preemergence herbicide used in onion. However, DCPA can be uneconomical in most high-weed situations, or the usage may be restricted due to possible groundwater contamination. Potential substitutes evaluated were bromoxynil, dimethenamid-P, and pendimethalin. Main broadleaf weeds were redroot pigweed (Amaranthus retroflexus L.) and common lambsquarters (Chenopodium album L.). In general, all herbicides, except bromoxynil, provided acceptable broadleaf weed control 4 weeks after treatment. The highest herbicide rate provided greater weed control compared with the lowest rate for each herbicide. However, onion height was also reduced with the highest herbicide rate. In addition, the two highest rates of dimethenamid-P reduced the onion stand compared with the untreated. A postemergence application of bromoxynil + oxyfluorfen + pendimethalin to onion at the four- to five-leaf stage controlled the few broadleaf weeds that escaped the preemergence treatments and provided residual control of mid- and late-season germinating broadleaf weeds at two of the three locations. Intense germination
of redroot pigweed during July at the Oakes location reduced onion yield with all treatments compared with the hand-weeded check. In contrast, total onion yields with all herbicide treatments except the high rate of dimethenamid-P were similar to the hand-weeded check at Absaraka and Carrington.

Detection and Distribution of Viruses Infecting Field-grown Sweetpotato in East Africa

Douglas Miano1, Don LaBonte1, Christopher Clark2

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Sweetpotato is an important staple food crop in Sub-Saharan Africa, with production being concentrated in East Africa, particularly around Lake Victoria. Productivity of the crop is greatly constrained by viral diseases. Four main viruses have consistently been detected from various surveys done in the region viz., sweetpotato feathery mottle virus (SPFMV), sweetpotato chlorotic stunt virus (SPCSV), sweetpotato mild mottle virus (Sp.m.MV), and sweetpotato chlorotic fleck virus (SPCFV). The most severe symptoms have been caused by co-infection with SPCSV and SPFMV, resulting in the synergistic sweetpotato virus disease (SPVD). Some local sweetpotato genotypes have been reported to recover from, or have localized distribution of SPVD, suggesting that the disease is not fully systemic. This has led to the suggestion that uninfected cuttings may be obtained from previously infected plants. Experiments were set to determine the possibility of obtaining cuttings long enough for propagation that are free from virus infection. This would form a basis for recommending to the local small-holder farmers of a way to reduce losses due to the disease. Field-grown sweetpotato vines were cut into three pieces (15, 15–30, and >30 cm from the apex) and tested for SPCSV and SPFMV. Nine genotypes were selected from a group of 21 local clones and used for this study. The two viruses were equally present in all the three sections of infected vines, indicating that it is not easy to obtain a virus-free cutting for field propagation from an infected virus. Virus assays in the past has mainly been limited to the use of serological methods. Use of PCR resulted in detection of begomoviruses infecting sweetpotatoes for the first time in the region.

Effect of Solarization and Fumigation on Productivity and Fruit Quality of Strawberry

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A study of solarization and fumigation with methyl bromide (MB) on productivity and fruit quality of strawberry were investigated during two successive seasons of 2002–03. There were nine treatments: fumigation with methyl bromide (MB), solarization, their combination, and Nemalless. Results demonstrate that plant height, number of leaves per plant, average leaf area, root length, and crown diameter were significantly increased by fumigation with MB as compared with solarization or using Nemalless in the two tested seasons. Significant increments were obtained also in early and total yield, as well as total soluble solids and ascorbic acid when soil was fumigated with MB compared with solarization or using Nemalless. The highest total yield found with treatments was MB at 70 g/m², followed by MB at 50 g/m², 2-month solarization plus MB at 30 g/m², 1 month plus MB at 30 g/m², MB at 30 g/m², 2 months solarization, one month solarization, Nemalless, and control in the both tested seasons, respectively. Nemalless caused significant increments in early and total yield compared with the control in the two tested seasons. The results of this study provide evidence to suggest that a better understanding of different fumigation methods may aid us in the efforts to improve management of strawberry production.

Oral Session 5—Plant Biotechnology

27 July 2006, 4:15–5:45 p.m. Borgne
Moderator: Jessica L. Boldt

Micropropagation Cultures for Genetic Transformation of Grapevine

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A major drawback to the use of embryogenic cultures for transformation of grapevine is that their ability to undergo genetic transformation is cultivar-dependent. Also, depending on cultivar, embryogenic cultures are difficult to impossible to maintain over time, reducing their utility for use in genetic transformation. An alternative to the use of embryogenic cultures for transformation of grapevine is the use of micropropagation cultures, which are easier to initiate from a wide range of grapevine cultivars and can be maintained over time without loss of function. Vitis vinifera ‘Thompson Seedless’ was used as a model for genetic transformation using micropropagation cultures. In vitro cultures were initiated from apical meristems of actively growing vines and maintained in C2D medium containing 4 µM of 6-benzylaminopurine (C2D4B). Shoot tips and nodes were collected from proliferating in vitro cultures for transformation studies. A variety of wounding techniques, including nicking, sonication, and fragmenting of meristematic tissues was employed in order to enable Agrobacterium infection. We used a construct containing a bidirectional 35S promoter complex with a marker gene composed of a bifunctional fusion between an enhanced green fluorescent protein (EGFP) gene and a neomycin phosphotransferase (NPTII) gene in one direction and a hybrid lytic peptide gene in the other. Transgenic shoots growing in C2D4B medium containing 200 mg·L⁻¹ each of carbenicillin and cepotaxime and 20 mg·L⁻¹ of kanamycin were selected based on GFP fluorescence. Transgenic shoots were rooted and transferred to a greenhouse. To date, 18 transgenic lines have been generated. Details on the transformation procedure will be discussed.

Comparison between Protoplast Transformation and Co-transformation in ‘Hamlin’ Sweet Orange [Citrus sinensis (L.) Osbeck]

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Citrus canker disease caused by the bacterial pathogen Xanthomonas axonopodis pv. citri is becoming a worldwide problem. Xa21 gene is a member of the Xa21 gene family of rice, which provides broad spectrum Xanthomonas resistance in rice. ‘Hamlin’ sweet orange [Citrus sinensis (L.) Osbeck] is one of the leading commercial cultivars in Florida because of its high yield potential and early maturity. ‘Hamlin’ also has a high regeneration capacity from protoplasts and is often used in transformation experiments. Since the citrus canker pathogen is in the same genus, this gene may have potential to function against canker in citrus. The wild-type Xa21 gene contains an intron, and there are some questions whether dicot plants can process genes containing mononucleot introns (the cDNA is intron-free). Plasmids DNA, encoding the non-destructive selectable marker EGFP (Enhanced Green Fluorescent Protein) gene and the cDNA of the Xa21 gene were transformed or co-transformed into ‘Hamlin’ orange protoplasts using polyethylene glycol. More than 200 transgenic embryos were recovered. More than 400 transgenic plants were developed from 75 independent transgenic events. PCR analysis revealed the presence of the cDNA of the Xa21 and the GFP genes in the transgenic plants.
Some of the plants have the GFP only. Southern analysis is showing integration of the cDNA into different sites ranges from one to five sites. Western analysis is showing the expression of the cDNA of the Xa21 gene in the transgenic citrus plants. This is the first time that a gene from rice has been stably integrated and expressed in citrus plants. Canker challenge assay is in progress.

Meristem Identity Genes and the Control of the Reproductive Development in *Brassica oleracea*

Denise Duclos*, Thomas Björkman

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The genetic factors that control reproductive development in *B. oleracea* remain a mystery. Broccoli differs from cauliflower in its floral development stage at harvest. We are studying the role of meristem identity genes (MIGs) in the transition from inflorescence meristem (cauliflower) to floral buds (broccoli). The objectives are to determine stage-specific roles of MIGs during reproductive development and to check whether expression of flowering genes in heading *B. oleracea* is as predicted by the *Arabidopsis* flowering model. We tested a model of arrest in *B. oleracea* that incorporates FUL, a redundant gene of AP1 in controlling inflorescence architecture and floral meristem identity, the meristem gene TFL1, the flowering gene LFY, and AP1/CAL, and genes involved in flower transition. Conclusions. 1) Arrest at the inflorescence meristem stage is highly correlated with a decrease in LFY to TFL1 ratio, given by a decrease in TFL1 expression. 2) Transcription of AP1c is stimulated at the time of floral primordium initiation, suggesting a role in floral transition but not in floral organ specification. Plants recessive for AP1a, AP1c, and CAL formed normal floral buds containing all four whorls of organs, and did not necessarily form curd. We suggest that their ability to flower could be related with the ectopic expression of FUL by affecting TFL1 expression. FUL paralogs were highly expressed at all stages of development of the triple mutant plants. 3) The lack of upregulation in AP1 transcripts at the floral bud stage, and the absence of an A-function mutant phenotype imply that other genes act redundantly with AP1 in the specification of sepal identity and questions the role of AP1a and AP1c as A-function genes in *B. oleracea*.

Characterization of Physiological Resistance to White Mold and Search for Molecular Markers Linked to Resistance via Advanced Backcross QTL Analysis in an Interspecific Cross between *Phaseolus coccineus* and *P. vulgaris*

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White mold, caused by *Sclerotinia sclerotiorum* (Lib.) de Bary, causes major losses in dry and snap bean (*Phaseolus vulgaris*) production. With little genetic variation for white mold resistance in common bean, other potential sources for resistance must be investigated. Accessions of scarlet runner bean (*P. coccineus*) have been shown to have partial resistance exceeding any to be found in common bean. Resistance is quantitative with at least six QTL found in a *P. coccineus* intraspecific resistant × susceptible cross. Our goal is to transfer high levels of resistance from *P. coccineus* into commercially acceptable common bean lines. We developed interspecific advanced backcross populations for mapping and transfer of resistance QTL. 111 BC* F*₂ lines from a cross between OR91G and PI255956 have been tested in straw tests and oxalate tests, as well as in a field trial. The data show that the OR91G × PI255956 population carries a high level of resistance, but because of the quantitative nature of resistance, it may be necessary to intercross individuals to achieve higher levels. SSR, RAPD, and AFLP markers are being used in the population to construct a linkage map for placement of QTL. QTL identified from each type of test (straw, oxalate, and field) may provide additional information about the genetic architecture of white mold resistance. Three other populations are from advanced backcrosses of the recurrent parents G122, OR91G, and MO162, with PI433251B as the donor parent in each. Analyses and advance of these populations will follow, the results of which should confirm QTL identified in the OR91G × PI255956 population, as well as possible additional resistance QTL from PI433251B.

Water Potential Characteristics of Transgenic Petunias Over-expressing Two *Arabidopsis* C-repeat Binding Factor cDNAs

Jessica L. Boldt*, James E. Barrett, David G. Clark

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*Petunia × hybrida* ‘Electric Purple’ plants, genetically transformed (Selecta Klemm Co.) via *Agrobacterium tumefaciens* to constitutively express the Cauliflower Mosaic Virus 35S promoter (CaMV35S) fused to two separate *Arabidopsis* c-repeat binding factor cDNAs (CBF3 & CBF4), were utilized to evaluate water relations. Non-stressed plants followed a classical stomatal conductance pattern, with maximum conductance between 1000 hr and 1400 hr. CBF3 and CBF4 plants showed an increase in transpiration rates and a decrease in stomatal resistance at 1230 hr, compared to ‘Electric Purple’. Transpiration rates (per unit leaf area) were similar in CBF3 and ‘Electric Purple’ plants, but CBF4 plants were 12% less than ‘Electric Purple’. Xylem water potentials at visible wilt were between –1.4 and –1.5 MPa and there were no significant differences between line or irrigation treatment. A fourth experiment observed differential plant responses to stress cycles. Under non-stress irrigation conditions, CBF4 plants showed an increase in stomatal resistance and a decrease in transpiration rate compared to ‘Electric Purple’ plants. There were no differences in the xylem water potential at visible wilt for the first and third stress cycles, but, for the second cycle, xylem water potentials at wilt were –1.9, –1.7 and –1.4 Mpa for CBF4, ‘Electric Purple’ and CBF3 plants, respectively. CBF3 and CBF4 plants showed small differences in performance as compared to ‘Electric Purple’ and under mild stress conditions as imposed in these experiments apparent heterologous overexpression of the *Arabidopsis* CBF3 & 4 transgenes may not be sufficient for conferring drought tolerance in petunia.

Optimization of the RAPD Marker Techniques in *Camellia*

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Randomly amplified polymorphic DNA (RAPD) technique is based on DNA amplification by polymerase chain reaction (PCR) of random DNA segments using single arbitrary nucleotide sequences. It has been widely used for genetic mapping, plant and animal breeding programs, and DNA fingerprinting. However, there is no single set of PCR conditions that can be applied to all situations. In order to adjust reaction component concentrations within suggested ranges for efficient amplification during the use of RAPD in detection of genetic variation of genus *Camellia*, crucial factors, such as concentrations of MgCl₂ and DNA, annealing temperature (37 to 44 °C), and the use of an AmpliTaq® DNA polymerase and Stoffel fragment were examined. Five camellia cultivars, ‘Winter’s Beauty’, ‘Pink Icicle’, ‘Polar Ice’, ‘Winter’s Hope’, and ‘Snow Flurry’, were under investigation. Clear and reproducible amplification products were produced with 3.0 µM MgCl₂, and 30 ng template DNA/25 µL reaction mixer at annealing temperature 37 °C and 40 °C, compared with MgCl₂ at 1.5, 2.0, and 2.5 µM. When annealing temperature increased, the RAPD-PCR stringency was increased, as expected. Stoffel fragment was found to provide highly reproducible results.

ORALS–THURSDAY
Oral Session 6—Teaching Methods/Human Issues 1
27 July 2006, 4:00–5:45 p.m.  Nottoway
Moderator: Ann Marie VanDerZanden

Increasing Teaching Effectiveness through Collaborative Learning Activities
Elsa Sanchez*, Richard Craig
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The Plant Systematics course at Penn State University was reformatted in 1995 based on a three-dimensional model. It now includes several collaborative learning activities: a learning fair hosted by the enrolled students for elementary school students; applied laboratory exercises; and applied laboratory examinations. Each activity has a specific objective and was constructed to strengthen teaching effectiveness and to aid students in developing useful skills for future employment. A survey was administered to students enrolled in the course from 2003 through 2005 in part to assess the collaborative learning activities. Most students “strongly agreed” or “agreed” that they liked working in collaborative groups and learned from other group members. Students preferred working in groups for laboratory examinations more than for the Asteraceae Fair and learned more from their peers while completing the laboratory exercises than in laboratory examinations. Student participation in the lecture portion of the course increased as collaborative learning activities were completed. Camaraderie with peers through group work may have created an atmosphere conducive to participation and/or involvement during lectures. Organization and planning were vital to the success of these activities, as were using small groups and providing adequate incentives for completing activities. These activities engaged students to become active participants in the teaching and learning process.

Pre- and post-course Assessment of Knowledge by Students in an Introductory Horticulture Course
James N. McCrimmon*
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The Introduction to Horticulture course in the Department of Agriculture at Southeast Missouri State Univ. provides an overview of the principles of various horticulture crops. It is a lower-level course comprised primarily of freshmen and sophomores. Although many of the students that take the course are majors in the horticulture option, there are some students taking the course that are not horticulture majors, since the course is a requirement for all majors in the department. The objective of this study was to have students assess their knowledge of various types of horticultural plants before and after the course. During the first day of class, a pre-course student profile and survey was given to each student in order to determine their background and to assess their knowledge of certain horticultural plants. They were asked their knowledge of these topics; and, they rated their knowledge as follows: excellent, good, average, fair, or poor. Throughout the semester, these topics and plants were discussed or demonstrated in either the lecture or the laboratory. At the end of the semester, students were given a post-course survey to assess their knowledge of the same topics and horticultural plants which they rated their knowledge of the first day of class. Comparisons between pre- and post-course student assessment of their knowledge of topics and plants will be discussed.

Assessing a Garden-based Curriculum for First Graders in Iowa: Parental Perceptions of Change
Cynthia Haynes*, Kimberly Hilgers*, Joanne Olson*
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The interest, use, and recognized benefits of gardens as educational tools for youth has increased in recent decades and has prompted the development of garden-based curricula for use in schools. Iowa State University Extension developed Growing in the Garden (GITG), a curriculum designed for use in kindergarten through third grade classrooms. This study examined the impact of the GITG curriculum on the awareness and interest of first graders in the areas of science, nutrition, and the environment. A survey was used to determine parental perceptions of their child’s interest and awareness after experiencing three lessons from the GITG curriculum. Forty-seven parents (60.2% response rate) of first graders from four classrooms in Iowa completed the survey. A significant number of parents surveyed noted an increased awareness and interest of their children in the areas of science and the environment. Factors such as socio-economic status, ethnicity, and gender did not influence the outcomes.

An Interactive Online Case Study to Improve Problem-solving Skills of Landscape Horticulture Students
Ann Marie VanDerZanden*, David R. Sandrock*
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Horticulture graduates entering the landscape industry will be faced with a multitude of complicated management decisions where they will need to integrate their understanding of plant science, site constraints, state and federal environmental regulations, and the human impact on the built landscape. To help students develop and refine their problem-solving skills, an interactive online case study was created. The case study was used in two different landscape horticulture courses at Iowa State University and Oregon State University. The case study centers on a residential backyard with eight landscape problem scenarios. Each scenario is identified on the clickable landscape map of the area and contains links to audio files, PDF documents, images, and Internet links. After investigating each scenario, students submit an analysis, diagnosis, and recommendation about the landscape problem via WebCT or Blackboard, depending on the institution. Student evaluation of the case study as a teaching tool was positive (3.5, where 1 = poor; 5 = excellent). Students answered additional questions using a scale where 1 = strongly disagree and 5 = strongly agree. As a result of using this teaching tool, students felt that they were able to summarize the data (3.9), diagnose the landscape problem (3.9), and make a recommendation to the homeowner (3.6). Further, they felt this teaching tool was an effective way to deliver information (3.9); the interactive format aided their learning (3.7); that they were comfortable using a web-based format (4.2); and they liked learning using case studies (4.1). Our goal is to make the case-study framework available to other teaching colleagues who can then add their own data.

OASIS: An Experiential Learning Class in Organic Production
Erin Silva*, Connie Falk
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New Mexico State University has designed a course in Organic Vegetable Production centered on a working CSA (Community Supported Agriculture) Farm. This project, named “OASIS” (Organic Agriculture Students Inspiring Sustainability), was funded by a 3-year USDA Hispanic Serving Institutions (HSI) grant from 2002–05. The project has multiple objectives, including: to provide students with a multi-disciplinary experiential educational opportunity; to investigate the feasibility of small-scale organic drip-irrigated farming in the Chihuahuan desert; to demonstrate the CSA model to the local community; and to trial vegetable varieties. The class is co-listed in the Department of Plant and Environmental Sciences and the Department of Agricultural Economics and Agricultural Business. Recently, the class was adopted in the Honors College and also became part of the General Education (G) program at NMSU. The course meets twice a
were actively involved in storm cleanup and recovery. Some, however, economic hardships ranging from 1 month to permanent, most landscape impacted by Hurricane Rita. While growers and retailers experienced plant dealers affected by Hurricane Rita numbered 329 (24% of the state total). Louisiana’s retail plant dealers affected by Hurricane Katrina numbered 367 (28% of the state total). Louisiana’s retail plant dealers affected by Hurricanes Katrina and/or Rita were estimated at least 20,000 of the 56,600 green industry employees in Louisiana were affected by Hurricanes Katrina and/or Rita to some degree. Louisiana’s green industry overall provides about $2.2 billion in economic contributions annually.

**Oral Session 7—Controlled Environments**

**28 July 2006, 8:00–9:00 a.m.**

**Southdown**

**Moderator: Chieri Kubota**

**Effect of Volatile Ethanol Exposure on the Growth and Development of Three Radish Cultivars**

Gary Stutte*, Ignacio Eraso

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NASA has intensively studied the use of plants to regenerate the atmosphere, purify water, and produce food within a bioregenerative life support system for many years. A unique aspect of growing plants in a controlled environment is chronic exposure to low levels of atmospheric volatiles. Alcohols are one of the most common classes of atmospheric contaminants currently detected onboard the International Space Station. A series of experiments were performed in specialized volatile organic compound analysis (VOMA) chambers in order to determine sensitivity of three *Raphanus sativus* L. to atmospheric exposures of ethanol. Three radish cultivars, Sora, Cherry Belle, and Cherry Bomb Hybrid II, were grown under continuous exposure to 0, 50, 100, 300, 500, or 1000 ppm ethanol for 21 days in the VOMA chambers with environmental setpoints of 23 °C, 75% relative humidity, and 18/6 photoperiod under T8 triphosphor fluorescent lamps at 300 µmol·mol⁻¹·PAR and 1200 µmol·mol⁻¹·CO₂. These concentrations corresponded to 5%, 10%, 30%, 50%, and 100% of the human exposure limits established by NASA and OSHA. Exposures to less than 10% of the legal exposure limit resulted in a 30% reduction in total biomass, 12% reduction in leaf area, and a 6% reduction in harvest index. Extreme stunting, chlorosis, and plant death were observed at only 50% of the exposure limit. All three cultivars were sensitive to ethanol exposure, with Cherry Bomb Hybrid II being slightly less sensitive than either Sora or Cherry Belle.

**Reconfigurable LED Lighting System Development: Potential Energy Savings for CEA**

Gioia D. Masso*, Jeffery C. Emmerich1, Robert C. Morrow, C. Michael Bourgeau1, Cary A. Mitchell1

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Electrical cost, primarily for lighting, is one of the largest factors inhibiting the development of “warehouse-based” controlled environment agriculture (CEA). In a jointly sponsored collaboration, we have developed a reconfigurable LED lighting array aimed at reducing the electrical energy needed to grow crops in controlled environments. The lighting system uses LED “engines” that can operate at variable power and that emit radiation only at wavelengths with high photosynthetic activity. These light engines are mounted on supports that can be arranged either as individual intracanopy “lightsicles” or in an overhead plane of lights. Heat is removed from the light engines using air flow through the hollow LED strip mounts, allowing the strips to be placed in close proximity to leaves. Different lighting configurations depend on the growth habit of the crops of interest, with intracanopy lighting designed for planophile crops that close their canopy, and close overhead lighting intended for erectophile and rosette crops. Tests have been performed with cowpea, a planophile dry bean crop, growing with intracanopy LED lighting compared to overhead LED lighting. When crops are grown using intracanopy lighting, more biomass is produced, and a higher index of biomass per kW-h is obtained.
than when overhead LEDs are used. In addition, the oldest leaves on intracanopy-grown plants are retained throughout stand development, while plants left from overhead drop inner-canopy leaves due to mutual shading after the leaf canopy closes. Research is underway to increase the energy efficiency and automation of this lighting system. This work was supported in part by NASA: NAG5-12686.

Application of 1-MCP for Quality Preservation of Tomato (Lycopersicon esculentum) Seedlings during Long-distance Transportation
Chi Kubieta, Mark Kroggel
The University of Arizona, Department of Plant Sciences, Tucson, AZ, 85721-0036

Increasing numbers of vegetable growers purchase their seedlings from specialized transplant producers. However, early yield reduction due to abnormal first fruit truss development was often observed after long-distance transportation of seedlings. 1-Methylcyclopropene (1-MCP), an inhibitor of ethylene-mediated reactions, is widely used for postharvest management. If ethylene accumulated inTrailers causes such abnormal first fruit truss development, application of 1-MCP to seedlings may prevent such problems. To test this hypothesis, 'Duranta' tomato seedlings with visible flower buds were placed in chambers for 4 days under one of the following conditions: 1) conventional transportation at air temperature of 18 °C without 1-MCP, 2) 18 °C with 1-MCP, 3) 12 °C without 1-MCP, and 4) nonstored control. The target initial 1-MCP concentration was 1 µmol·mol\(^{-1}\) inside the chamber, and the concentration was estimated to reach 0.2 µmol·mol\(^{-1}\) after 96 h. Three weeks after transplanting, 81.3% of first trusses on the plants treated at 18 °C without 1-MCP exhibited an abnormal, delayed fruit development. Both 1-MCP application and 12 °C air temperature successively reduced the symptom to 4.7% and 3.1%, respectively; not significantly different from the nonstored control (1.6%). The average first truss yield was the lowest for 18 °C without 1-MCP (223 g per truss), followed by 18 °C with 1-MCP (582 g), and was the greatest (609–637 g) for 12 °C without 1-MCP or the control. Ethylene accumulation was the primary cause of the delayed fruit development causing yield reduction. Application of 1-MCP during transportation was shown to prevent such undesirable yield loss, although lowering temperature was the most effective under the present experimental conditions.

Measurements of Ambient Ozone Concentrations Show Elevated Levels within Commercial Greenhouses
Hazel Y. Wetzstein1, S. Edward Law2
1University of Georgia, Horticulture Department, Athens, GA, 30602-7273; 2University of Georgia, Biological and Agricultural Engineering, Athens, GA, 30602

Ozone is a highly oxidizing phytotoxic air pollutant, whose effects are documented to adversely affect crop growth and productivity. In contrast to the large body of published work investigating the effects of atmospheric ozone on outdoor agronomic and forestry crops, relatively few studies have addressed the effects of ozone exposure on greenhouse-grown crops. Outdoor concentrations of ozone can commonly attain concentrations in the 50–150 ppb range, which are known to detrimentally impact plant growth. The objective of this study was to characterize ozone exposure in commercial greenhouses as a prelude to the determination of dose–response effects on specific greenhouse crops and the development of ozone abatement methods, if appropriate. This study documented the levels and diurnal fluctuations in atmospheric ozone concentrations over two annual June–October “ozone seasons.” Measurements were taken every 10 min. for both indoor and outdoor ozone concentration, solar radiation, and temperature. Unexpectedly, indoor ozone concentrations often exhibited elevated levels that were 25% to 35% higher than outdoor concentrations, even in well-ventilated houses. These findings suggest that additional ozone production may occur within the greenhouse environment. Evaluations of causative factors and ozone effects on commercial crop production are warranted.

Oral Session 8—Nursery Crops 1
28 July 2006, 8:00–9:15 a.m. Bayside A

Moderator: Hannah M. Mathers

Bark Splitting and Other Cold Hardiness Effects of Ornamental Herbicides
Hannah M. Mathers*, Michele M. Bigger
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Many nurseries within Ohio and northeastern, southeastern, and western United States, and Canada have reported severe bark splitting and scald-type problems in 2005. The amount and severity of damage seen in 2005 has been unlike anything seen before. At Ohio State University, samples from across the state started appearing in 2003–04 and increased in incidence in 2005. Growers’ reports of exceeding losses of 5% of their inventory or 3000 to 4000 trees per nursery are not uncommon. At an average cost of $125 per tree and with the number of nurseries reporting problems, the stock losses in Ohio have been staggering, in excess of several million dollars. The trees that we have seen problems on in 2005 have been callery pears, yoshino cherry, kwanzan cherry, crab apples, sycamore, serviceberry, mountain ash, black gum, paper bark maple, japanese maples, norway maple ‘Emerald Queen’, red maples, kousa dogwood, magnolia ‘Elizabeth’ and the yellow magnolias such as ‘Butterflies’, ‘Sawada’s Cream’, ‘Yellow Bird’, and ‘Yellow Lantern’. It has long been observed that the actual cause of a bark crack was “preset” by a wound such as the improper removal of a basal sprout, herbicide, leaving of a branch stub, or lack of cold hardiness. Cold and frost may be contributing to the increase in bark splitting across the United States; however, new research results at Ohio State University regarding the effects of DNA preemergent herbicides in the reduction of root hardiness and regrowth potential, sprout removal and other mechanical injuries, and postemergent herbicide application will reveal these are more the causal agents.

Taxodium Growth Under Different Substrate Moisture Levels
Jon Sammons*, Daniel K. Struve
The Ohio State University, Horticulture and Crop Science, Columbus, OH, 43210

Water is quickly becoming one of the world’s most precious resources. Micro- and cyclic irrigation are two effective ways that reduce irrigation volume without reducing plant quality. Development of a control mechanism to deliver timely and appropriate irrigation volumes combined with the advantages of micro- and cyclic irrigation will allow maximum water conservation and plant quality. For container-grown nursery plants, the interaction of container geometry and media physical properties dictate the volume of water available for plant uptake. The maximum amount of water a container substrate can hold under gravity is container capacity (CC). We managed season-long irrigation volumes by maintaining CC at three levels; 100% CC; 80% CC; and 60% CC; and used a set irrigation as a commercial control. The results showed similar plant growth for the 100% and set irrigation control groups through the growing season. However, the scheduled regime applied 50% more water than the group maintained at 100% CC. Our system increased water use efficiency without decreasing plant quality.

The Use of Cyclanilide to Promote Lateral Branching in Container-grown Whips
Petra Sternberg*, Daniel K. Struve
The Ohio State University, Horticulture and Crop Science, Columbus, OH, 43210

In nursery production, increased branching is desirable, especially when growing stock that will be marketed at smaller sizes. Typically,
branching is increased by pruning, which reduces growth potential. As an alternative to mechanical pruning, a chemical branching agent, Cyclanilide, has been evaluated for its ability to increase branching in container-grown whip production systems. Cyclanilide sprays of 0, 50, 100, and 200 mg·L⁻¹ were applied to elongating shoots of *Acer × freemanii* ‘Jeffred’, *Cercis canadensis*, *Diospyros virginiana*, *Eucommia ulmoides*, *Malus × Prairie Fire*, *Malus × Harvest Gold*, and *Quercus rubra* whips. Branching was increased in all taxae except *Eucommia* at concentrations >100 mg·L⁻¹, without significantly reducing plant dry weight. For *Diospyros*, branching was increased when combined with pruning before Cyclanilide application.

**Manipulating Light Intensity and Fall Fertilization to Influence Photosynthesis and Freeze Resistance of Azaleas**

Frank Henning*, Timothy J. Smalley, Orville M. Lindstrom, John M. Ruter  
The University of Georgia, Department of Horticulture, Athens, GA, 30602

On 1 May 2004, a 4 × 2 split-plot experiment was initiated in Athens, Ga., on *Rhododendron × kureane* ‘Pink Pearl’. The four main-plot treatments were low irradiance, low irradiance May–October, low irradiance November–May, and high irradiance (high and low correspond to average daily PPF of 23.6 and 30.4 mol·m⁻²·d⁻¹). The two subplot fall fertigation treatments were 75 mg·L⁻¹ of nitrogen (N) and 125 mg·L⁻¹ N. Plant stem tissue was harvested monthly from November to March, and analyzed for freeze resistance (LTₙ₀). Maximum quantum efficiency of PSII (Fv/Fm) was analyzed monthly with a Mini-pam photosynthesis yield analyzer. No interactions existed between fertilizer application and light intensity and the 125 mg·L⁻¹ N fertilizer treatment reduced freeze resistance of azalea stems throughout the study. Fall fertilization had no effect on fluorescence and no interactions existed between fertilizer and irradiance treatments. In November, plants that received low irradiance May–October were less freeze-resistant than plants from the high-irradiance treatment. However, in January, plants that received low irradiance throughout the study were more freeze-resistant than plants that received the high-irradiance treatment. In November, Fv/Fm was higher in the low irradiance and low irradiance November–May treatments. In February and March, Fv/Fm was lower in the low May–November treatment that received low irradiance during summer than the low November–May treatment that received low winter irradiance. The use of shade to reduce irradiance may delay the acquisition of freeze resistance in fall. However, shade may reduce photosystem damage and increase a plants ability to acquire and maintain greater freeze resistance.

**Evaluation of Container Media and Cyclic Irrigation on *Ilex × meserveae* Growth and Nutrient Concentration in Leachates**

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*Ilex × meserveae* ‘Blue Princess’ plants were grown in a pot-in-pot using container media consisting of pine bark-peat-sand 90:9:10, 75:15:10, and 60:30:10 by volume. During the summer season, plants were irrigated using a cyclic irrigation regime consisting of two and three irrigation applications and were compared to a traditional irrigation regime with one irrigation application that equaled the total volume applied in the cyclic regime. Nitrate concentrations in leachates were three times lower, whereas ortho-phosphate levels were two times lower in three irrigation application than those in one irrigation application. Increasing the percentage of bark in container media increased nitrate levels and reduced ortho-phosphate levels in leachates. There was no significant difference in growth index among treatments.

**Oral Session 9—**  
Postharvest Physiology/MCP/Ethylene  
28 July 2006, 9:30–11:30 a.m.  
Southdown

**Gene Expression Associated with Apple Aroma Biosynthesis**

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A microarray containing over 10,000 gene fragments was used to link changes in gene expression with changes in aroma biosynthesis in ripening apple (*Malus × domestica* Borkh.). The microarray was probed with fluorescent-tagged cDNA derived from RNA extracted from ‘Jonagold’ apple skin and cortex tissue representing eight distinct physiological stages spanning 70 days during ripening and senescence. The ripening stages, in chronological order, were: 1) early preclimacteric; 2) late preclimacteric and onset of trace ester biosynthesis; 3) onset of the autocatalytic ethylene and rapidly increasing ester biosynthesis; 4) half-maximal ester biosynthesis and engagement of the respiratory climacteric; 5) near maximal ester biosynthesis, peak in respiratory activity, and the onset of rapid tissue softening; 6) maximal ester biosynthesis prior to its decline, the conclusion of the respiratory climacteric, and the completion of tissue softening; 7) midpoint in the decline in ester biosynthesis and maximal ethylene biosynthesis; and 8) postclimacteric minimum in ester production. Patterns in gene expression reflecting the rise and fall in ester formation were found in some putative genes for beta-oxidation (acyl-CoA oxidase, enoyl-CoA hydratase, and acetyl-CoA acetyl transferase), ester formation (ami notransferase, alcohol dehydrogenase, and alcohol acyl transferase), and fatty acid oxidation (lipoygenase), but not fatty acid biosynthetic genes. A marked decline coinciding with the onset of ester production was detected in several putative genes for ADH.

**Effect of AVG and MCP on Volatile Production of ‘Gala’ Apple**

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Our goal was to determine how aminoethoxyvinylglycine (AVG) and 1-methylcyclopentene (MCP) interact to influence postharvest storability and volatile production of ‘Gala’ apple. In 2004 and 2005, AVG was applied to ‘Gala’ apple trees 4 weeks before harvest. After harvest, control and AVG-treated fruit were treated for 20 h at 30 °C with MCP, and fruit were ripened at ambient temperature immediately after harvest, after MCP treatment, or after storage at 4 °C for 6 and 12 weeks. For both seasons, control fruit reached the highest internal ethylene concentration (IEC) during ripening at ambient temperature immediately after harvest. After storage, control fruit had very low IEC in 2004, but the highest in 2005. In general, the combined treatment repressed ethylene production the most for all harvest dates and lengths of storage. AVG plus MCP-treated fruit consistently had the highest flesh firmness (FF) but also had the lowest total volatile production (TVP) by flesh or peel after 6 and 12 weeks in cold storage following both harvest dates. The activity of alcohol acyltransferase was affected by the treatments, but could not explain all the variation found in TVP. TVP was lower for flesh than peel of control and treated fruit, but feeding alcohol substrates to the fruit resulted in a significant increase in TVP, regardless of tissue type or treatment. The results indicate that the combination of AVG plus MCP maintained apple fruit FF in cold storage better than the treatments used alone, but also substantially reduced TVP. Substrate availability seemed to be the most limiting factor affecting TVP by flesh and peel of ‘Gala’ apples treated with AVG plus MCP.
Sprayable 1-MCP Effects on Maturity and Quality of Apple Fruit at Harvest and After Storage: The New York Experience

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A sprayable formulation of 1-MCP (250 µL·L⁻¹) and 1% oil adjuvant was applied to ‘McIntosh’ and ‘Empire’ apple trees 24, 14, and 7 days prior to anticipated optimum harvest dates (early, mid-, and late-spray timings, respectively), and fruit harvested sequentially over 2 to 3 weeks from this date. At harvest, internal ethylene concentrations (IEC), percentage of blush, starch indices, firmness, and soluble solids concentration (SSC) were measured, as well as ethylene production of fruit maintained for 7 days at 20 °C. Additional fruit were stored in air (0.5 °C) with or without postharvest 1-MCP treatment. Preharvest drop of ‘McIntosh’ apples was also measured. Quality of these fruit was assessed at intervals for up to 4.5 months (‘McIntosh’) or 6 months (‘Empire’). All spray timing resulted in marked delays of preharvest drop. For both cultivars, increases of IEC were inhibited or delayed by sprayable 1-MCP treatment, but effects on other maturity and quality factors were small. Ethylene production of treated fruit was lower than that of untreated fruit. The effects of sprayable 1-MCP on IEC and firmness were maintained during storage, but the longevity of these effects was affected by cultivar, spray timing, and storage period. Postharvest application of 1-MCP further inhibited IEC and maintained firmness of the fruit during storage. These experiments show that sprayable 1-MCP may be a valuable tool to manipulate both pre- and postharvest responses of apple fruit. However, with the formulation used in these experiments, phytotoxicity, primarily as damage around lenticel areas, was observed at harvest indicating that further development of the formulation is necessary for industry use.

Efficacy of Sprayable 1-MCP on Apple Quality at Harvest and after Storage: The Ontario Experience

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A sprayable formulation of 250 µL·L⁻¹ 1-MCP and 1% oil adjuvant was applied to ‘McIntosh’, ‘Empire’, and ‘Delicious’ apple trees 1 week prior to anticipated optimum harvest. Other spray treatments included: none, 1% oil adjuvant alone, and a formulation of 125 µL·L⁻¹ 1-MCP and adjuvant (‘Empire’ only). Unsprayed fruit were treated postharvest with or without gaseous 1-MCP (1 µL·L⁻¹). At harvest, internal ethylene concentration (IEC), starch index, firmness, and soluble solids concentration were measured, as well as CO₂, ethylene, and total volatile production of fruit samples over a 14-day period at 22 °C. Additional fruit samples for all preharvest and postharvest 1-MCP treatments were held 14 days at 22 °C and IEC and firmness measured for treatment efficacy. Fruit quality was assessed at 3 and 6 month storage intervals and over a 2-week ripening period at 22 °C. For all cultivars, the production rates of CO₂, ethylene, and volatiles, as well as increases of IEC and decreases in firmness were inhibited or delayed by sprayable 1-MCP treatment. These effects were comparable to the postharvest 1-MCP treatment and were maintained during storage. The results of these experiments suggest that sprayable 1-MCP could be an additional tool for maintaining apple fruit quality. However, the sprayable formulation used in this study caused 100% incidence of skin damage to ‘McIntosh’ and a slight amount to ‘Empire’ (<5%). Lesions were halo-like, centered around lenticels, and tended to be more severe near the calyx. No skin damage was observed in ‘Delicious’ or in fruit treated with the adjuvant only or postharvest 1-MCP.

1-Methylcyclopentene, CO₂, and Diphenylamine Interactions with External CO₂ Injury of ‘Empire’ Apples

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The ‘Empire’ apple cultivar is susceptible to external CO₂ injury, a physiological disorder that is expressed as tan-colored, smooth, water-soaked areas that become irregularly shaped, rough, depressed, and wrinkled. 1-Methylcyclopentene (1-MCP) may increase susceptibility of fruit to external CO₂ injury during controlled atmosphere (CA) storage. We have investigated the effects of 1-MCP on external CO₂ injury of ‘Empire’ apple using several approaches. 1) Fruit were treated with 1%, 2.5%, and 5% CO₂ during storage. Higher injury levels were associated with exposure to higher CO₂ concentrations. 2) Fruit were exposed to 2.5% or 5% CO₂ for 3-week periods throughout storage, otherwise being kept at 1% CO₂. Most injury occurred in fruit treated with elevated CO₂ during the first 3 weeks of storage, and 1-MCP did not extend the period of susceptibility to injury. 3) Exposure of fruit to CA with 5% CO₂ after harvest was delayed for up to 14 days. Susceptibility to injury remained high during the delay in 1-MCP-treated fruit in contrast to untreated fruit. 4) Fruit were treated with 250, 500, and 1000 µL·L⁻¹ diphenylamine (DPA), an antioxidant applied for control of superficial scald that is known to prevent susceptibility of fruit to CO₂ injury at 1000 µL·L⁻¹. The DPA eliminated injury in 1-MCP treated fruit, even at 250 µL·L⁻¹. Our data show that 1-MCP increases susceptibility of ‘Empire’ apples to external CO₂ injury and extra care is therefore required to avoid fruit losses. Nonchemical means may reduce losses, but only DPA application has been shown to eliminate risk of injury.

Effects of 1-MCP and Ozone on Carrot Volatiles during Storage

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Volatiles compounds contribute to carrot (Daucus carota) flavor. However, effects of postharvest treatments on these compounds are not defined. To characterize treatment effects, fresh carrots (cv. Sunrise) were treated with 0 or 1.0 µL·L⁻¹ 1-methylcyclopentene (1-MCP) at 10 °C for 16 h, then exposed to 0, 0.3, or 1.0 µL·L⁻¹ ozone (O₃) at 10 °C for 1, 2, or 4 days, and subsequently stored at 0 °C for up to 24 weeks. Twelve terpenes were identified in the headspace over whole carrots, including dimethylallyl (22.5%), alpha-pinene (19.1%), Caryophyllene (15.8%), beta-pinene (9.1%), p-cymene (8.3%), limonene (7.7%), gamma-terpinene (6.7%), myrcene (4.7%), gamma-terpinolene (4.5%), camphene (1.0%), alpha-phellandrene (0.52%), and sabine (0.03%). Most terpenes responded similarly to treatments and storage. Immediately after treatment with 1.0 µL·L⁻¹ O₃ for 1, 2, or 4 days, total terpene concentrations were 45%, 85%, and 87% greater than concentrations in non-treated controls. Caryophyllene, beta-pinene, and sabine did not increase in response to the O₃ treatment unlike the other terpenes. 1-MCP reduced terpene concentrations by an average of 18%. O₃ treatments also stimulated stress volatile production. Ethanol headspace concentrations were 8-, 21-, and 43-times greater than the nontreated controls immediately following treatments with 0.3 nL/L O₃ for 4 days or 1.0 µL·L⁻¹ O₃ for 2 or 4 days, respectively. However, after 8 weeks, no differences among treatments were observed. Hexanal production also was stimulated by all O₃ treatments, being 2- to 11-times greater than controls immediately following treatment. 1-MCP depressed O₃-stimulated ethanal and hexanal production by 23% and 8%, respectively.

Harvest Maturity Affects Response of Beit-alpha Cucumber Fruit to Postharvest Ethylene Exposure

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The present study was conducted to explore the process of watersoaking seen previously in bei alpha-type cucumber fruit treated with ethylene. Fruit were harvested at four levels of maturity: Immature (4 to 8 days after anthesis, DAA), Mature (10 to 14 DAA), Breaker (16 to 20 DAA), and Yellow (35 to 40 DAA). Fruit were then stored at 13 °C in
the presence of air (control) or either 10 µL·L⁻¹ ethylene or 1300 µL·L⁻¹ propylene for up to 12 days. The physiological response to ethylene treatment varied with fruit maturity. Immature-stage fruit treated with ethylene for 9 days had mesocarp watersoaking, epidermal sloughing, and lower hue (118°, control 124°), endocarp pH (4.4, control 5.4), and whole fruit firmness (23 N, control 46 N). Mature-stage fruit behaved similarly to Immature-stage fruit, but lacked mesocarp watersoaking. In contrast, after 9 days of ethylene exposure, the Breaker- and Yellow-stage fruit exhibited no watersoaking, accumulated beta-carotene in 95% to 100% RH abscised. Fruit that ripened prior to the appearance of sepal shrivel; no fruit stored ripeness stage, while no abscission occurred in fruit that reached the sepal shrivel became noticeable before the fruit reached the full red stage. Fruit from clusters stored at 20 °C and 20% or 50% RH abscised if ethylene for 9 days had mesocarp watersoaking, epidermal sloughing, and lower hue (118°, control 124°), endocarp pH (4.4, control 5.4), and whole fruit firmness (23 N, control 46 N). Mature-stage fruit behaved similarly to Immature-stage fruit, but lacked mesocarp watersoaking. In contrast, after 9 days of ethylene exposure, the Breaker- and Yellow-stage fruit exhibited no watersoaking, accumulated beta-carotene in 95% to 100% RH abscised. Fruit that ripened prior to the appearance of sepal shrivel; no fruit stored ripeness stage, while no abscission occurred in fruit that reached the sepal shrivel became noticeable before the fruit reached the full red stage.

**Interaction of Water Loss and Fruit Ripening**

**Promote Postharvest Cluster Tomato Fruit Abscession**

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Abscession of cluster tomatoes commonly limits product marketability in the retail environment. Ripening and exogenous ethylene exposure are assumed to play important roles in cluster tomato fruit abscession. ‘Clarence’ and ‘DRW7229’ fruit harvested at either mature green or partially ripened stages did not abscise during storage for 2 weeks at 20 °C and 95% to 100% relative humidity (RH), although respiration and ethylene production indicated that all fruit reached the postclimacteric stage. Exogenous ethylene (1 or 10 ppm) exposure for 8 days at 20 °C and 95% to 100% RH also did not induce fruit abscession for either cultivar, although pedicel and sepal yellowing were observed. Fruit from clusters stored at 20 °C and 20% or 50% RH abscised if sepal shrivel became noticeable before the fruit reached the full red ripeness stage, while no abscission occurred in fruit that reached the full red stage prior to the appearance of sepal shrivel; no fruit stored in 95% to 100% RH abscised. Fruit that ripened prior to the appearance of sepal shrivel were “plugged” (i.e., tissue underlying the stem scar was pulled out) if manual fruit detachment from the pedicel was attempted. These results indicate that there is an interaction of water loss and fruit ripening in promoting abscession zone development in cluster tomatoes.

**Growth of Geranium Plants in Soilless Media Containing Sphagnum Peat and Anaerobic Digestion-Derived Biosolids**

Michael Compton*, Timothy Zauche

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Anaerobic digestion-derived biosolids (ADB) has the potential to become a complete or partial substitute for sphagnum peat in the greenhouse and nursery industry. Bedding plant production being one of the largest segments of the floriculture industry may possess the greatest application for this new organic addendum to soilless media. An experiment was conducted in which geraniums (Pelargonium × hortorum ‘Red Elite’) were grown in potting mixes formulated with vermiculite and perlite plus various concentrations and combination of anaerobic digestion-derived biosolids (ADB) and sphagnum peat to determine if ADB could be used as a partial or complete replacement for sphagnum peat in soilless horticultural growing media. Plants were grown during June and July 2003–05 in the greenhouse at 75 ± 5 °F and normal light and photoperiod. Plant growth was assessed by measuring the dry weight of stem tissue. Plants were harvested when at least 50% of the total number of plants produced at least one inflorescence. Floriferousness was measured by counting the number of visible inflorescences per plant. Dry weight of plants grown in media containing ADB was greater than those grown in media containing sphagnum peat as the sole organic addendum. Plants grown in media containing ADB were also more floriferous. This study demonstrates that ADB has great potential for use as an organic addendum to horticultural growing media as a partial or complete replacement for sphagnum peat. Use of anaerobic digestor-derived biosolids in horticultural growing media is a protected intellectual property and available for license through the WiSys Technology Foundation.

**The Effect on Substrate Silica Incorporation on Post-germination Damping Off of Vinca**

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Vinca (Catharanthus roseus) is a common annual bedding plant species that is susceptible to root and stem rot caused by Phytophthora nicotianae. The experimental design was a 6×2×1 factorial with a total of 12 treatment combinations that had five replications and was repeated twice. Vinca seeds were planted in the middle nine plugs of a 5×5 five-milliliter round plug tray filled with sphagnum peat (control) or peat amended with 2.1 kg/m³ calcite lime, 5.9 and 7.3 kg/m³ potassium silicate alone and combined with 3.0 kg/m³ calcium sulfate. A peat control drenched with metalaxyl after inoculation was also included. After germination, when the seedlings had one true leaf, half of the treatments were inoculated with 500 cfu of Phytophthora nicotianae per plug cell while the other half remained uninoculated. The percentage of germination for the potassium silicate combined with calcium sulfate (KSCS) (79% and 78%) was similar to the control (86%) and
the metalaxyl treatment (83%), whereas the potassium silicate alone had poorer germination (69% and 71%) and plant growth. The percentage of mortality for the KSC treatment (6% and 14%) was similar to the metalaxyl treatment (9%) but was significantly less than the control (100%). The average dry shoot and root weights for the KSCS treatments (4.4 and 4.9 mg; 2.7 and 2.2 mg) were similar to the metalaxyl treatment (5.0 and 3.6 mg) and the uninoculated control (5.0 and 3.2 mg), but were higher than the potassium silicate treatment alone (2.1 and 1.6 mg; 0.7 and 0.6 mg).

Effect of Potassium Concentration on a Hybrid Phalaenopsis Grown in a Bark Mix or Sphagnum Moss

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Vegetatively propagated plants (15-cm in leaf spread) of a white-flowered Phalaenopsis Taisuco Kaaladian clone were imported bare-root in late May and planted in a mix consisting of three parts of medium-grade fir bark and one part each of perlite and coarse Canadian peat (by volume) or in Chilean sphagnum moss. All plants were given 200 mg·L-1 each of N and P, 100 mg·L-1 Ca, and 50 mg·L-1 Mg. K concentrations were 0, 50, 100, 200, 300, 400, and 500 mg·L-1. After 7 months, plants grown in moss produced an average of two more leaves than those in the bark mix (4 to 5 vs. 2 to 3 leaves), regardless of K rates. In any given medium, K rate did not alter the rate of leaf production. The K rate did not affect the size of the top leaves when grown in the bark mix. However, plants grown in moss had increasingly longer and wider top leaves as K rate increased. The lower leaves on plants in the bark mix receiving no K showed deficiency symptoms of purple tinting, yellowing, necrosis, and even death. Yellowing and necrosis started from the leaf tip and progressed basipetally. The K at 50 mg·L-1 reduced and 100 mg·L-1 completely alleviated the symptoms of K deficiency. Plants grown in moss and receiving no K showed limited signs of K deficiency. Flowering stems started to emerge (spiking) from plants in the bark mix up to 4 weeks earlier than those planted in sphagnum moss. For plants receiving no K, all plants in the bark mix bloomed, whereas none planted in sphagnum moss produced flowering stems. Overall, at least 200 mg·L-1 K (~250 mg·L-1 K2O) is recommended to produce quality plants with maximum leaf growth and early spiking.

P rates resulted in taller plants with equally more nodes compared to 0 mg·L-1. As K rate increased from 0 to 100 mg·L-1, height and node number increased, but there were no further increases in height at high rates. Number and percentage of leaves remaining increased as N and K rates increased.

Nutrient Ranges in Pelargonium × hortorum and Pelargonium Species

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1ARS, USDA, Toledo, OH, 43606; 3University of Toledo, Department of Biological Sciences, Toledo, OH, 43606; 4Ohio State University, Ornamental Plant Germplasm Center, Columbus, OH, 43210; 3University of Toledo, Department of Earth, Ecological, and Environmental Sciences, Toledo, OH, 43606

Zonal geranium (Pelargonium × hortorum) and scented geranium (Pelargonium sp.) together are among the top-selling floriculture plants in the United States today, with several hundred cultivars and species available each year. With such diversity in appearances, growth habits, and developmental traits, we hypothesize a correspondingly wide range of nutritional uptake and partitioning characteristics. Mature leaves from 55 cultivars or breeding lines of zonal geranium and 60 species of Pelargonium sp. were sampled from paired plants twice throughout the year from the Ornamental Plant Germplasm Center. Their tissue was analyzed for essential macro- and micronutrients using ICP-OES. Generally, macronutrients varied by a factor of 3–5, whereas micronutrients varied by up to 100-fold. The micronutrient boron was a notable exception with variation across the samples of only about a factor of 5. With this information, attempts will be made to correlate tissue nutrient concentrations with genetic source (cultivars and breeding lines) and environmental conditions from the origin of the different Pelargonium species from South Africa. This work illustrates the challenges in associating specific sufficiency or deficiency values for nutrient concentrations in tissue of plants based on only a few cultivars, species, or locations.

Growth of Cypripedium Orchids in Soiless Media Containing Anaerobic Digestion-derived Biosolids

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Lady slipper orchids have great potential as a perennial bedding plant in temperate-zone climates. Unfortunately, many gardeners fear these species because of their high cost and perceived difficulties associated with growing plants outdoors. The former factor can be addressed by improving the production of plants at the wholesale level. Growers contest that sphagnum peat and coconut coir are poor organic addenda for these species due to their natural acidity. Anaerobic digestion-derived biosolids (ADB) are not acidic like sphagnum peat or coconut coir, and may be the perfect organic addendum for the culture of ladyslipper orchids. Hence, 3-year-old plants of showy (Cypripedium reginae) and yellow ladieslipper (Cypripedium parviflorum var. pubescens) orchids were grown in soilless potting mixes containing vermiculite and perlite plus various concentrations and combinations of ADB and coconut coir. Plants were grown in the greenhouse at 70 ± 5 °F and received normal light and photoperiod during Summer 2005. Growth, as assessed by the dry weight of dormant stem tissue, of showy ladyslipper potted in media containing ADB was three- to four-times greater than those grown in media containing coconut coir. Growth was similar among yellow ladieslippers grown in media containing ADB or coconut coir due to the fact that these plants had produced all their stem growth for the season before the experiment was initiated. ADB has great potential as an organic addendum to horticultural growing media used for the culture of Cypripedium species. Use of anaerobic digester-derived biosolids in horticultural growing media is a protected intellectual property and available for license through the WiSys Technology Foundation.
Costs and Returns of Producing Outdoor Cut Flowers
Robin Brunfield*
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Field-grown cut flower production, in general, is a low-overhead business. This is both good news and bad news. Good—because it doesn’t require a lot of capital to get started in this business. Bad—because competition can develop rapidly, sometimes from marginal producers for whom profitability is a low priority. Thus, it is important for producers to know the costs of growing each product so that they can make profitable production and marketing decisions. A cost accounting program was developed to help producers calculate the cost of each crop. In addition, a series of benchmark budgets were developed for specialty cut flowers. These budgets are on the Rutgers University Farm Management Website (http://aesop.rutgers.edu/~farmmgmt).

Oral Session 11—
Vegetable Crops Culture & Management
28 July 2006, 10:30 a.m.–12:00 p.m. Bayside B
Moderator: Alan Walters

Can Cover Crop-based Systems Reduce Vegetable Crop Fertilizer Nitrogen Requirements in the Southeastern United States?
Laura Avila1,3, Johannes Schollberg1, Lincoln Zotarelli2, Robert McSorely1
1University of Florida, School of Natural Resources and Environment; 2University of Florida, Agronomy; 3University of Florida, Entomology and Nematology

Poor water- and nutrient-holding capacity of sandy soils, combined with intense leaching of rainfall events, may result in excessive N-fertilizer losses from vegetable production systems. Three cover cropping (CC) systems were used to assess supplemental N-fertilizer requirements for optimal yields of selected vegetable crops. Fertilizer N-rates were 0, 67, 133, 200, and 267; 0, 131, and 196; and 0, 84, 126, 168, and 210 kg N/ha for sweet corn (Zea mays var. rugosa), broccoli (Brassica oleracea), and watermelon (Citrullus lanatus), respectively. Crop rotations consisted of sunn hemp (Crotalaria juncea), which preceded a winter broccoli crop. Bell pepper and tomato were planted on plastic mulched to evaluate the effects of three nitrogen (N) fertilizer rates (154, 192, 288 kg·ha−1 N for pepper vs. 166, 208, and 312 kg·ha−1 N for tomato) and three irrigation scheduling methods were evaluated. Depending on sensorreadings, soil moisture sensor (SMS) irrigation treatments allowed up to five watering events per day where as for the fixed duration treatment irrigation was applied once a day. For tomato, the effect of subsurface drip irrigation (SDI) was also evaluated. Compared to TIME, use of SMS control system reduced water use by 29% to 44% and 37% to 66% for tomato and pepper, respectively. Tomato yield was significantly higher on SMS and SDI treatments compared to TIME treatments. For pepper yield and biomass accumulation were not affected by irrigation treatments. The average yields were 24.6 and 27.8 Mg·ha−1 of fresh marketable fruits for pepper and tomato, respectively. Nitrogen rate did not affect yield and optimal yield N rate did not affect yield for either crop. On average, SMS treatments increased irrigation water use efficiency 2–3 times compared to TIME treatments for both tomato and pepper.

Performance of Bell Pepper Cultivars in a Commercial Field Infested with Phytophthora capsici
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Phytophthora blight, caused by Phytophthora capsici, is a widespread problem of many vegetables including bell peppers. Four bell pepper cultivars marketed as resistant/tolerant to P. capsici include ‘Paladin’ (resistant), ‘Alliance’ (tolerant), ‘Aristotle X3R’ (tolerant), and ‘Revolu- tion’ (tolerant). These cultivars, along with four other widely grown cultivars (‘Commandant’, ‘king Arthur’, ‘Legionnaire’, and ‘Red Knight X3R’) and a susceptible control (‘Califonia Wonder’), were evaluated for their performance in a commercial field highly infested with P. capsici. ‘Paladin’ had the lowest incidence of Phytophthora blight and the greatest yield compared to all other cultivars. ‘Alli-ance’, ‘Aristotle X3R’, and ‘Revolu- tion’ (the tolerant cultivars) also had lower Phytophthora blight incidence and greater yields compared to the other five cultivars evaluated. Results indicated that in fields that historically have high incidence of Phytophthora blight, ‘Paladin’ could be a reliable choice for commercial production.

Influence of Slow Release Methylene Urea Products on Tomato Yield, Quality, Nutrient Uptake, and Economics
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Two formulations of a new methylene urea product on tomato were evaluated. Applications of 150, 200, 250 lb/acre of N in eastern North Carolina and 175 and 250 lb/acre of N in western North Carolina of both liquid and dry formulation of the material were made. The liquid was applied the first 6 weeks of growth and the dry applied at planting. These treatments were compared with 200 lb/acre of N (standard) and 300 lb/acre of N, which were fertigated throughout the season. In eastern North Carolina, all rates of the liquid and high rate of dry formulations produced more yield of larger fruit than the standard. In western North Carolina, all methylene urea sources out-performed the standard. Soil and foliar nitrate was somewhat greater than the standard throughout the season, but, at end of season in the west, only the 250 dry material had more N in the soil. Methylene urea treatments took up more N than...
Effect of Root Substrates and Nutrient Solution Electrical Conductivity on Tomato Transplant Characteristics

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In order to evaluate alternative rooting media as a substitute to sphagnum peat in tomato transplant, fresh rice hulls (2 and 4 mm particle size), perlite, and peat were compared. In the same experiment, four nutrient solutions differing in electrical conductivity [EC] 2.5, 3.5, 4.5 and 6.0 mS/cm], but not in nutrient content, were used. Seed of tomato (Lycopersicon esculentum L.) ‘Brigade’ (ASGROW) were sown in 55 × 35 × 6.5 cm polystyrene transplant trays containing 336 cells (15 mL) and filled with the root substrates. The trays were placed in a glass-glazed greenhouse. Trays were kept under intermittent mist for 6 days and then fertilized twice per week with 2.6 L per tray of solution. A split-plot design with three replications was used with nutrient solution serving as the main plot and root substrates serving as the subplots. During the growing cycle (once a week) and when plants were ready to transplant (16 cm tall, with an average of five to seven true leaves), stem diameter, hypocotyl length, plant height, number of true leaves, fresh shoot weight, and dry shoot weight were measured. Also at transplant, root fresh and dry weight and above- and below-ground biomass were analyzed to determine N, P, K, Ca, Mg, Fe, and Mn content. Plants grown in rice hulls were as marketable as those in peat, but showed a higher content in N, K, and Mn. Increased nutrient solution affected not only dry matter accumulation, but also stem diameter and plant height, which were greater in plants grown with high EC.

Optical Tools, a Suitable Means to Reduce Nitrogen Use in Fertigated Tomato Crop

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Technology provides new tools for agriculture to be able to optimize fertilization. Optical instruments are becoming valid tools for farmers in making decisions about fertilization, even though they need to be calibrated for specific crops. Chlorophyll meters and multispectral radiometers have been tested on rice, corn, and wheat and afterwards on vegetables, in timing fertilization. Today, threshold lines that are able to detect crop N status in tomato crops are available. These thresholds, obtained in experiments carried out at Padova University, were validated in three open-field experiments. The first experiment was carried out in 2004 at the University experimental farm on tomato cv. Perfect Peel. The second and third experiments were conducted in a commercial farm at Codigor (Ferrara) in 2004–2005. Tomato cultivars used were ‘UGX 822’ and ‘Precocix’ in 2004, in 2005 ‘Jet’ was also used. In all trials, a “standard fertilization” management was compared with fertigation guided using SPAD and/or Cropscan. Optical tools were used to manage fertigation adopting both “threshold method” and “reference plot method”. In general “guided fertigation” resulted in less nitrogen application (N supply reduced between 18% and 45%), especially when “threshold method” was adopted. Yields were comparable to “standard fertilization” treatments, showing a better efficiency of “guided fertigation”. In some cases, guiding fertigation by means of optical instruments allowed higher fruit fresh weight, although dry matter content and ”Brix” were not influenced. Guided fertigation reduced also the number of damaged fruit and the percentage of nonmarketable product.
Promotion of Flowering in Apple with NAA and Ethrel
Steven J. McArtney*, Dick Unrath
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Experiments were carried out in the southeastern United States between 1998 and 2006 to evaluate the potential for applications of NAA, Ethrel, or both, in the on-year of a biennial bearing cycle to increase return bloom in apple. Four bi-weekly applications of 5 ppm NAA beginning in mid June (summer NAA) increased return bloom, measured as the percentage of floral spurs in the year after treatment. The level of return bloom on trees receiving a summer NAA program was more than 2-fold higher than on untreated control trees, averaged across seven different experiments. Four applications of 5 ppm NAA at weekly intervals leading up to harvest (August/September) increased return bloom also. Combining 150 ppm Ethrel with summer NAA sprays resulted in an additive effect on return bloom compared to NAA or Ethrel alone. The effect of flower cluster density on return bloom the following year was more negative on control trees than it was on trees sprayed with Ethrel in the previous year. Treatment effects on fruit maturity at harvest were generally neutral, although flesh firmness was reduced in some experiments. NAA or Ethrel sprays in the on-year of a biennial bearing cycle may provide a strategy for achieving more consistent flowering and cropping in apple.

Developmental Anatomy of Russet of ‘McIntosh’ Apple Fruit Induced by the Fungus Aureobasidium pullulans
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The fungus Aureobasidium pullulans is ubiquitous and can cause russet of fruit in New York orchards. The details of russet induction by this fungus are not well known. We inoculated ‘McIntosh’ apple fruits with a suspension of A. pullulans spores (10 million colony-forming units/mL) 1–2 weeks postbloom or later at about 30 days postbloom. We dropped inoculum into plastic “microwells” attached to the fruit surface. The cuticle of uninoculated fruit (wells filled with water only) had no russet by autumn. Skin susceptibility to russet diminished with fruit age. The cuticle of inoculated young fruit began to break down in a few days, likely through direct cuticular digestion. Further erosion and breaking of the protective cuticle caused underlying epidermal cells to die. Within 1–2 weeks, cuticle disruption and epidermal cell death were widespread. This stimulated the fruit to initiate a repair process that involved periderm formation (russet), where many rows of cells were produced in nearby tissue to seal off the injury. This type of repair is not stretchable, so as young fruit expanded, additional skin splits and checks developed. This breakdown–repair process repeated itself, which created a scurfy skin. Older fruit did not expand as much after inoculation as did young fruit, and so they developed few obvious leathery patches of periderm. Older cuticle also resisted digestion better than did the young fruit cuticle, but we do not know if resistance resulted from increased cuticle thickness in older fruit or a change in cuticular compounds during fruit growth. Regardless, A. pullulans applied to older fruit did not progress beyond the early phase of cuticle digestion, even after 3 weeks postinoculation.

Influence of Indolebutyric Acid Potassium Salt on Propagation of Semi-hardwood Stem Cuttings of Bougainvillea
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Bougainvillea glabra is a tropical species with reportedly difficulty to propagate. Previous research has shown the importance of t alc-based rooting hormones when propagating Bougainvillea, yet little has been published on the efficacy of liquid-based formulations. Therefore, our objective was to determine the optimum concentration of indolebutyric acid potassium salt (KIBA) needed to effectively root semi-hardwood stem cuttings of Bougainvillea ‘California Gold’ and ‘Helen Johnson’. Sub-terminal cuttings measuring 6.5 cm were harvested from stock plants of Bougainvillea on 3-week intervals from 6 June to 8 Aug. and repeated 6 Sept. to 8 Nov. 2005. Cuttings were dipped 0.5 cm in a solution of 0, 1500, 3000, or 6000 mg L^-1 KIBA or in a 1500-mg L^-1 solution containing indolebutyric acid (IBA) 1%: naphthaleneacetic acid (NAA) 0.5% and propagated under mist. Cuttings were evaluated for percent survival, rooting quality (1 = poor; 5 = best), and number of primary and lateral roots 5 weeks after planting (WAP). Differences in ‘California Gold’ for percent survival, average rank, and number of roots were determined not significant at P ≤ 0.05. However, application of rooting hormone to ‘Helen Johnson’ increased rooting quality, number of primary roots, and number of lateral roots by up to 24%, 53%, and 50%, respectively. Results indicated rooting performance was generally improved with application of KIBA; therefore, cuttings of Bougainvillea may benefit from a 1500-mg L^-1 solution. KIBA was also found to be as effective as the industry standard liquid formulation.

Response of Coleus (Solenostemon scutellarioides) to Plant Growth Regulators Applied during Propagation
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A daminozide plus chlormequat chloride tank mix spray was applied to six Coleus cultivars or breeding lines at different times during propagation. For UF 03-8-10 and ‘Coco Loco’, plants sprayed on day 7 or day 10 were shorter than control plants at transplant, but plants sprayed on day 13 were not. Other cultivars did not respond to single applications. Five of the six cultivars responded to application on days 7 and 13.
Plants of UF 03-8-3 and ‘Coco Loco’ were significantly shorter than control plants at transplant. Plants of UF 03-8-10, UF 03-6-1, and UF 03-17-8 were shorter than control plants at 3 weeks after transplant. ‘Hurricane Louise’ did not respond to the tank mix. A second study found a cultivar specific response to three chemical treatments applied as a spray on day 10 of propagation. At transplant, UF 03-8-10, UF 03-8-3, UF 03-6-1, and ‘Coco Loco’ plants sprayed with the tank mix at 2500 plus 1500 mg L⁻¹, respectively, were significantly shorter than the control plants. A uniconazole spray at 2 mg L⁻¹ reduced elongation in UF 03-8-10, UF 03-8-3, and UF 03-6-1, compared to control plants. Ethephon at 250 mg L⁻¹ reduced elongation in UF 03-8-10, UF 03-8-3, and ‘Coco Loco’ plants. None of the chemical sprays reduced elongation in ‘Hurricane Louise’ at the concentrations applied. Ethephon increased axillary branching in all cultivars, and induced lower leaf abscission in UF 03-17-8 and ‘Hurricane Louise’; leaf malformation in UF 03-6-1 and ‘Coco Loco’; and color alteration in UF 03-6-1, UF 03-8-3, and ‘Coco Loco’.

The Influence of Plant Growth Regulators on Budbreak and Shoot Growth from Large Stem Segments of Acer saccharinum L.
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A factorial combination of gibberellic acid (GA₃) and benzyladenine (BA) was applied in 20% white exterior latex paint to large (40 cm long, >2.5 cm diameter) stem segments of Acer saccharinum L. (silver maple) to determine the effects on forcing new softwood shoots in the greenhouse or laboratory and the subsequent growth of these new shoots in vitro. Stem segments were harvested from 10-year-old field-grown coppice shoots. The GA/BA-paint mixes were applied to the entire stem segments that were forced in plastic flats filled with 1 perlite : 1 vermiculite (by volume) and watered with care so as not to wet the new softwood shoots. The flats and stem segments were drenched weekly with Zerotol (0.18% H₂O₂). The softwood shoots were harvested when they were at least 3 cm long. After disinfecting and rinsing, the nodal and shoot tip explants were established aseptically in vitro on DKW medium with no cytokinin or with 10-8M thidiazuron. Coppice shoots were harvested, cut, and painted on 9 Sept., 28 Oct., and 12 Dec. 2005. Although there were no significant differences in shoot production among stem segments painted with various combinations of GA/BA, stems treated with plant growth regulators produced a mean of 2.7, 1.8, or 0.5 shoots for the three harvest dates compared to 0.5, 0.0, or 0.25 shoots on control stem segments. It is well-known that shoot forcing is poor from September through January; however, use of GA/BA resulted in growth of dormant epicormic shoots. Shoot tip explants produced the most shoots in vitro after 8 weeks if they were harvested from stem segments treated with 0.03 mM GA₃, whereas nodal explants produced the most shoots if harvested from segments that had been treated with 0.01 mM GA₃.

Different Developmental Stages of Mother Plants Induce Different Morphogenesis Pathways in In Vitro Culture of Fritillaria imperialis and Fritillaria persica
Ahmad Khalighi*,1, Manijeh Mohammadi Dehcheshmeh1, Esmaili Ebrahimi2, Manoochehr Sardari1, Rohangiz Naderi1, Rohangiz Naderi1
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Fritillaria imperialis and Fritillaria persica are important medicinal and ornamental plants that are native to Iran. Wild populations of Fritillaria are at risk of extinction. For the first time, capability of developmental stages in respect to induction of different morphogenesis pathways from petal tissue was studied in detail. The developmental stages were green unopened flowers, colored unopened flowers, and open flowers. Direct bulbelt regeneration and direct somatic embryogenesis were observed from green unopened flowers in both F. imperialis and F. persica. More bulbelt regeneration was produced in F. imperialis in contrast with F. persica in colored unopened flowers.
Somatic embryogenesis via callus was established in green unopened flowers of *F. persica* with cold pretreatment. The effect of light on induction of different morphogenesis pathways was nonsignificant except for green unopened flowers of *F. persica* with cold treatment. Our results showed that the developmental stages of petal explants play a significant role in micropropagation of *Fritillaria* and induction of different morphogenesis pathways.

Oral Session 14—Fruit Breeding

28 July 2006, 4:15–5:15 p.m.  Bayside A

Moderator: David Byrne

Studies with Crisp-textured Blueberries

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Over the past two decades, selections that produce crisp-textured blueberries have been noted by breeders. Research was conducted to determine how these selections differ from standard cultivars. Four blueberry clones with crisp texture were compared, using firmness, with 94 advanced selections from the University of Florida blueberry breeding program. The clones, tested for berry firmness with an Instron machine, produced a normal distribution. The crisp clones were at the high end of the distribution, but were not qualitatively different from other firm-fruited selections. Firmness was tested during final stages of berry development to determine if crisp clones softened more slowly than standard cultivars. In both 2003 and 2004, firmness decreased greatly from the white to pink stages of development, with slower loss of firmness thereafter. Crisp and commercial clones were similar in the timing of firmness loss. Berries from six crisp clones and four firm commercial cultivars were subjected to shear cell tests to see if the two groups could be distinguished. Shear cell tests from early and late harvests in the same year showed good agreement. Three of the four crisp clones were much higher in shear force than the other clones tested. A consumer sensory panel was conducted to determine if the average person could distinguish between the berries of crisp and standard cultivars. Ninety-five subjects were given two samples of each of crisp and non-crisp blueberries, and asked to designate the one sample they thought the most crisp. Seventy-five subjects chose one of crisp and 20 chose one of the standard clones. This research indicates that crisp texture in blueberry exists and is recognizable and repeatable, but is difficult to objectively define.

Progress in Selection for Cold-hardiness, Adaptation, and Quality in *Vaccinium ashei* and *Vaccinium ashei*/*V. constablaei*: Derivatives and the Potential for Northern-adapted Rabbiteye Cultivars

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In recent years, the U.S. Department of Agriculture has generated *V. ashei* and *V. constablaei* derivatives to provide late-flowering, early-ripening rabbiteye germplasm for the southern U.S.; however, this germplasm has also performed well in New Jersey, and could potentially provide northern-adapted rabbiteye types. When combined, these germplasms complement each other in many respects. Crosses with varying percentages of *V. constablaei* germplasm ranging from 100% to 0%, in 25% increments, were evaluated for mid-winter cold-hardiness using a detached twig assay. Hybrids with 50% or more of *V. constablaei* germplasm were hardy to −25°C or lower. Further backcrosses to *V. ashei* resulted in dramatic segregation for hardiness, but still yielded some progeny as hardy as typical northern highbush. Assays of rabbiteye cultivars have been recently completed to enhance the ability to generate cold-hardy hybrids. Recombination and selection have begun to yield hybrids improved for critical commercial characteristics, and further rapid progress is expected.

Molecular Marker Use in Tree Fruit and Woody Ornamental Plant Breeding

David Byrne*

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Fruit and ornamental breeders were surveyed about their use of molecular markers in either their breeding programs or in their related research programs. Responses were obtained from over 100 fruit and ornamental breeding programs from throughout the world. Of these, less than 50% used molecular markers in their programs. The two most common uses of these markers were for studies in plant identification and diversity. These were followed by the use of markers in developing molecular maps, in discovering molecular tags and/or trying to identify the genes for specific plant traits, for marker assisted selection, and finally, for the elucidation of plant taxonomy. In conclusion, although there is much research in this area, few programs are actually using markers in the context of an applied breeding program. The major reason for this situation is the lack of available markers and the cost of using these markers to screen large numbers of progeny. Those that use markers in their breeding tend to use them to verify the genotype of the parents or confirm the genotype of selected seedlings rather than screen unselected seedlings.

A Fresh Look at Avocado Pollination

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The synchronously dichogamous flowering behavior of avocado has historically been assumed to promote cross-pollination. Preliminary studies in southern California have revealed that self-pollination is more typical. The primary objective of the California research is to determine the paternity of individual fruit sampled during early and late fruit development using SSR markers. Cultivars included Hass as the primary cultivar and Bacon, Ettinger, Fuerte, Harvest, Lamb Hass, Marvel, Nobel, SirPrize, and Zutano serving as cross-pollinating cultivars. We were able to: 1) estimate proportions of self- and cross-pollinated ‘Hass’ fruit with cultivars planted in rows of varying proximity to the ‘Hass’ rows; determine if the proportion of outcrossed fruit increased during maturity due to preferential abscission of self-pollinated fruit; and 2) determine if there is preferential retention of fruit cross-pollinated by a specific cultivar during maturation. On average, cross-pollination by any individual cultivar in 2004 was 6% or less in marble-sized fruit. Over 70% of the fruit were self-pollinated. This is greater than the proportion of self-pollination (about 30%) observed in near-mature fruit harvested in the previous year, 2003. Proportions of marble-sized fruit pollinated by each cultivar within each row were compared to the proportions of self or cross-pollinations in fruit harvested from the same trees at near-maturity. We observed about a 10% increase in proportion of self-pollinated fruit and a concomitant decrease in retained fruit derived from cross-pollination. Self-pollination appears to be the dominant mode of pollination. These preliminary results indicate that trees benefit from it, perhaps in preference over cross-pollination.

Oral Session 15—

Vegetable Crops Culture & Management 3

28 July 2006, 4:15–5:45 p.m.  Southdown

Moderator: Dean Kopsell

Rapid Reconnaissance Method to Assess Hurricane Damage to Horticultural Crops in Miami–Dade County

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The University of Florida Miami-Dade County Extension, as a member...
of the USDA’s County Emergency Board, is required to assess damage to commercial horticultural crops (tropical fruit, ornamentals, and vegetables) immediately following natural disasters. While trying to determine dollar values following a freeze in Jan. 1997, Extension and the Farm Service Agency (FSA) developed a spreadsheet that lists all the major crops by commodity along with average yield per acre and price based on how the crop is sold. Acreage is another component, as is the percentage of each crop that was “lost” during the disaster in question. These components are multiplied to give a dollar value of the loss for each individual crops and are totaled to give losses for the major commodities in Miami-Dade. While acreage is relatively stable for ornamental and tree fruit crops, it fluctuates considerably for vegetables, depending on the time of year. Within roughly 24 h of a disaster, the committee assesses actual damage to different crops by conducting a windshield survey of the local growing area. This allows staff to calculate the percentage of damage experienced by each sector and current acreage. Then, acreage and crop loss figures are plugged into the equation and dollar values are generated. Crop loss can also be translated into lost jobs, which can assist migrant service providers with funding requests. This presentation will review the different types of damage experienced during hurricanes Katrina and Wilma in 2005 and their effects on the local economy. Katrina caused extensive flooding, with some structural damage, while damage from Wilma was primarily due to high winds and micro-bursts.

**Impact of Hurricanes on Vegetable Crops in South Florida**

Kent Cushman*1, Monica Ozores-Hampton1, Eric Simonne2, Eugene McAvoy3, Darrin Parmenter4, Teresa Olczyk2

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Vegetable producers in south Florida suffered the effects of four major hurricanes during 2004 and two during 2005, causing damage to crops and farms estimated at well over 1 billion dollars each year. Producers were quick to respond by replanting or nursing damaged crops back to health. Green beans and leafy crops appeared least likely to recover or produce acceptable yields after exposure to high winds and driving rains. Young tomato plants up to the second or third string were at times completely stripped of leaf material, yet recovered surprisingly quickly. A replant study showed no benefit in replanting compared to keeping damaged plants in the field. Older tomato plants were marginal in their ability to recover with 10% to 60% reductions in yield for first and second harvests when compared to yields common in the region. As much as 100% of Palm Beach County’s 2005 early fall bell pepper planting was destroyed by storms. Other peppers in the region were affected by flooding and subsequent development of root diseases such as phytophthora. Damaged eggplant recovered slowly. Research plantings located in commercial fields and at Research and Education Centers were devastated. In addition to loss of crops, costs to vegetable growers included labor to remove damaged plastic and reset stakes, installation of replacement plastic mulches, replanting, and structural damage to buildings and packing facilities. Some transplant houses and greenhouses for specialty peppers were completely destroyed. Removing plastic coverings before a storm’s arrival saved structures and crops. Transplants of all crops were in short supply. Labor was lacking due to reconstruction efforts in New Orleans and the Gulf Coast. Successful and not-so-successful recovery efforts will be shown.

**Crop Strategies Impact on Yield and Head Quality Components of Globe Artichoke in Southwest Texas**

Daniel Leskovar*1, Smijana Goret1, Kil Sun Yoo1, Giovanni Piccinni1, Shinshuke Aghar1

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Introduction of artichokes in the Wintergarden of Texas, an area with mild winters and hot summers, depends on the development of strategies that will overcome limiting climatic conditions for bolting, earliness, and length of harvest. Cultivars with different bolting requirements were evaluated at two planting times and irrigation rates. The cultivars Emerald, Experimental Red, Imperial Star, Green Globe, and Purple Romagnia were transplanted in the field on 27 Sept. and 3 Dec. 2004, and evaluated at 100% and 75% crop evapotranspiration rates (ETc) at Uvalde, Texas (29°1’ N; 99°5’ W). Harvests started on 24 Mar. and 21 Apr. 2005 for the first and second planting dates, respectively. Yield increased more than 3-fold for the first compared to the second planting date. Irrigation rates did not affect yield, water use efficiency, or head quality. The cultivars Emerald, Imperial Star, and Experimental Red were earlier than Green Globe and Purple Romagnia. The highest yield was measured for cv. Imperial Star, while the largest head weight was for cv. Green Globe. Total fibers, crude protein, and phenolic compounds concentration depended on cultivar, whereas the total sugar concentrations in the edible part of the head were similar among cultivars. Head weight, percentage of heart, and crude protein concentration decreased, whereas total fiber content increased as the harvesting season progressed. Integrating environmental and cultivar strategies aimed at earliness, large head size, and enhanced level of health-promoting compounds, will contribute to the potential production of globe artichokes in the region.

**Yield and Isoflavone Content of Edamame Varieties at Different Planting Dates and Densities**

Allison E. Stewart*, Debra J. Carpenter, Vincent R. Pantalone, Carl E. Sams

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Consumer interest in Edamame (edible soybean) is increasing due to reported health benefits associated with diets high in soy. The purpose of this study was to compare four varieties of edible soybean grown at four plant spacings on three planting dates. The lines were grown at the Plateau Research and Education Center in Crossville, Tenn. They were analyzed for horticultural traits and isoflavone content. All lines were at the R6 stage. Fresh weight of pods, weight of 200 pods per plot, the number of seeds per 200 pods, and the weight of 100 seeds were recorded from two-row plots (6.10m x 1.52 m). A significant (P < 0.001) difference was found for fresh weight among planting dates. The May planting had the highest mean fresh weight (3118 g/plot), followed by the June (3068 g/plot) and July (2131 g/plot) dates. The weight per 100 seeds was significantly different (P < 0.001) for planting date and genotype. May seed weight was highest at 49 g, followed by June at 45 g, and July at 42 g per 100 seeds. ‘Gardensoy-43’ was the highest-yielding variety, with a mean of 3253 g/plot. It was followed by ‘TN00-60’ and ‘TN03-349’, with mean fresh weights of 2730 and 2723 g/plot, respectively. The line ‘TN5601T’ had the lowest mean fresh weight of 2389 g/plot. Both fresh weight (P < 0.001) and weight...
Response of Seed Potato (Solanum tuberosum) Cultivars to Glyphosate
Harlene M. Hatterman-Valenti*, Collin P. Auwarter, Paul G. Mayland
North Dakota State University, Plant Sciences

Field trials were initiated during 2004 at a dryland site near Prosper, N.D., to evaluate the effects of simulated drift from glyphosate to ‘Russet Burbank’ and ‘Red Lasoda’ seed potato during the early senescence stage. Glyphosate was applied at rates 1/3, 1/6, 1/12, 1/24, and 1/48 the use rate for spring wheat desiccation on 10 Sept. 2004 with a CO2 pressurized sprayer operated at 280 L/ha and 276 kPa. The amount of a.m.S added to the spray solution was also reduced accordingly. Following harvest, samples from each plot were placed into cold storage until the following March. A subsample from each plot was slowly warmed to initiate sprout formation. Remaining samples were cut into 57-µm pieces, dusted with a seed piece treatment, and stored at 15 °C with about 90% RH until planted. Plots consisted of two 3-m rows at 91 cm-row spacing with a border row on each side and three spacers between plants within plots. The trial was arranged as a randomized complete block with four replications. Plots were desiccated on 12 and 19 Sept., and harvested 11 Oct. Tubers were hand-grafted shortly after harvest. Results indicated that glyphosate at 70 g ae/ha, or more inhibited tuber budbreak by 75% or more compared to untreated. In the field, injury was observed as delayed emergence and, in several instances, no plants emerged. Total yield for ‘Red Lasoda’ was 34.8 Mg/ha for the untreated, which was significantly greater than glyphosate treatments of 280, 140, and 70 g ae/ha. ‘Russet Burbank’ total yield was considerably less at 23.5 Mg/ha, which was significantly greater than glyphosate treatments of 280, 140, and 70 g ae/ha.

Organic Garlic Research in Colorado; Winter Mulching, Irrigation Systems, Spacing, Scape Removal, and Flame Cultivation
Debra Guenther*, Frank Stonaker*
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The Specialty Crops Program at Colorado State University conducted research of hardneck garlic (Allium sativum ophioscorodon) production on certified organic land at the Horticulture Field Research Center northeast of Fort Collins, Colo., during the garlic growing seasons of 2002–03 and 2003–04. Winter mulches and irrigation treatments were studied during the first season. It was found that garlic that was covered by any type of winter mulch (grass hay, single or double layers of floating row cover) resulted in better yields (higher average bulb weight) than garlic which was not covered at all (ANOVA, F = 2.93, P = 0.034). Yields from sprinkler and furrow irrigation were essentially the same; however, furrow irrigation used nearly 30% more water. Too little water was applied to the drip-irrigated treatment and yield suffered. Our findings suggest that yields are negatively impacted when less than 12 inches of combined precipitation and irrigation are received. During the second season, clove planting spacings of 3, 4.5, and 6 inches, and flame weeding and scape removal effects on yields were studied. The bulbs that grew at a 6-inch spacing were significantly larger than those grown at 3 and 4.5 inches (ANOVA, F = 46.5, P = 0.001). Flame weeding had no significant effects on yields (t-test, P = 0.6) and may be more economical compared to hand weeding depending on fuel costs. Removing the scapes did result in slightly higher bulb weights (t-test, P = 0.06). Removing scapes takes extra labor and may not be worth the time for only slightly higher bulb weights; however, selling the edible scapes may offset the cost and generate extra income.
tural production. Thus, a more holistic approach is required to reduce N loading associated with vegetable crops production on soils that are prone to N leaching. By linking fertilizer N uptake efficiency (FUE) with irrigation management, root interception capacity, and N uptake dynamics, we aim to improve FUE. Nitrogen uptake for peppers, tomato, potato, and sweet corn followed a logistic N accumulation patterns. Up to 80-85% of N uptake occurred between 4 to 7 weeks (sweet corn) vs. 6 to 12 weeks (other crops), while N uptake during initial growth and crop maturation was relatively low. Maximum daily N accumulation rates occurred at 5 weeks (sweet corn) vs. 8-10 weeks (other crops) and maximum daily N uptake were 4-8 kg N/ha. Overall FUE for most vegetables may range between 23% and 71%, depending on production practices, soil type, and environmental conditions. Maximum root interception capacity was typically attained 3 to 5 weeks prior to crop maturity. It is concluded that, during initial growth, root interception may be the most limiting factor for efficient N use. Although recent uptake studies have shown that FUE may be highest toward the end of the growing season, this may not coincide with the greatest crop demand for N, which occurs during the onset of the linear growth phase. As a result, yield responses to N applied later in the season may be limited. Integration of these results into best management practices and expert systems for vegetable production can minimize the externalities associated with commercial vegetable production on vulnerable soils in the southeastern United States.

Maturity, Yield, and Quality Modeling for Processing Carrots
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Carrot processing demands a continuous supply of uniform root grades for various product lines. Consequently, producers frequently harvest carrots with disregard to optimum maturity and quality, resulting in reduced yields, recovery, and profits. Beyond management inputs, weather conditions influence carrot growth and maturity through their intrinsic processes connected with carbon fixation and utilization. Establishing the relationship between the weather parameters and crop maturity, bulking, and quality of various processing carrot varieties would help in predicting crop growth, maturity, yield, and quality; thus leading to better harvest planning. Accordingly, experiments were conducted during the growing seasons of 2002–04, using seven carrot varieties in commercial plots at various locations in Nova Scotia. Weather stations were installed at each location to constantly record air temperature, rainfall, solar radiation, relative humidity, soil temperature, wind speed and direction, from which degree days and evaporation were calculated. Crop measurements included plant stand, leaf biomass (top growth), root girth and length, and gross yield. Recovery of marketable grades was arrived after the final yield was determined. Cumulative data was compiled for all of the weather parameters measured to coincide with the sampling dates. Multiple regression analyses were performed to quantify the association between cumulative weather parameters and maturity traits. All varieties, in all locations, showed strong correlations between bulking and various cumulative weather parameters. Field trials were repeated at three adjacent locations for all varieties during the 2005 growing season and the data obtained will be used to validate the fitness of the proposed model.

Nitrate Leaching, Yields, and Water-use Efficiency of Zucchini Squash (Cucubita pepo) under Different Irrigation and Nitrogen Rates and Methods in a Sandy Soil
Lincoln Zotarelli1*, Johannes Scholberg1, Michael Dukes2, Hannah Snyder1, Eric Simonne1, Michael Munoz-Carpena
1University of Florida, Agronomy Department, Gainesville, FL, 32611-0965; 2University of Florida, Agricultural and Biological Engineering, Gainesville, FL, 32611-0570; 3University of Florida, Horticultural Science, Gainesville, FL, 32611-0500

On sandy soils, potential N contamination of groundwater resources associated with intensively managed vegetables may hamper the sustainability of these systems. The objective of this study was to evaluate the interaction between irrigation system design/ scheduling and N fertilization rates on zucchini production and potential N leaching. Zucchini was planted during Fall 2005 using three N fertilizer rates (73, 145, 217 kg/ha) and four different irrigation approaches. Irrigation scheduling included surface-applied drip irrigation and fertigation: SUR1 (141 mm applied) and SUR2 (266 mm) using irrigation control system (QIC) that allowed time-based irrigation (up to five events per day) and a threshold setting of 13% and 15% volumetric water content (VWC), respectively; Subsurface drip irrigation (SDI) using a QIC setting of 10% VWC (116 mm) combined with surface applied fertigation; and a control treatment with irrigation applied once daily (424 mm). Leachate volumes were measured by drainage lysimeters. Nitrate leaching increased with irrigation rate and N rate and measured values ranged from 4 to 42 kg N/ha. Use of SDI greatly reduced nitrate leaching compared to other treatments. SDI and SUR1 treatments had no effect on yields (29 Mg/ha). However, SDI had a 15% and 479% higher water use efficiency (WUE) compared to SUR1 and the fixed irrigation duration treatment. Application of N in excess of intermediate N-rate (standard recommendation) did not increase yield but yield was reduced at the lowest N-rate. It is concluded that combining sensor-based SDI with surface applied fertigation resulted similar or higher yields while it reduced both water use and potential N leaching because of improved nutrient retention in the active root zone.

Phenolic Composition and Antioxidant Activity of Minimally Processed Sweetpotatoes
Malkeet S. Padda*, David H. Picha
Louisiana State University, Horticulture

Three different style cuts of minimally processed sweetpotatoes (shredded, French-fry, and sliced) were stored at 0 °C and 5 °C for 4 and 8 days. Total phenolic content, individual phenolic acids, and...
free radical scavenging activity were determined using Folin-Denis reagent, reversed-phase HPLC, and 1,1-diphenyl-2-picrylhydrazyl (DPPH) methods, respectively. Total phenolic content in sliced cut sweetpotatoes held at 5 °C was higher than in the shredded cut. Both sliced and French-fry cut sweetpotatoes held at 5 °C had significantly higher antioxidant activity than shredded cut sweetpotatoes. All treatments, except shredded sweetpotatoes held at 0 °C, had significantly higher total phenolic content and antioxidant activity after 4 and 8 days of storage. Minimally processed sweetpotatoes held at 5 °C accumulated more phenolic compounds and had a higher antioxidant activity than sweetpotatoes held at 0 °C. Chlorogenic acid followed by 3,5-dicaffeoylquinic acid were the predominant phenolic acids present in sweetpotatoes. The rate of increase in individual phenolic acid content with storage time was higher at 5 °C than at 0 °C. No tissue browning was observed in any of the cuts after 8 days of storage and the products were considered to be marketable.

**Physiological Changes in Cantaloupe during Development and in Stored Fresh-cuts Prepared from Fruit Harvested at Various Maturities**

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Cantaloupe (*Cucumis melo* Var. *reticulatus*, Naudin) were evaluated during development and then fresh-cuts were stored after preparation from various maturities to track quality changes during storage. Flowers were anthesis tagged one morning and developing fruit were harvested weekly at 13, 20, 27–28, and 34–35 days after anthesis (DAA). Mature fruit were harvested at 37–38 DAA with five distinct maturities: 1/4-, 1/2-, 3/4-slip, full-slip and over-ripe. Hunter L* and a* color values indicated change from pale green to light orange that occurred after 28 DAA. There were significant decreases in L*, a* and b* by day 9 in storage as fresh-cuts. After 28 DAA, sucrose dramatically increased, and this was positively correlated with increases in both total sugars (r = 0.882, P = 0.084) and *Brix* (r = 0.939, P = 0.041). Gradual subjective deterioration occurred during storage, which was independent of maturity. There was a negative linear trend over the length of storage in hand-held firmness for each maturity level and the slopes decreased significantly with increasing maturity; indicating the effect of storage duration decreased as maturity increased. Vitamin C had a significant increasing trend (*P*-value = 0.042) during development from 12 through 35 DAA, then losses were greater in fresh-cuts prepared from full-slip fruit (65%) than in less mature fruits, quarter-slip 40%, half-slip 48%, and three-quarter-slip 50%. The pH of mesocarp tissue dropped to the lowest value (5.25) just prior to physiological maturity, then peaked after harvest (6.51–6.79), and generally declined by the end of fresh-cut storage. In sum, considering other publications on this study, and herein, fruit should be harvested at greater than or equal to 1/2-slip to attain optimum quality and storability.

**Cold Storage Effects on Pawpaw Fruit Ripening and Quality**

Federica Galli*1, Douglas D. Archbold2, Kirk W. Pomper2

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Pawpaw (*Asimina triloba* (L.) Dunal) has significant potential as a new fruit crop. During ripening, loss of firmness is extremely rapid, and this trait may be the biggest obstacle to the development of a broader market. Cold storage of pawpaw fruit seems limited to 4 weeks at 4 °C, though fruit softening merely slows during storage. A study of several cultivars with commercial appeal has shown that none have superior cold storage life. Extending the cold storage beyond 4 weeks resulted in increasing loss of fruit firmness, poor poststorage ripening, and development of quality traits, and many fruit exhibiting flesh and peel discoloration. Cold storage duration affected fruit volatile production. By 4 weeks of cold storage, ethyl hexanoate and ethyl octanoate were the major volatiles produced, replacing methlyl hexanoate, which was the major volatile produced by ripe fruit after harvest. By 8 weeks of cold storage, volatile ester production was generally low and ethyl hexanoate became the only major volatile. This loss of volatile production was accompanied by a decrease in alcohol acetyl transferase activity. Also, during cold storage, there was an increase in total phenolic content, lipid peroxidation products, and polyphenol oxidase activity. These changes may contribute to the black discoloration that developed in fruit cold-stored for 8 weeks or more. It is apparent that cold storage alone may not be sufficient to extend the storage life of most, if not all, current pawpaw cultivars beyond 4 weeks.

**Influence of Commercial Packing and Storage on Navel Orange Flavor, Quality Constituents, and Juice Ethanol Concentration**

David Obenland*1, Paul Neipp1, Sue Collin2, Jim Sievert2, Kent Fjeld2, Margo Toyota2, Julie Doctor2, Mary Lu Arpaia2

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It is commonly believed within the citrus industry that handling, waxing, and storage of navel oranges may have undesirable effects on flavor. However, the effect of each potential influencing factor under commercial conditions is not completely understood. The purpose of this study was to systematically investigate these potential influences on navel orange flavor. Navel oranges were harvested on two separate dates, using three grower lots per harvest date, and the fruit run on a commercial packing line. Fruit were sampled at four different stages of the packing process: in the field bin; after the washer; after the waxer; and after packaging into standard cartons. Fruit quality, flavor, and juice ethanol concentration were evaluated immediately after sampling and following 3 and 6 weeks of storage at 5 °C. The overall hedonic score, a measure of flavor, significantly declined from 6.5 to 5.7, as a result of 6 weeks storage. Fruit selected from field bins, from after the washer, and after the waxer were all judged by the taste panel to be equivalent in flavor. The packed fruit were judged to be slightly inferior in flavor. Titratable acidity declined while soluble solids increased as a result of storage; the stage of the packing process influenced neither. Waxing and storage both were associated with higher ethanol levels in the fruit.

**Some Biochemical Changes in Carrot Roots Induced by Erwinia carotovora var. carotovora**

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Carrot is a rich source of nutrients. Carrots contains carotene and lyco-pene, which gives bright color to the roots. The quality of the carrots was assessed based on the carotene, lycopene, and other biochemical constituents such as sugars, starch, and protein. To study the effect of various isolates of the *Erwinia carotovora* var. *carotovora* on the above biochemical constituents, the pathogens were inoculated and the contents were analyzed separately at 1, 2, 3, 4, and 5 days after inoculation. The contents of β-carotene increased significantly due to all the three isolates of the pathogen and the Coimbatore isolate recorded highest of 36.03%. The same trend was also observed in the lycopene content, with 93.55% increase over control. The contents of total and reducing sugars were found to significantly increase due to inoculation with the pathogen. The starch content showed a decreasing trend in all the isolates tested. The maximum reduction of 62.98% was observed in the roots inoculated with Coimbatore isolate. The protein content showed a decreasing trend up to 5th day of inoculation, and further reduction of about 25.45% was recorded with Coimbatore isolate on the 5th day. The total phenol content in the roots of carrot decreased significantly, and reached the least on 5th day due to the infection by all
the three isolates and the maximum reduction of 22.79% was observed in roots treated with Coimbatore isolate.

Encapsulation of Naturally Occurring Antifungal Compound into β-cyclodextrins: A New Technology for Reducing Postharvest Losses

Eva Almenar*, Rafael Aurus, Maria Rubino, Bruce Harte

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The United States is the world’s largest producer of blueberries and strawberries. Successful marketing for both of them requires fruit of the highest quality and appearance. However, these fruits have a relatively short postharvest life, mostly due to the incidence of molds such as Colletotrichum acutatum, Alternaria alternata, and Botrytis cinerea. At present, several natural occurring plant volatiles have been shown to be effective against fungal growth, but, even so, those compounds could not be maintained at constant concentration during the whole postharvest period due to their volatility. In this work, two naturally occurring aldehydes (acetaldehyde and hexanal) were tested and compared against the growth of the above mentioned fungi at 23 °C. After that, the most effective antifungal compound for each fungus was encapsulated in β-cyclodextrins (β-CD) and tested during storage period. Both aldehydes were effective in reducing and avoiding fungal proliferation depending on concentration. Fungal proliferation depended on daily, and not initial, volatile concentrations. Volatiles encapsulated in β-CD showed higher antifungal activity compared to that obtained using the pure volatile during storage. Tested volatiles showed both fungicidal and fungistatic capacities after storage of fungal cultures in air. Results suggested β-CD-acetaldehyde and β-CD-hexanal complexes can be used as a new technology to release a naturally occurring antifungal compound during storage against several fungal diseases.

Oral Session 18—Vegetable Breeding

29 July 2006, 8:00–9:15 a.m.

Moderator: Linda Wessel-Beaver

Investigation of Doubled Haploid Performance and Combining Ability in Short-day Onion

Ryan L. Walker*, Sunggil Kim†, Javier F. Betran‡, Kilsun Yoo†, Leonard M. Pike†

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Onions suffer from severe inbreeding depression, which has inhibited the development of homozygous inbred lines in breeding programs. The creation of doubled haploid (DH) lines in onion provides a unique opportunity to evaluate the utility of such lines as parents in a breeding program. For this purpose, two diallele cross experiments were conducted. The first consisted of a six-parent diallele cross using six DH lines developed at Texas A&M University. The second, a four-parent diallele cross performed with two DH lines and two inbred lines developed at Texas A&M University. The second, a four-parent diallele cross performed with two DH lines and two inbred lines (n = 9). A total of 36 hybrids formed by crossing nine parents were evaluated for horticultural characters, including head weight, head stem diameter, plant height, plant width (in a row), and maturity (e.g., days from transplant to harvest) in four environments. When averaged across all four environments, roughly half of the hybrids exhibited high parent heterosis for head weight (1 to 30 g) and stem diameter (0.2 to 3.5 cm). Almost all hybrids showed high parent heterosis for plant height (1 to 10 cm) and width (2 to 13 cm). Unlike other traits, there was negative heterosis for maturity, indicating that heterosis for this character in hybrids is expressed as earliness. With modern broccoli inbreds, heterosis for head characteristics appears less important than for traits that measure plant vigor.

The Inheritance of Bacterial Soft Rot Tolerance through Stem Scar Water Infiltration in Tomato

Sarah M. Smith*, John W. Scott†, Jerry A. Bartz‡

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When tomato (Lycopersicon esculentum Mill.) fruit come in contact with water at the packing house dump tanks, they can infiltrate water through the stem scar. If the water is infused with Erwinia carotovora, the fruit can infiltrate the bacteria, which will later develop into bacterial soft rot. To determine the inheritance of low water infiltration and thus tolerance to soft rot, a complete diallel was produced using six parents that infiltrate different amounts of water. The parents and hybrids were grown in a completely randomized block design with three blocks and 10 plants per block. The amount of water infiltrated by the fruit was measured by the change in weight after the fruit were immersed in water in a pressure cooker for 2 min. Both general combining ability (GCA) and specific combining ability (SCA) were significant, with GCA having a higher significance than SCA. There appeared to be a cytoplasmic effect on water uptake, where less water was taken up when the low-uptake parent was used as a female. When orthogonal contrasts were performed on reciprocal hybrids from parents that were significantly different, 33% of them were significantly different.

Variation for Tipburn Resistance in Lettuce

Ryan Hayes*

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Tipburn (TB) is a physiological disorder that results in necrosis along the margins of lettuce leaves. The disorder is objectionable to consumers and reduces the shelf life of whole and minimally processed lettuce. The objectives were to 1) determine the variation for tipburn resistance in iceberg, romaine, green leaf, and red leaf cultivars; and 2) determine the genotype × location interaction for tipburn resistance. Tipburn incidence was recorded on 10 plants in each of three replications in Salinas, Calif., and Yuma, Ariz., trials with 20 iceberg, 21 romaine, 11 green leaf, and six red leaf cultivars. Data were analyzed using analysis of variance type statistics of ranked data. Variations for TB resistance was found in all lettuce types at both locations, although iceberg cultivars (average percentage of TB = 31% Salinas; 77% Yuma) had significantly (P < 0.01) higher levels of resistance at both location than romaine (58% Salinas, 81% Yuma), green leaf (52% Salinas; 88% Yuma), and red leaf (43% Salinas, 89% Yuma). The Yuma, Ariz., trial was more conducive for TB, and had less variation (range of percentage of TB = 33% to 100% Yuma, 0% to 100% Salinas). Four iceberg, one green leaf, and one red leaf genotype with industry acceptable levels of TB (<5%) were identified in the Salinas environment. Genotype × location interaction was present (P < 0.01), and included rank order changes within all lettuce types. The correlation between the locations was low, 0.26, but significant (P = 0.045). A need exists for romaine, green leaf,
and red leaf germplasm with improved TB resistance, particularly in the Yuma environment. The presence of variation within each lettuce type and genotype × location indicates that genetic improvement should be possible using within type crosses followed by selection in the Yuma or Salinas target environment.

A New Dominantly Inherited Source of TSWV Resistance in Tomato Derived from *L. chilenense*, which Resists Isolates that Overcome *Sw-5*

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Tomato spotted wilt virus (TS WV), a tospovirus, is a thrips-vectored disease infecting more than 1000 species of both monocots and dicots, including many species of agriculture importance. TSWV is the limiting factor for tomato (*Lycopersicum esculentum* Mill.) production in several areas of the world. For a number of years, the *Sw-5* gene (derived from *L. peruvianum* Mill.) has provided acceptable control of this disease. Recently, *Sw-5* derived resistance has been overcome by virulent pathogen isolate(s) in tomato production areas such as Spain and Italy. In earlier studies, we identified a potential new source of resistance to TSWV derived from *L. chilenense* Dun. accession LA1938. In a set of recent field studies, it was demonstrated that this putative new source of resistance was highly resistant to TSWV in Hawaii, Florida/Georgia, and South Africa. Furthermore, greenhouse screening trials have clearly demonstrated that the *L. chilenense* source of TSWV resistance is resistant to isolates that overcome tomatoes homozygous for *Sw-5*. In these same greenhouse and field studies, there is uniform evidence that this resistance is dominant. Subsequent greenhouse studies suggest that this resistance is controlled by a single gene. Studies have been initiated to verify the inheritance of the gene(s) and to develop linked molecular markers. Furthermore, studies are under way in Australia to test this resistance on non-TS WV tospoviruses. If the data demonstrate that this is a single dominant gene we suggest this gene be designated *Sw-7*.

Assessment of Cowpea Genotypes for Use as a Weed-suppressing Cover Crop

Howard F. Harrison*,1 Judy A. Thies2, Richard L. Fery3, J. Powell Smith2

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A preliminary screening experiment was conducted to evaluate 47 cowpea (*Vigna unguiculata*, (L.) Walp.) genotypes for use as a weed-suppressing cover crop. Lines evaluated in this study included forage varieties, PI accessions, experimental breeding lines, and land races of unknown origin. Of these, 11 were selected for further testing on the basis of vigorous growth and weed-suppressing ability. In a field experiment repeated over 4 years, the selected genotypes were not different from the leading cover crop cultivar, ‘Iron Clay’, in biomass production. Vigor ratings, vine growth ratings, and canopy widths of some genotypes exceeded those of ‘Iron Clay’. Vigor ratings and canopy measurements were efficient selection criteria that could be useful for breeding cover crop cowpea cultivars. All selections except an African cultivar, ‘Lalita’, were highly resistant to southern root knot nematode (*Meloidogyne incognita*) (Kofoid and White) Chitwood, and the genotypes varied in seed size, photoperiod, and response to diseases.

The National, All-crops Plant Breeding Coordinating Committee

Linda Wessel-Beaver*,1 Ann Marie Thro2

1Univ of Puerto Rico, Dept. Agronomy & Soils, Mayaguez, PR, 00681-9030; 2CSREES, USDA, Plant and Animal Systems, Washington, DC, 20024

The Plant Breeding Coordinating Committee will be a forum for leadership regarding issues, problems, and opportunities of long-term strategic importance to the contribution of plant breeding to national goals. The committee will create the only regular opportunity to provide such leadership across all crops. The nature of plant breeding as an integrative discipline par excellence will be reflected in multidisciplinary committee membership. The past decade has brought major changes in the U.S. national plant breeding investment. In order for administrators and other decisionmakers to understand the implications of the changes and respond most effectively for the future, there is need for a clear analysis of the role of plant breeding for meeting national goals. Although recent changes in investment are the impetus for this committee, the need to articulate the role of plant breeding in meeting national goals is likely to be on-going, regardless of immediate circumstances. This presentation will describe recent progress on organizing this committee, and will ask all plant breeders to begin thinking about the questions to be addressed at the upcoming national workshop.

### Oral Session 19—Floriculture 4

#### The Influence of Cold on the Greenhouse Forcing of Woody Shrubs

Allan M. Armitage*, Natalia K. Hamill, Stephanie L. Anderson

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As part of the New Floriculture Crop Program at the University of Georgia, a research project was initiated in Fall 2004 to determine the suitability of woody shrubs for forcing in the greenhouse. This paper will provide an overview of the research, indicating plants that were determined to be suitable for greenhouse forcing and sales in the retail area and those that were discarded from the program. About 15 taxa were initially selected for the program based on habit, foliar qualities, and flowering (if present). All plants were subjected to 1.7 °C to 4.4 °C for 0, 6, or 10 weeks in a controlled temperature cooler. Based on growth and visual characteristics, *Leptodermis oblonga*, *Indigofera pseudotinctoria* ‘Rose Carpet’, *Forsythia × intermedia* ‘Golden Peep’, and *Philadelphus coronarius* ‘Manteau d’Hermaine’ were discarded. *Caryopteris × clandonensis* ‘Sunshine Blue’, *Leycesteria formosa* ‘Golden Lanterns’, *Sambucus nigra* ‘Black Lace’, *Philadelphus coronarius* ‘Variegata’, and *Physocarpus opulifolius* ‘Summer Wine’ were investigated further. Data presented for *Physocarpus* suggested that cooling was not necessary for growth; however, 10 weeks of cooling resulted in the least time to finish in the greenhouse. Zero, 6, and 10 weeks cold resulted in 17, 10, and 7 weeks finish time, respectively. Additional work on *Kolkwitzia, Buddleia*, and *Wegelia* conducted in 2005 and future research will be discussed.

#### The Influence of Cooling on Growth of Three Shrubs for Greenhouse Forcing

Natalia K. Hamill*, Allan M. Armitage, Stephanie L. Anderson

University of Georgia, Horticulture, Athens, GA, 30602

As part of the New Floriculture Crop Program at the University of Georgia, a research project was initiated in Fall 2004 to determine the suitability of 12 taxa of woody shrubs for forcing in the greenhouse. In this study, the influence of cooling on greenhouse forcing of (*Caryopteris × clandonensis* ‘Sunshine Blue’, *Leycesteria formosa* ‘Golden Lanterns’ and *Sambucus nigra* ‘Black Lace’) was evaluated. Dormant rooted liners were cooled for 0, 6, or 10 weeks at 1.7 °C to 4.4 °C. With 0 and 6 weeks cooling, *Caryopteris* never reached an acceptable finish stage. With 10 weeks cooling, plants finished in 7 weeks in the greenhouse. With 0 weeks cooling, *Leycesteria* was ever reaching an acceptable finish stage. With 10 weeks cooling, plants finished in 7 weeks in the greenhouse. With 0 weeks cooling, *Leycesteria* was
salable in 13 weeks. With 6 and 10 weeks cooling, plants finished in 7 and 8 weeks, respectively. With 0 weeks cooling, *Sambucus* never reached a salable stage. With 6 weeks cooling, plants were salable in 11 weeks; with 10 weeks cooling, plants finished in 6 weeks. The data suggest that cold is necessary to force *Caryopteris* and *Sambucus* in the greenhouse, and that 10 weeks of cold resulted in the shortest production time for both taxa. Data show that 6 weeks cooling of *Leycesteria* resulted in the shortest production time, but cooling is not necessary. This experiment was repeated in 2005–06 and will be compared to the 2004 findings. Additional experiments conducted in 2006 will also be discussed.

**Short Days or Vernalization Promote Flowering in *Aquilegia × hybrida* Sims ’Origami Blue and White’**

Catherine M. Whitman, Erik S. Runkle*, Arthur C. Cameron
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Flowering of *Aquilegia* is generally considered to require vernalization, while photoperiod has little or no effect. The cold treatment is most effective when plants have passed the juvenile stage (often 12 to 15 leaves) prior to vernalization. We performed experiments on a cultivar reported to have a reduced vernalization requirement. Seedlings of *Aquilegia × hybrida* Sims ’Origami Blue and White’ in 128-cell plug trays with four or five leaves were either placed directly into a 5 °C cooler or transplanted to 1.3-cm containers. Plants were grown (bulked) for 0, 3, or 6 weeks at 20 °C under 9-h short days (SD) or 16-h long days (LD) provided by incandescent lamps at 1 to 3 µmol·m⁻²·s⁻¹. Plants had seven or eight leaves after 3 weeks bulking and 13 or 14 leaves after 6 weeks bulking. They were then cooled at 5 °C for 0, 5, or 10 weeks and placed in a common forcing environment of 20 °C under an LD provided by high-pressure sodium lamps. *Aquilegia* plants placed directly into the forcing environment flowered in 89 and 97 days in years 1 and 2, respectively. Flowering percentage of plants cooled in the plug tray decreased with increasing duration of cold treatment, and only 15% flowered after a 10-week cold treatment. All plants bulked for 3 or 6 weeks prior to cold treatment flowered, and in 26 to 35 days. Surprisingly, all plants that were moved directly from bulking treatments to the forcing environment (no cold treatment) flowered, and flowering was most rapid (36 days) in plants exposed to 6 weeks of SD before forcing. Therefore, our data indicate that SD can at least partially substitute for a cold treatment in this *Aquilegia* cultivar.

**Photoperiod, Irradiance, and Cool Temperature Effects on *Gymnocalycium*, *Rebutia*, *Lobivia*, and *Sulcorebutia* sp. Growth and Flowering**

John Erwin*, Esther Gesick, Ben Dill, Charles Rohwer
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A study was conducted to determine if photoperiod, irradiance, and/or a cool temperature impacts flowering of selected species in five cactus genera. *Gymnocalycium*, *Rebutia*, *Lobivia*, and *Sulcorebutia* plants were grown for 4 months under natural daylight conditions (August–November) in a greenhouse maintained at 26 ± 2 °C. Plants were then placed in either of two greenhouses: 1) a greenhouse maintained at 22 °C day/18 ± 1 °C night temperature with an 8-h daylength (SD) or natural daylight plus night interruption lighting (NL; 2200–0200 HR); or 2) a greenhouse maintained at 5 ± 2 °C under natural daylight conditions (8–10 h). After 12 weeks at 5 °C, plants were moved to the SD and NL lighting treatments in the before mentioned greenhouse and additional lighting treatment [natural daylight plus supplemental high-pressure sodium lighting (85–95 µmol·m⁻²·s⁻¹; 0800–0200 HR)]. In all cases, plants were moved out of lighting treatments after 6 weeks and were then grown under natural daylight conditions in a greenhouse maintained at constant 22 ± 1 °C. Data were collected on the approximate date growth commenced, the date when each flower opened (five flowers only), flower number per plant, and individual flower longevity (five flowers only). Species were classified into photoperiodic and irradiance response groups where appropriate and whether species exhibited a vernalization requirement was reported.

Lastly, whether dormancy occurred and what conditions overcame that dormancy was reported.

**Photoperiod, Irradiance, and/or Cool Temperature Effects on *Lobivia × Chamaecereus* Hybrid ’Rose Quartz’ Flowering**

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Photoperiod, irradiance, and/or a cool temperature effects on *Chamaeloobia* hybrid ’Rose Quartz’ flowering was studied. Two- to 3-year-old plants were grown for 4 months under natural daylight (DL; August–November) in a greenhouse maintained at 26 ± 2 °C. Plants were then placed in either of two greenhouses: a cool temperature house (5 °C day/18 ± 1 °C night temperature, respectively). The lighting treatment house had eight light environments: 1) short day (SD; 8 h; 0800–1600 HR); 2) SD+25–35 µmol·m⁻²·s⁻¹; 3) SD+45–50 µmol·m⁻²·s⁻¹; 4) SD+85–95 µmol·m⁻²·s⁻¹; 5) DL plus night interruption lighting (NI; 2200–0200 HR; 2 µmol·m⁻²·s⁻¹ from incandescent lamps); 6) DL+25–35 µmol·m⁻²·s⁻¹ (lighted from 0800–0200 HR); 7) DL+45–50 µmol·m⁻²·s⁻¹; and 8) DL+95 µmol·m⁻²·s⁻¹. Supplemental lighting was provided using high-pressure sodium lamps. Plants were placed in the cool temperature environment for 0, 4, 8, or 12 weeks before being placed under lighting treatments. All plants received a 6-week lighting treatment and were then placed in the finishing greenhouse (22 ± 2 °C). Data were collected on the date when each flower opened (five only), the flower number per plant, and flower longevity (five only). Vernalization interacted with photoperiod to affect flowering. Unvernalized plants exhibited an obligate long-day requirement for flowering. Vernalized plants exhibited a facultative long-day requirement for flowering. The impact of vernalization, photoperiod, and irradiance on flower number, time to flower, and longevity will also be discussed.

**Floating System Production of *Liatris spicata* (L.) Wild.**

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*Liatris* is an ornamental plant cultivated as a garden perennial for more than 70 years. Since the early 1970s, *Liatris spicata* has gained importance as a cut flower because of its long-lasting flowering and its peculiar downward flowering succession. This species is usually cultivated in beds both outdoors and in greenhouses. However, in order to improve yield and quality production, some research has been carried out on soilless cultivation. In particular, floating systems seem to provide the best performance, although different nutrient solutions or their concentrations have been studied. In this research, in addition to two different concentrations of Hoagland solution [full-strength (H) and a half-strength (1/2H)], three corm circumferences (8/10, 10/12, and 12+), and three plant densities (36, 48, and 60 plants/m²) were also evaluated. The full-strength solution gave the best performance from both qualitative and quantitative standpoints. This nutrient solution also showed, at the end of the experiment, very high residual nitrate-N, which could induce environmental pollution during disposal. Furthermore, the management of the solution appeared more difficult and time-consuming. All these aspects should be taken into account by growers in making choices. Corm size also affected production. Increasing circumference from 8/10 to 12+ increased marketable stems per plant and their quality traits, but, because of the highest mortality of plants observed with the bigger corms, yield per square meter did not increase over corm size of 10/12. Finally, rising plant density from 36–60 plants/m², the biomass of the single plant decreased. However, it resulted also in the enhancement of sellable production per square meter.
American–Japanese Expedition to Hokkaido to Collect Berry Crops in 2004
Kim E. Hummer*,†, Tom Davis‡, Hiroyuki Iketani§, Hiroyuki Imanishi‡

1USDA ARS, National Clonal Germplasm Repository, Corvallis, OR, 97333-2521; University of New Hampshire, and Akita Prefectural College of Agriculture, Japan. Additional assistance was provided by the Hokkaido Governmental Plant Genetic Resources Center, several Forest Research Stations of the Hokkaido University, and private botanists. The expedition obtained 100 accessions encompassing eight genera and 29 species. In all, 84 seedlots, and 23 plants were obtained. The genera included: Actinidia, Fragaria, Lonicera, Morus, Ribes, Rubus, Sambucus, and Vaccinium. Plant and seed accessions from this trip are preserved and distributed from the USDA ARS National Clonal Germplasm Repository in Corvallis, Ore., and from MAFF. The target nursery for this expedition was Fragaria, so the trip was planned for July. Multiple samples of the two Japanese diploid strawberry species, Fragaria × ananassa and Fragaria × intermedia (synonym = F. veyoensis H. Har) were obtained during their prime ripening time. Ribes, Rubus, and Vaccinium fruits ripened later in the summer, but were collected when fruit were observed. Unfortunately, seeds of some of these accessions proved to be immature or nonviable upon extraction. We suggest that expeditions to collect these genera should be planned for late August. Morphological and molecular evaluation of collected germplasm is underway at the USDA ARS Corvallis Repository and at the University of New Hampshire.

Microsatellites are Used to Examine Apple and Pear Identities and Genetic Relationships
Nahla Bassil*, Kim Hummer, Joseph Postman
NCGR, USDA/ARS, Corvallis, OR, 97333

Simple Sequence Repeat (SSR) markers developed in apple and pear were used to determine genetic relationships among heritage apple and pear cultivars from Portugal’s Azore Islands, and to develop identity fingerprints for European and Asian pear accessions at the USDA—ARS National Clonal Germplasm Repository (NCGR). We used 11 SSR markers (six from apple and five from pear) to examine 18 heritage apple and 9 heritage pear cultivars from the Azores. Eight additional Portuguese and economically important cultivars of apple and eight of pear were used as standards. Cluster analysis separated the apple and pear accessions into two distinct groups. Among apple genotypes, 12 unique accessions and five groups of synonyms were identified, while, in pear, seven unique genotypes and three pairs of synonyms were found. None of the accessions obtained from the Azores corresponded to widely grown standard Portuguese apple or pear cultivars. To examine 144 NCGR pear accessions, we used nine polymorphic SSR loci that were developed from GenBank sequences. Cluster analysis identified five sets of synonyms (four in P. communis L. and one in P. ussuriensis Maxim.) and four pairs of homonyms (three in P. communis and one in P. pyrifolia Burn. f. Nakai), and confirmed three clonal sets. Morphological evaluations and additional SSR markers will be used to confirm these results, and to genetically document the identities of pear genotypes. SSR markers will greatly assist the management of ex situ pome fruit germplasm collections by helping to eliminate duplicate accessions and expanding the genetic diversity represented.

Mango Genetic Diversity Analysis and Pedigree Inferences for Florida Cultivars using Microsatellite Markers
Raymond Schnell*1, J. Steven Brown1, Cecile Olano1, Alan Meero1, Richard Campbell2, David Kuhn1
1SRHS USDA-ARS, Plant Genetics, Miami, FL, 33158; 2Fairchild Tropical Botanical Garden, Botany, Coral Gables, FL, 33134; 3Florida International University, Biological Sciences, Miami, FL, 33199

Mangifera indica L. germplasm can be classified by origin with the primary groups being cultivars selected from the centers of diversity for the species, India and Southeast Asia, and those selected in Florida and other tropical and subtropical locations. Accessions have also been classified by horticultural type: cultivars that produce monoembryonic seed vs. cultivars that produce polyembryonic seed. In this study, we used 25 microsatellite loci to estimate genetic diversity among 203 accessions. The 25 microsatellite loci had an average of 6.96 alleles per locus and an average PIC value of 0.552. The total propagation error in the collection, i.e., plants that had been incorrectly labeled or grafted, was estimated to be 6.13%. When compared by origin, the Florida cultivars were more closely related to Indian than to Southeast Asian cultivars. Unbiased gene diversity (Hnb) of 0.600 and 0.582 was found for Indian and Southeast Asian cultivars, respectively, and both were higher than Hnb among Florida cultivars (0.538). When compared by horticultural type, Hnb was higher among the polyembryonic types (0.596) than in the monoembryonic types (0.571). Parentage analysis of the Florida cultivars was accomplished using a multistage process based on introduction dates of cultivars into Florida and selection dates of Florida cultivars. Microsatellite marker evidence suggests that as few as four Indian cultivars, and the land race known as ‘Turpentine’, were involved in the early cultivar selections. Florida may not represent a secondary center of diversity; however, the Florida group is a unique set of cultivars selected under similar conditions offering production stability in a wide range of environments.
Methylation Sensitive Amplification Polymorphism in Date Palms and Their Offshoots

Jinggui Fang, ChihCheng T. Chao*
Univ. of California-Riverside, Dept. of Botany & Plant Sciences, Riverside, CA, 92521-0124

DNA methylation plays an important role in the regulation of gene expression in eukaryotes. The extent and pattern of DNA methylation were assessed in the date palm (*Phoenix dactylifera* L.) mother plants and their offshoots using the methylation sensitive amplification polymorphism (MSAP) technique. Three types of bands were generated using 12 pairs of primers. Type I bands were present in both EcoR I + Hpa II and EcoR I + Msp I lanes; type II bands were present in EcoR I + Hpa II lanes, but not in EcoR I + Msp I lanes; and type III bands were present in EcoR I + Msp I lanes, but not in EcoR I + Hpa II lanes. The total numbers of these three types of bands were 782, 55, and 34. Among these three types of bands, the polymorphic bands were 34, 10, and 0, respectively. The distribution of polymorphic bands among mother-plants and offshoots could suggest the methylation variation occurred to the mother plants and offshoots. The methylation variation during offshoot growth of date palm was characterized as a process involving mainly of demethylation. Hypomethylation of DNA in offshoots compared with mother plants reflects the marked expression of this molecular feature, which may related to gene expression during development of offshoots. The methylation or demethylation status of specific loci in the mother plants and their offshoots might not relate their lineage but occurred randomly.

Screening the U.S. National Fig Collection for Potential Fresh Fruit Genotypes

Ed Stover*, 1 Malli Aradhya1, Carlos Crisostom2, Louise Ferguson3

1USDA-ARS, National Clonal Germplasm Repository, Davis, CA, 95616; 2University of California, Plant Sciences Dept., Davis, CA, 95616

Currently, 94% of California fig production is dried or otherwise processed, but there is interest in expanding fresh fig sales. Since cultivars dominating the industry were largely selected for dried fig use, the fig collection of the National Clonal Germplasm Repository (NCGR) in Winters, Calif., was screened for traits of interest in fresh fruit production. For some traits, the bearing collection of 137 accessions was screened, while for most traits, data was collected on a core group of 30 accessions. While current commercial cultivars feature flavors of honey or caramel, some NCGR accessions have bright fruity flavors, reminiscent of berries or citrus, as well as noticeable acidity. Considerable variation was observed for time of maturity. Breba (figs on previous year’s wood ripe in June/July) production was markedly greater in 'King' than in any other core-group genotype, with ≥3× more fruit per branch than the next most breba-productive variety and 8× higher than the commercial standards. Earliness of ripening in the large collection was most pronounced in ‘Yellow Neches’, ‘Orphan’, and ‘Santa Cruz Dark’, with ≥3× as many ripe fruit per tree in early August as the earliest commercial standard. Several commercial standards scored among the varieties with greatest late-season production (≥200 fruit per tree ripe after mid-September), comparing favorably with ‘Zidi’, ‘Panachee’, and ‘Ischia Black’, among others. The SSC at commercial ripeness ranged from 13% to 19%, and SSC at tree-ripeness averaged 30% higher than in commercially ripe fruit. Several accessions were observed to have fruit traits that might also contribute to sustained quality through market channels.

Oral Session 21—Cross Commodity Nutrition

29 July 2006, 9:30–10:30 a.m. Bayside A
Moderator: John M. Smagula

Response of Lowbush Blueberry to Several Organic Fertilizers

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Four organic fertilizers were evaluated in a commercial lowbush blueberry field with a history of N and P deficiency. In nonorganic production, diammonium phosphate (DAP) is the standard fertilizer for correcting N and P deficiency. Nitrogen a rate of 67 kg ha⁻¹ [Renaissance (8-2-6), Pro-Holly (4-6-4), Pro Grow (5-3-4), Nutri-Wave (4-1-2), or DAP (18-46-0)] was applied preemergent to 1.8 m × 15 m treatment plots. Leaf N and P were deficient (<1.6% and 0.125%, for N and P, respectively) in the unfertilized plots that served as controls. DAP and Pro-Holly raised leaf N to satisfactory levels (>1.6%). Only DAP raised leaf P concentrations (0.144%), compared to controls (0.122%). Leaf K was not deficient, but was raised by Pro-Holly. Soil pH was slightly lowered by Renaissance (4.2) and raised by Pro-Holly (4.4), compared to the control (4.3). Soil P concentrations were raised by DAP and soil S by Pro-Holly. Soil K was raised by all fertilizers except DAP, compared to the control. Pro-Holly and DAP were equally effective in increasing stem height, branching, branch length, flower bud formation, and yield, compared to the control and the other organic fertilizers. Pro-Holly could effectively substitute for DAP in organic wild blueberry production.

Genotypic Variability of Iron and Zinc in Sweetpotato

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Louisiana State University, Horticulture Department, Baton Rouge, LA, 70803

Sweetpotato (*Ipomoea batatas* (L.) Lam.) is a major subsistence crop in southern Africa, where iron and zinc deficiency in humans is an important health problem. A cultivar of sweetpotato that is suited for subsistence farming in this region and that is high in iron and zinc could be an important means of combating these deficiencies. As part of a program of the HarvestPlus program, under the auspices of the International Potato Center (CIP) to develop such a cultivar, we are working to identify the high and low range of iron and zinc in sweetpotato cultivars grown throughout the world by testing a number of cultivars for these nutrients. Subsidiary objects include determining the heritability of iron and zinc levels and surveying the variability in the levels of these nutrients from root to root on the same plant, from plant to plant of the same cultivar, from the proximal to the distal end of a given root, and from cambium to cortex. For the roughly 80 cultivars in the genotypic variability study, results showed a three-fold difference between the high- and low-yielding cultivars on a fresh weight basis and a two-fold difference on a dry weight basis, for both iron and zinc.

Update on Nitrogen BMP Efforts with Tomato Production in Florida

Monica Ozores-Hampton*, Eric Simone, Eugene McAvoy1, Phil Stansly5, Sanjuy Shakul1, Fritz Roka1, Tom Obaress, Ken Cushman1, Phyllis Gilreath1, Darrin Parmenter1


Florida tomato growers generate about $600 million of annual farm gate sales. The *Florida Vegetable and Agronomic Crop Water Quality/Quantity Best Management Practices Manual* was adopted by rule in the Florida Administrative Code in 2006 and describes cultural practices available to tomato growers that have the potential to improve water quality. By definition, BMPs are specific cultural practices that are proven to optimize yield while minimizing pollution. BMPs must be technically feasible, economically viable, socially acceptable, and based on sound science. The BMP manual for vegetables endorses UF-IFAS recommendations, including those for fertilization and irrigation. Current statewide N fertilizer recommendations are 28 kg·ha⁻¹ for base rate and 224 kg·ha⁻¹ for supplemental fertilizer applications 1) after a leaching rain, 2) under extended harvest season, and 3) when plant nutrient levels (leaf or petiole) fall below the sufficiency range. An on-farm project in seven commercial fields was conducted in 2004 under cool and dry growing conditions, to compare grower practices (ranging from 264 to 34142 kg·ha⁻¹) with UF-IFAS recommendations. Leaf N and P concentrations ranged from 2.0% to 8.5% and 0.125% to 1.6% for UF-IFAS recommendations. Under the highest rates of fertilizer, leaf P concentrations were raised by all fertilizers except DAP, compared to the control. Pro-Holly and DAP were equally effective in increasing stem height, branch length, flower bud formation, and yield, compared to the control and the other organic fertilizers. Pro-Holly could effectively substitute for DAP in organic wild blueberry production.
Wool and Hair Waste as Nutrient Source for High-value Crops

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Container and field experiments were conducted to evaluate sheep wool and human hair wastes as soil amendments and nutrient sources for high-value crops. Overall, wool-waste or hair-waste additions to soil increased yields from basil, garden sage, peppermint, valerian, thorn apple, marigold, foxglove, and Swiss chard; increased the amount of secondary metabolites (such as essential oils and alkaloids); increased NH4-N and NO3-N in the soil; and increased total N (and protein) content in plant tissue. The wool-waste or hair-waste additions did not affect soil microbial biomass, but decreased mycorrhizal colonization of plant roots. Scanning electron microscopy (SEM) and Energy Dispersive X-ray (EDX) analyses indicated that some of the wool and hair in soil from the container and field experiments (after two field seasons and several harvests) retained its original structure, a significant amount of S, some N, and was not fully decomposed. Results from this study suggest that wool and hair wastes can be used as soil amendment and nutrient source for high-value container or field crops.

Predicted Crop Value for a Cling Peach and Three Nectarines of Different Harvest Seasons as a Function of Crop Load

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Several field experiments to assess the effect of tree size and crop load on fruit size and yield were conducted in a ‘Ross’ cling peach orchard and in three nectarine orchards of different harvest seasons in Chile. Trees were randomly selected in each orchard and then hand-thinned at the beginning of pit hardening to a wide range of crop loads. The fraction of above-canopy photosynthetically active radiation intercepted by the canopy (PARi) was determined at harvest and all fruits were counted, weighted, and average fruit weight calculated. Cropload and yield were expressed in terms of fraction of PARi. Data on farm gate prices for export fruit of different sizes and export dates were obtained from a Chilean export company. For each orchard, the relationship between cropload and fruit size or cropload and yield efficiency was assessed by regression analysis. Fruit size distribution was calculated from adjusted fruit size assuming a normal fruit size distribution and valued according to shipment date and price. Using crop load as a covariate, fruit size adjusted for cropload was calculated for each nectarine orchard. Differences in adjusted fruit size and yield efficiency were detected among cultivars. Predicted crop value, normalized in terms of PARi intercepted, was calculated for all the cultivars. Large differences in predicted crop value were found for early, mid-season, and late-ripening nectarines. The early and late ripening cultivars showed the highest predicted crop value, especially at lower crop loads and larger fruit sizes. On the other hand, ‘Ross’ cling peach showed its highest crop value at a medium crop load with high yield and relatively small fruit size. (Funded by FONDECYT grant 1930695.)

Mechanical Thinning in Cling Peach

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Production of extra-early cling peach varieties in California typically results in a $988 per hectare loss for Sacramento Valley growers, based on a 2004 University of California cost analysis study. This net loss is due to a number of factors, including lower yields than late-harvested peaches; and pruning, thinning, and harvest labor. The estimated cost per hectare to hand-thin extra-early varieties is $1515, which is 31% of all cultural costs. A conservative estimate for machine thinning with transportation costs would be $136 per hectare, a cost savings of about 90%. Machine thinning operates at about 200 trees per hour with transportation costs would be $136 per hectare, a cost savings of about 90%. Machine thinning operates at about 200 trees per hour with two persons (operator and supervisor), compared to four to six trees per hour with two hand-thiners. In recent years, equipment to mechanically thin and harvest has become more sophisticated. We evaluated different types of equipment and settings in two experimental orchards trained in two pruning systems in 2005. We compared effects of crop load and variability in fruit development at time of shaking, as well as the timing of shaking with respect to fruit growth after bloom and compared mechanical and hand thinning. We found an optimum “window” for mechanical thinning based on fruit size and crop load, with tree architecture less important than these factors. Machine-thinning with follow-up hand-thinning reduced the thinning time by 30% to 41%. When machine thinning without follow-up hand-thinning was compared to hand-thinning alone, total yield was improved by 22% and salable yield was improved by 18% in the machine-thinned trees. The net increase in undersized yield in the machine-thinned only treatment was less than 6%.
Selective Summer Pruning as a Tool to Develop Compact ‘Sweetheart’ Sweet Cherry Trees on Mazzard Rootstock

Roberto Nunez-Elisea*, Lilia Caldeira
Oregon State University, Mid-Columbia Agricultural Research and Extension Center, Hood River, OR, 97031

We tested two severities and four timings of summer pruning in 2-year-old ‘Sweetheart’ (Prunus avium L.) trees on seedling mazzard (P. avium L.) rootstock to evaluate growth and precocity responses. Trees were planted at 3.6 m × 5.6 m (497 trees/ha). Canopies consisted of three to four scaffolds and about 20 current-season shoots. All shoots on summer-pruned trees (n=6) were either headed or tipped on 24 June, 9 July, 26 July, or 9 Aug. 2004. Control trees were trained as steep leaders, with comparative current season shoots left intact. Trees had no bloom in 2004 and negligible bloom or fruiting in 2005. All 2005 shoots were headed in late July, except for controls, where only leaders were headed. By late Fall 2005, controls were 3.4 m tall with a canopy diameter of 3 m, while headed and tipped trees were about 65% and 75% the size of controls, respectively. Growth modules consisting of the original shoot and subsequent growth showed distinct responses to summer pruning treatments. Control shoots did not branch in 2004 and modules had an average of 17 spurs. Headed shoots branched in 2004 (except those headed 9 Aug.) and produced compact modules with a similar amount (24 June) or about 25% fewer (later heading treatments) spurs than controls. Shoots tipped in 24 June or 9 July branched in 2004 and produced modules with about 50% more spurs than controls. Shoots tipped in 26 July or 9 Aug. produced no new growth in 2004 and modules had about 30% the spurs of controls. Selective summer pruning produced compact trees which are expected (based on spur number) to yield at least 15 kg of fruit in 2006 (4th year) and appear suitable for densities of about 750 trees/ha. Yields, fruit quality, and future canopy management will be discussed.

Biomass and Total Nonstructural Carbohydrate Partitioning in Relation to Nursery Digging Date, and Subsequent Growth, Development and Fruiting Pattern of Strawberry Runner Plants Propagated in California High-latitude Nurseries

Daniel S. Kirschbaum*, Kirk D. Larson2, Steven A. Weinbaum3, Theodore M. DeJong

The pattern of total nonstructural carbohydrate [starch and soluble sugars (TNC)] accumulation in strawberry (Fragaria ×ananassa Duch.) nursery runner plants, cv. ‘Camarosa’, was determined for three growing seasons. A similar study was conducted on ‘Selva’, but for only one year. Growth, development and fruit production patterns of plants transplanted to growth chambers (GC) or fruiting fields were also evaluated. The experiments were carried out on plants propagated in high latitude (41°50’ N) nurseries in California (Siskiyou County). Plants were sampled beginning late summer through early autumn and analyzed for dry mass (DM) and TNC. Plants from different digging dates were established in GC or fruit evaluation plots in Irvine, Calif. (33°39’ N). Initial TNC concentration in storage tissues at the time of nursery digging increased steadily from the second week of September to the third week of October. Crown and root TNC concentration and content were correlated positively with the accumulation of chilling units (CU = hours ≤7.2 °C) in the nursery. Root TNC concentration consistently increased from 6% to 10% DM in ‘Camarosa’ (a short-day cultivar), and from ~4% to 14% DM in ‘Selva’ (a day-neutral cultivar) from mid-September to the first week of October. The root TNC content increased ~2.5 times in ‘Camarosa’ and ~3.7 times in ‘Selva’ during the same period. Transplant growth, development, and fruiting pattern were affected by digging date. Root TNC concentration and content were more sensitive to CU accumulation than crown TNC concentration and content. Therefore, root sampling appeared to be more appropriate than crown sampling for assessing the carbohydrate status and optimal digging dates of strawberry nursery runner plants early in the fall.

Application of Hydrated Lime to Hydrogen Cyanamide-treated Grapevines Reduces Lemon Leaf Abscission in Neighboring Lemon Orchards

Anwar G. Ali*, Carol J. Lovatt
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Previous research in our laboratory provided evidence that hydrogen cyanamide (HC) applied to grapevines (Vitis vinifera) to stimulate budbreak resulted in ethylene production, which, in addition to HC drift at application, caused abscission of leaves in neighboring ‘Eureka’ lemon [Citrus limon (L.) Burm. F.] orchards. Foliar-applied hydrated lime [Ca(OH)2] at 140 kg per 2337 to 2807 L ha-1 to commercial ‘Thompson Seedless’, ‘Perlette’, ‘Red Flame’, or ‘Princess’ vineyards 2–48 h after HC treatment reduced leaf abscission from 2-year-old ‘Eureka’ lemon trees placed inside the vineyards, with no negative effects on budbreak or yield of any grape cultivar. Hydrated lime is an effective inexpensive tool that grape growers can use to protect neighboring lemon orchards.

Automatic Detection of Fine Roots in Minirhizotron Images

Guang Zeng1, Stanley Birchfield1, Christina Wells2, Desmond Layne1, Anwar G. Ali*, Carol J. Lovatt

Minirhizotrons and specialized camera equipment have been widely adopted for in situ observation of fine root dynamics in horticultural settings. However, the laborious nature of data collection from minirhizotron images limits the number and size of experiments that can reasonably be analyzed. Here we present an algorithm for the automatic detection and measurement of roots in minirhizotron images, including the discrimination of light-colored roots from bright background objects. First, two-dimensional matched filtering and local entropy thresholding are used to produce binarized images from which roots are detected. Next, a strong root classifier based on geometric and intensity features is used to discriminate roots from unwanted background objects. A labeling algorithm identifies each individual root in the image, and root lengths and diameters are measured using Dijkstra’s algorithm and the Kimura–Kikuchi–Yamasaki method for obtaining the length of a digitized path. This approach allows us to identify and measure fine roots as individuals, rather than simply measuring the aggregate root length in an image. Experimental results from a collection of 250 peach (Prunus persica) root images demonstrate the effectiveness of the approach. The algorithm is able to detect and measure a variety of roots of different shapes, sizes, and orientations, with a detection rate of 92%, a false-positive rate of 5%, and an average measurement error of 4.1% and 6.8% for length and diameter, respectively. Current work involves improving the efficiency of the algorithm and incorporating it into an application. We are also exploring algorithms for tracking the location of a root over time as it grows darker in color and blends with the surrounding soil.

Leaf Abscission in Neighboring Lemon Orchards

Application of Hydrated Lime to Hydrogen Cyanamide-treated Grapevines Reduces Lemon Leaf Abscission in Neighboring Lemon Orchards

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Liquid Efluent from Poultry Waste Bioremediation as a Nutrient Source for Hydroponic Cucumber Production
Barbara E. Lied, Kristen Wilfong, Christina Taylor, Kari Mazzufiero
West Virginia State University, Agricultural and Environmental Research Station, Institute, WV, 25112-1000

Fertilizer costs and increased awareness of point-source pollution are amplifying the pressures on farming economics along with public demand for sustainable production methods and organically grown produce. Our research focuses on using effluent from thermophilic anaerobic digestion of poultry litter as an alternative fertilizer. Cucumbers (Cucumis sativus L.) were grown hydroponically using a batu bucket system to evaluate the effects of liquid effluent as a nutrient source versus a commercial nutrient solution. Seeds of the beet alpha cultivar ‘Manar’ were started in Hortcubes and transplanted into buckets containing a perlite/coir media. The effluent fertilizer consisted of effluent diluted to the same ppm nitrogen found in the commercial fertilizer based on ammonium measured in the effluent. Hydroponic solutions were monitored twice a day to maintain a pH of 5.6-6.0. Fruit was harvested three times a week and graded on size and shape. Fruit of each grade were counted, weighed, and recorded. Average fruit weight and fruit number produced was statistically significant between the two fertilizer regimes with the commercial fruit, averaging 84 g compared to 75 g for effluent fruit. The effluent treatment produced a greater percentage of grade 1 fruit (33%) compared to the commercial treatment (26% grade 1 fruit). Thus, 74% of the commercial harvest was grade 2 or cull fruit compared to only 66% of the effluent harvest. Correlating grade with average fruit weight analysis identified statistical differences between treatments for the grade 1 fruit, but not the grade 2 or the culls. While effluent from thermophilic anaerobic digestion shows promise as an alternative hydroponic fertilizer, it is not better than the commercial fertilizer regime.

The Changing Needs with Time for Mineral Nutrition of an Organic Stone Fruit Orchard Under Mediterranean Conditions
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1Agricultural Research Organization, Environmental Horticulture, Neve Ya’ar Research Center, Ramat Yishay, 30095, Israel; 2Agricultural Research Organization, Soil and Water, Neve Ya’ar Research Center, Ramat Yishay, 30095, Israel

Fruit growers apply fertilizer at high rates with soil organic matter (SOM) below 2.0%. As organically certified fertilizers are costly, our objective was to compare the effects of two modes of organic nitrogen nutrition to conventional control on plum tree yield and soil properties. The orchard is located on a Vertisol soil, and planted to plums in 1998. The tested treatments were: A) conventional control, receiving an average of 350 kg of N/ha per year; B) fertilization using cattle manure compost (15 tons/ha per year) + feather meal (1 ton/ha per year); and C) a combination of the same amount of compost + 500 kg of feather compost (15 tons/ha per year) + feather meal (1 ton/ha per year). In the FL and MU treatments, roots were noticed to be superficial and their frequency was higher close to the tree. In SSS, root frequency was similar between the two fertilizer treatments, roots were noticed to be deep in the soil profile and they extended farther from the tree. As a result, soil bulk density of treatments B and C declined with no increase in the soil’s nutrient content in the organic treatments over the next 3 years, due to continued mineralization of the SOM pool. Various soil microbial characteristics (microbial counts, total hydrolytic activity, functional richness, and diversity) were determined. In all these parameters the organic treatments showed higher levels than treatment A. Stem circumferences and yields were similar for all treatments. It can be concluded that soil productivity is affected by SOM, so that after achieving a threshold level of SOM, fertilization needs are reduced considerably.

Effect of Ground Floor Management Systems on Root Architecture of Pacific Gala on M.9 NAKB 337 under Organic Protocol
Dario Stefanelli*, Ronald L. Perry
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One of the main problems facing organic horticulture is orchard ground floor management. Several works report that ground floor management affects root architecture of fruit trees, changing the position and depth of the roots. The purpose of this work is to study the effects of orchard ground floor management systems (GFMS) in an apple orchard under organic protocol in Michigan. The research was conducted at the Clarksville Horticultural Experimental Station of Michigan State University, in the organically certified (by OCIA) orchard of ‘Pacific Gala’ grafted on M9 NAKB 337, established in May 2000. The GFMS being studied are: 1) mulch (MU) made of alfalfa hay on the tree rows, with a width of 2 m; 2) “Swiss Sandwich System” (SSS) that consists in superficial tillage of two strips 90 cm wide at each side of the tree row, leaving a 40-cm strip in the middle (under the canopy) where volunteer vegetation is allowed to grow; 3) flaming (FL) of the weeds in a 2-m strip underneath the tree canopy by a propane burner. Root architecture was studied in Sept. 2005 through the frequency of roots by the profile wall method. Trenches (3.36-m long × 1.32-m deep) were dug in the soil 45 cm from the tree trunk. Two 158 cm × 130 cm metal grid frames divided by strings into a 28 cm × 22 cm grid were placed against the profile faces to facilitate the counting and mapping of the root distribution. The GFMS did affect the root distribution of the two classes of roots under study (<2 mm and >2mm). In the FL and MU treatments, roots were noticed to be superficial and their frequency was higher close to the tree. In SSS, root frequency was similar until 80 cm deep in the soil profile and they extended farther from the tree.

Nutrition Management in No-till Organic Cling Peaches
Janine Hasey, Roland Meyer, Karen Klonsky, Pete Livingston, Anil Shrestha
1University of California, Cooperative Extension Sutter & Yuba Counties, Yuba City, CA, 95991; 2University of California, L.A.W.R., Davis, CA, 95616; 3University of California, Agriculture & Resource Economics, Davis, CA, 95616; 4University of California, UC IPM, Parlier, CA, 93648

Growing tree crops organically is gaining in popularity as growers seek ways to protect the environment and retain economic viability. Five row mid-till nutritional treatments were established and costs recorded following the 2001 planting of a cling peach [Prunus persica (L.) Batsch cv. Klamtr] orchard transitioning to organic production. Treatments were: sulfametamide N + chess + 45 kg N/ha, 1) N compost; 2) mulch (50 kg hay + 45 kg N/ha compost); and 3) compost (90 kg N/ha compost). The compost was chicken manure in 2002–03 and yard waste in 2004–05. Compost analysis showed lower nitrogen (N) than expected in 2003, and high moisture content in 2005. The self-reseeding subclover and soft chess remained stable over 4 years. Burclover populations peaked in 2004 in the treatments receiving compost. Subclover treatments showed a trend for higher cover crop dry matter yield and nutrient content. Tree leaf N levels at 2.67% or higher were maintained in the subclover treatment. All compost treatments received sodium nitrate in 2004 and 2005 when leaf analysis showed borderline N deficiency (<2.5%) in several plots. The subclover and the 90 kg ha N compost treatments had the most rapidly growing trees: 94.4 and 90.0 cm2 in 2005 and 116.1 and 114.5 cm2 in 2006, respectively. There were no significant differences in yields, fruit size, or firmness in...
2004–05; however, more brown rot damage was seen in the treatment receiving the most compost and sodium nitrate. Annualized cost per hectare for row middle nutrition, ranked from lowest to highest, was: subclover/soft chess = $50; subclover = $53; resident vegetation + 45 kg N = $134; soft chess + 45 kg N = $138; and resident vegetation + 90 kg N = $204.

**Integrative Approaches for Weed Management in Organic Citrus Orchards**

Jose Linares*,1, Johannes Scholberg1, Carlene Chase2, Robert McSorley3, James Ferguson3

1University of Florida, Agronomy, Gainesville, FL, 32601; 2University of Florida, Horticultural Science; 3University of Florida, Entomology and Nematology

Lack of effective weed control may hamper organic citrus establishment. Cover crop/weed biomass (CCW) indices were used to assess the effectiveness of annual and perennial cover crops (CC) in reducing weed growth. The CCW values for perennial peanut (PP) were 0.06, 0.14, 0.4, and 0.5 during 2002, 2003, 2004, and 2005, respectively (very poor to poor weed control). Initial PP growth was slow and repeated mowing was required, but, over time, PP became more effective in controlling weeds. Weed biomass with sunn hemp was 0.3 Mg/ha in 2002 (CCW = 25, outstanding weed control) compared to 1.4 Mg/ha with use of cowpea (CCW = 1) in 2004. In 2004, the dry weights (Mg/ha) for different summer CC were: hairy indigo = 7.6, pigeon pea = 7.6, sunn hemp = 5.3, cowpea = 5.1, alcyce clover = 2.9, velvet bean = 1.3, and lablab bean = 0.8. Corresponding 2005 values were: 9.5, 3.7, 12.6, 1.0, 1.9, and 1.4. Respective CCWI values were: 7, 4, 2, 16, 28, 0.6, and 0.3 (2004) vs. 17, 2, 64, 80, 0.5, 2, and 14. In 2004, winter CC production (Mg/ha) was radish (R) = 3.2, crimson clover (CR) = 1.7, oats (O) + lupine = 1.6, and rye (WR)/vetch (V) mix = 1.1. Results for 2005 were: CR + R + WR = 8.0, WR = 6.0, CR + R = 5.3, CR + 0 + WR = 5.0, R = 4.3, and O = 3.6 Mg/ha. Corresponding values for CCW-indices were 15, 2, 1, and 3 (2004) and 100, 25, 76, 35, 62, 11, and 16 (2005). Although OMRI-approved herbicides showed up to 84% weed injury for selected species, none of these products provided long-term weed control. Combination of repeated tillage, use of compact/reseeding CC mixes in tree rows, more vigorous annual CC and/or perennial PP in row middle and repeated use of organic herbicides near sprinklers and tree trunks are thus required to ensure effective weed suppression in organic citrus.

**Living Mulches for Weed Suppression and Enhanced Water Infiltration in Fall Broccoli**

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1University of Florida, Horticultural Science, Gainesville, FL, 32611-0690; 2Florida A&M University, Agronomy Program & Center for Water Quality, Tallahassee, FL, 32307-4100

The effect of living mulches (LM) on weed suppression, crop growth and yield, and soil hydraulic conductivity were evaluated in broccoli in North Central Florida at Citra and in North Florida at Live Oak, using organic production methods. ‘Florida 401’ rye, ‘Wrens Abruzzi’ rye, black oat, and annual ryegrass, were either mowed or left untreated and compared with weedy and weed-free controls. Cover crop biomass was highest with ‘Florida 401’ at both locations, intermediate with black oat and ‘Wrens Abruzzi’, and lowest with ryegrass. The greatest weed infestation occurred with the weedy control. In Citra, ryegrass decreased weed biomass by 21% compared with ≈45% by the other LM with no differences due to mowing. However, at Live Oak, mowed LM and the weedy control had similar amounts of weed biomass; whereas unmowed LM had 30% to 40% less weed biomass than the weedy control. At both locations, broccoli heights were greatest with the weed-free control, intermediate with the cover crops, and lowest with the weedy control. Total above-ground broccoli biomass and marketable weight of broccoli at Live Oak, and number of marketable heads at both locations, were unaffected by the LM. At Citra, total broccoli biomass with LM and the weedy control decreased in a similar manner, so that total broccoli biomass was highest with the weed-free control. Rye grass and the weedy control suppressed marketable broccoli weight by 24%; however, greater decrease in marketable weight (39% to 43%) occurred with ‘Florida 401’, ‘Wrens Abruzzi’, and black oat. At both locations, mowing of LM had no effect on broccoli growth or yield. There was no difference in saturated hydraulic conductivity among treatments.

**Vegetable Crop Yield and Quality following Differential Soil Management (Compost Versus No Compost Application) in Transitional- and Certified-organic Systems in Ohio**

Matthew Kleinhenz*, Annette Wszelaki, Sonia Walker, Senay Ozgen, David Francis

The Ohio State Univ., Ohio Agricultural Research and Development Center, Horticulture and Crop Science, Wooster, OH, 44691-4096

Successful organic farming requires synchronizing soil-based processes affecting nutrient supply with crop demand, variable among and within crops. We report here on two studies conducted in transitional- (TO) and certified-organic (CO) systems containing subplots that, annually, were either amended with compost or not amended prior to vegetable crop planting. Dairymanure compost was added at rates providing the portion of a crop’s anticipated nitrogen requirement not provided by a leguminous rotation crop and/or carryover from previous compost application. In the TO study, potato (2003), squash (2004), green bean (2005), and tomato (2006) were planted in main-season plots in open fields and high tunnels, and beef, lettuce, radish, spinach, and swiss chard were planted in high tunnels in early spring and late fall. Long-term CO open-field plots (±compost) were planted to multiple varieties of lettuce, potato, popcorn, and processing tomato in 2004–2006. Drip irrigation was used in all TO plots and CO lettuce and processing tomato plots. Treatment effects on crop physical and biochemical variables, some related to buyer perceptions of crop quality, were emphasized in each study. Yield in TO, compost-amended plots exceeded yield in unamended plots by 1.3 to 4 times, with the greatest increases observed in high-tunnel-grown mesclun lettuce and the smallest response observed in potato. Similar results were found in CO plots, although compost effects differed by crop and variety. The data suggest that: 1) compost application and the use of specific varieties are needed to maximize yield in organic vegetable systems in temperate zones, regardless of age; and 2) production phase management may influence buyer-oriented aspects of crop quality.

**Summer Squash Planting Systems Following a Rye Cover Crop**

James W. Shreffer*,1 Warren Roberts2, Charles Webber2, Jonathan Edelson1, Merritt Taylor1

1Oklahoma State University, WWAREC, Lane, OK, 74555; 2USDA–ARS, SCARL, Lane, OK, 74555

Commercial organic vegetable production requires using soil improvement practices and effective weed control measures. Rye (Secale cereale) cover crops are known to suppress annual weeds. Research was begun in 2004 to measure crop yield, annual weed infestation, and weed control requirements for vegetable planting systems that begin with a rye cover crop. Poultry litter was used to supply nutrients and was applied based on a soil test and commercial vegetable recommendations. Rye ‘Elbon’ was seeded 21 Oct. 2004 on beds with 1.8-m centers. Zucchini squash (Cucurbita pepo) ‘Revenue’ was planted following the year using three crop establishment dates, such that transplanting occurred on 6 May, 3 June, and 29 June. Planting system treatments included: conventional tillage (CT), CT and plastic mulch (P), CT with stale seedbed, mow, mow and burn-down, mow and shallow till (ST), ST and burn-down. Following field preparation, squash was transplanted in a single row at the bed center with 0.77-m plant spacing. Drip irrigation was used in all plantings. Emerging weeds were removed by hoeing. Squash was harvested from each planting over approximately 3 weeks and total marketable fruit counts were determined. Marketable yields with P were approximately double those of the CT and ST treatments in the 6 May transplanting. Yields were comparable for CT and ST in the 3 June transplanting, but were significantly lower for the P treatment.
There were no significant differences among the treatments that received tillage in the 29 June planting. However, the non-tilled treatments had significantly lower yields compared to tilled treatments.

**Oral Session 24—Environmental Stress Physiology**

29 July 2006, 3:30–4:45 p.m.  
Southdown

Moderator: Marc W. van Iersel

**Within-crown Variation in the Development of Photosynthetic Capacity Is Proportional to Growth Temperature in Temperate Deciduous Trees**

William L. Bauerle*,1 Joseph D. Bowden1, Geoff G. Wang2

1Clemson University, Horticulture, Clemson, SC, 29634; 2Clemson University, Forest and Natural Resources

This study set out to test the hypothesis that the development in the capacity for the maximal rate of ribulose-1,5-bisphosphate carboxylase/oxygenase (VCmax) and the maximum regeneration rate of ribulose-1,5-bisphosphate (Jmax) per unit mass is proportional to the growth temperature under which the leaf develops and to investigate whether the capacity for photosynthetic acclimation to temperature varies genetically within a species by testing genotypes that originated from diverse thermal environments. Acer rubrum L. (red maple) genotypes were subjected to short-term and long-term temperature alteration to investigate the photosynthetic response. We minimized the variation of within-crown light gradients by growing trees in open grown field conditions and rate (A), growth temperature resulted in a decrease in maximum net photosynthetic rate (Amax) and had a 3 and 5 °C lower temperature optimum than the genotype native to the southern United States. The activation energy increased and was higher for Jmax than for VCmax in both genotypes. With respect to respiration, both genotypes downregulated about 0.5 µmol·m-2·s-1. Although respiration was lower, the increased energy of activation in response to growth temperature resulted in a decrease in maximum net photosynthetic rate (Amax) under saturating light and CO2. The results illustrate that the photosynthetic capacity adjusted in response to growth temperature but the temperature optimum was different among genotypes.

**Assessment of Kentucky Bluegrass Salt Tolerance with Remote Sensing**

James A. Poss1, Catherine M. Grieve1, Walter B. Russell1, Stacy A. Bonos2

1USDA-ARS-PWA George E. Brown, Jr., Salinity Laboratory, Plant Sciences, Riverside, CA, 92507; 2Rutgers, The State University of New Jersey, Plant Biology and Pathology, Brunswick, NJ, 08901

Six cultivars or selections of Kentucky bluegrass (Poa pratensis L.) exposed to salinity stress were evaluated with ground-based remote sensing plant reflectance (R) measurements at wavelengths ranging from 350 nm to 2500 nm. Cultivars Baron, Brilliant, Cabernet, Eagleton, Midnight, and the selection A01-856, a Texas × Kentucky bluegrass hybrid (Poa arachnifera × P. pratensis), were grown outdoors from vegetative clones in a gravelly-sand medium from Apr. to Sept. 2005, in Riverside, Calif., at soil water salinities ranging from 2 to 22 dSm-1. Two Normalized Difference Vegetation Indices (NDVI) were developed based on: 1) canopy reflectance in the visible domain at 695 and 670 nm and 2) an average of eight wavelengths in mid-infrared [Ravg = (R:1500, R:1680, R:1740, R:1940, R:2050, R:2170, R:2290, and R:2470 nm/8)] and the reference wavelength (670 nm). Both NDVIs were significantly sensitive to salinity-induced changes in grass canopies and were able to discriminate significantly between the salt-tolerant cultivars (‘Baron’, ‘Brilliant’, and ‘Eagleton’) and salt-sensitive cultivars (‘Cabernet’, ‘Midnight’, and A01-856). Another remotely sensed index, based on the derivative of the absorbance (1/R) in the red-edge region between 600 and 800 nm, also generated a similar ranking to the NDVIs and biomass for the six cultivars. These findings indicate that remote sensing of canopy reflectance may represent an additional tool to evaluate and explain the biophysical or physiological differences among Kentucky bluegrass cultivars related to salt tolerance.

**NaCl Stress in Hydroponic Tomatoes Can Be Alleviated by Calcium**

Francesco Montesano1, Marc W. van Iersel1,2

1University of Bari, Dipartimento Di Scienze Delle Produzioni Vegetali, Via Amendola 165, Bari, Italy; 2University of Georgia, Department of Horticulture, Athens, GA, 30602

The availability of good quality irrigation water is decreasing worldwide, and salinity is an increasingly important agricultural problem. To determine whether detrimental effects of NaCl can be minimized by additional Ca++, tomato (Lycopersicon esculentum Mill. `Super-sweet 100’ was grown hydroponically. The basic nutrient solution contained 11.9 mM NO3 and 3.2 mM Ca++. We added 14.1, 44.4 and 70.4 mM of NaCl to this solution to determine the effect of NaCl and there were treatments with 70 mM NaCl and 10 or 20 mM Ca++ to look at Ca++ effects. We also included three treatments in which all nutrient concentrations were increased (without NaCl) to distinguish between osmotic and ion-specific effects. 70.4 mM NaCl reduced leaf photosynthesis, chlorophyll content, gas phase conductance for CO2 diffusion, carboxylation efficiency, and dark-adapted quantum yield of photosystem II. The inclusion of 20 mM Ca++ prevented these effects of NaCl. NaCl also decreased leaf size and elongation rate, but this could not be prevented by adding extra Ca++ to the nutrient solution; these were caused by osmotic effects, rather than Na+ specifically. Likewise, plant dry mass was negatively correlated with solution EC, suggesting an osmotic effect. Our results indicate that leaf area development, which was inhibited by high EC, is more important for dry matter accumulation than leaf photosynthesis, which was inhibited by high Na+. Adding 20 mM Ca++ to the 70 mM NaCl solution reduced the Na+ concentration in the leaf from 79 to 24 mg·g-1, which may explain why Ca++ alleviates Na+ toxicity.

**Water Stress and Growth of Native and Introduced Shrub Species as Influenced by Irrigation Regime**

Sloane M. Scheiber*, Richard C. Beeson, Heather Bass

1University of Florida, Environmental Horticulture, Apopka, FL, 32703

Native plants are often promoted as an approach for water conservation in urban landscapes. However, information regarding plant water needs is based primarily upon anecdotal observations of plant performance. Direct comparisons between native and introduced species using physiological measures of plant water stress are unavailable to support or refute such recommendations. Ligustrum japonicum and Myrica cerifera, representing an introduced and native species, respectively, were transplanted into a fine sand soil to evaluate establishment rates and growth characteristics under two irrigation regimes. Each species was irrigated either daily or every 3 days and received 1.3 cm of irrigation per event for 8 months after transplant. Predawn, midday, and dusk water potentials were recorded on three consecutive days monthly, with cumulative stress intervals calculated. Height, growth indices, shoot dry mass, root dry mass and leaf area were also recorded. Water potential was significantly influenced by day of water stress level. On days without irrigation, water stress was generally greater and affected growth. Myrica irrigated daily had the greatest growth, yet plants receiving irrigation every 3 days had the least growth and greatest leaf drop. In contrast, for Ligustrum there were no differences between irrigation regimes in growth responses except for growth index.

**Variation in Leaf Anatomical Traits of Pecan Cultivars**

Madhulika Sagaram*, Leonardo Lombardini, Larry Grauke

Texas A&M University, Dept. of Horticultural Sciences, College Station, TX, 77843

An assessment of anatomical traits of pecan cultivars (‘Pawnee’, ‘Mohawk’, and ‘Starking hardy giant’) collected from three locations
We have developed a Nuclear Magnetic Resonance (NMR)-based approach to metabolomics research that enables the identification of bioactive compounds in crude plant extracts. For this work, we used black raspberries, which are known to contain compounds that exhibit chemopreventive activity toward oral, esophageal, and colon cancers. To ascertain bioactive components and their interrelationships, NMR results for black raspberry samples from four cultivars grown on commercial farms in Ohio were examined using principal component analysis. Multivariate analysis that included anthocyanin content (HPLC), antioxidant activity (DPH, ABTS, FRAP), total phenolics (Folin-Ciocalteau assay), and bioactivity as measured by inhibition of colon cancer HT-29 cell line proliferation showed correlations with specific regions of NMR spectra at 400 MHz. Correlations were also observed for major and minor groupings of the black raspberry samples. Replicate black raspberry samples were examined with a 750 MHz NMR spectrometer equipped with a cryoprobe that provided a 4- to 5-fold improvement in sensitivity. In this manner, even minor bioactive components in black raspberries could be examined to determine additive and synergistic effects.

Planting Date Effects on Anthocyanin Concentrations in Nine Lettuce (Lactuca sativa) Varieties and Relationships among Anthocyanin Levels and Instrumented and Visual Assessments of Color

Aparna Gazula1, Matthew Kleinhempstil1, Peter Ling2, Joseph Scheerens2
1The Ohio State University-Mansfield, Chemistry, Mansfield, OH, 44906; 2The Ohio State University, Ohio Agricultural Research and Development Center, Horticulture and Crop Science, Wooster, OH 44691-4096

Leaf samples collected from field plots of nine lettuce varieties established in the Early (ES) and Late (LS) Summer of 2002 and 2003 in Celeryville, Ohio, were subjected to spectrophotometric measurement of anthocyanin concentrations and/or color analysis based on colorimeter and spectroradiometer readings and human panelist ratings. Interactions between year (Y), planting date (PD), and variety (V) main effects for anthocyanin concentration were significant due to shifts in response magnitude, but not direction. Anthocyanin levels were higher following LS than ES planting, regardless of Y and V, and PD effects were pronounced in 2002, when differences in average daily temperature between ES and LS plantings tended to be larger. Also, regardless of Y and PD, anthocyanin levels followed the pattern ‘Impuls’ > ‘OOC 1441’ > ‘Valeria’ > ‘OOC1426’ > ‘Lootto’ > ‘SVR 9634’ > ‘OCC 1434’ > ‘OCC 1310’ > ‘Cireo’. Treatment-based color differences were also evident in colorimeter and spectroradiometer readings. And, panelists differentiated field-grown samples based on red color intensity. Strong correlations between analytical and instrumented and human panelist-based measures suggest that instrumented assessments of red color intensity may serve as reliable proxies for direct measures of anthocyanin levels or human panelist ratings, particularly if the aim is to establish color differences between major experimental groups and assign a quantitative, repeatable value to red color intensity.

Fertilizer Source and High Tunnel Production Environment Affect Antioxidant Levels of Pac Choi

Xin Zhao*,1 Edward E. Carey1, Takeo Iwamoto2
1Kansas State University, Horticulture, Forestry, and Recreation Resources, Manhattan, KS, 66506; 2Kansas State University, Biochemistry, Manhattan, KS, 66506

An experiment was conducted at Olathe, Kan., in Spring 2004 to investigate the influence of organic and conventional fertilizer sources and application rates on antioxidant levels of pac choi (Brassica rapa L. var. acephala).

Oral Session 25—Produce Quality, Safety, & Health Properties

Moderator: G.K. Jayaprakasha

Phenolics and Carotenoids Contribute to Antioxidant Activity in Navel Orange

G.K. Jayaprakasha*, Clark Wilson, Bhimanagouda S. Patil
Texas A&M University, VFIC, Department of Horticultural Sciences, College Station, TX, 7784-2119

Consumption of fruits and vegetables has been associated with reduced risk of disease, such as neurodegenerative disorders and certain forms of cancer, and aging. Antioxidants prevent the damage to macromolecules and cells by interfering with the free radicals. Several natural compounds that possess antioxidant activity have been reported from plant sources and are commercially promoted as nutraceuticals. Citrus fruits contain certain bioactive compounds such as phenolics, flavonoids, limonoids, carotenoids, and ascorbic acid. In this context, navel oranges were freeze-dried and extracted with five different solvents, such as hexane, ethyl acetate, acetone, methanol, and 8 methanol:2 water. The extracts were dried under vacuum and screened for their radical scavenging activity using the 1,1-diphenyl-2-picrylhydrazyl method at 250, 500, and 1000 ppm. The methanol: water and methanol extracts of navel orange were found to be maximum (92.9%) and minimum (63.89%) radical scavenging activity at 1000 ppm. Furthermore, the antioxidant capacity of all extracts was assayed through the phosphomolybdenum method and expressed as equivalent to ascorbic acid (µmol/g of the extract). The order of antioxidant capacity for navel orange extracts was found to be ethyl acetate > acetone > methanol: water > methanol > hexane. It seems that the antioxidant capacity of the extracts is in accordance with the amount of phenolics/lycopene present in each fraction and may provide a good source of antioxidants. This study showed that stomatal density as well as epidermal cell density index were observed between ‘Pawnee’ and ‘Mohawk’ at Chetopa. The project is based upon work supported by the USDA–CSREES under Agreement USDA IFAFS #2001-52102-02294 and USDA #2005-34402-14401 “Designing Foods for Health” through the Vegetable and Fruit Improvement Center.

A Nuclear Magnetic Resonance Spectroscopy-based Approach to Profile Biologically Active Plant Metabolites Using Black Raspberry Inhibition of Colon Cancer Cell Proliferation as a Model System

Faith J. Wyzgoski1, A. Raymond Miller2, Joseph C. Scheerens2, Peter L. Rinaldi3, Bert L. Bishop3, R. Neil Reese3, Mustafa Ozgen6, Artemio Z. Tulio, Jr.4, M. Monica Giusti7, Joshua A. Bomser8
1The Ohio State University-Mansfield, Chemistry, Mansfield, OH, 44906; 2The Ohio State University, Horticulture and Crop Science, Wooster, OH, 44691; 3University of Akron, Chemistry, Akron, OH, 44325; 4The Ohio State University, Computing and Statistical Services, Columbus, OH, 43210; 5South Dakota State University, Biology and Microbiology, Brookings, SD, 57007; 6Gazi University, Horticulture, Tatilciftlik, Tokat, 60240, Turkey; 7The Ohio State University, Food Science and Technology, Columbus, OH, 43210; 8The Ohio State University, Human Nutrition, Columbus, OH, 43210

We have developed a Nuclear Magnetic Resonance (NMR)-based approach to metabolomics research that enables the identification of bioactive compounds in crude plant extracts. For this work, we used black raspberries, which are known to contain compounds that exhibit chemopreventive activity toward oral, esophageal, and colon cancers. To ascertain bioactive components and their interrelationships, NMR results for black raspberry samples from four cultivars grown on commercial farms in Ohio were examined using principal component analysis. Multivariate analysis that included anthocyanin content (HPLC), antioxidant activity (DPH, ABTS, FRAP), total phenolics (Folin-Ciocalteau assay), and bioactivity as measured by inhibition of colon cancer HT-29 cell line proliferation showed correlations with specific regions of NMR spectra at 400 MHz. Correlations were also observed for major and minor groupings of the black raspberry samples. Replicate black raspberry samples were examined with a 750 MHz NMR spectrometer equipped with a cryoprobe that provided a 4- to 5-fold improvement in sensitivity. In this manner, even minor bioactive components in black raspberries could be examined to determine additive and synergistic effects.

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An experiment was conducted at Olathe, Kan., in Spring 2004 to investigate the influence of organic and conventional fertilizer sources and application rates on antioxidant levels of pac choi (Brassica rapa L. var. acephala).
The Response of Basil Accessions to Date of Planting in North Alabama

Cedric A. Sims*, Srinivasa R. Mentreddy
Alabama A&M University, Plant and Soil Science

Basil (Ocimum sp.), belonging to the mint family, Lamiaceae (Labiatae), is a popular herb grown for the fresh market or for its dried aromatic leaves, which are used as a spice or in potpourris. In Asian countries, basil, particularly O. tenuiflorum, is better known as a medicinal plant species used for treating ailments ranging from colds to complex diseases such as cancers and diabetes. In the United States, however, it has a limited acceptance as a fresh-market herb. There is much potential for developing basil as a medicinal plant to cater to the growing herbal medicinal products industry. A field trial was therefore conducted to determine optimum date of planting basil in Alabama. Six-week-old seedlings were transplanted from the greenhouse into field plots arranged in a split-plot design with four replications. Planting dates at monthly intervals beginning in April were the main plots and three Ocimum accessions, Ames 23154, Ames 23155, and PI 288779 were sub-plot treatments. The accessions were compared for growth, leaf area development, light interception, canopy cover, and dry matter accumulation and partitioning pattern over planting dates. Ames 23154, with greater canopy cover (98.5%) and photosynthetically active radiation interception (96.1%), also produced higher total plant biomass than other accessions. Accession PI 288779 appeared to partition greater dry matter to leaves, which are the primary source of bioactive compounds in basil. Among planting dates, second (May) date of planting appeared to be optimum for both total biomass and leaf dry matter production. Genotypic variation for dry-matter partitioning and relationships among agronomic parameters as influenced by planting date will be discussed in this presentation.

Oral Session 26—Genetics & Germplasm 3
30 July 2006, 8:00–9:15 a.m. Southdown

Moderator: Rose Palumbo

Genetic Variation and Relationships among Frangipani Cultivars

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Plumeria is a small genus of succulent trees and shrubs in the Apocynaceae native to tropical America. It is favored as a landscape ornamental in tropical and tropical regions due to its tolerance of hot, dry conditions, ease of propagation, and long season of bloom. Flowers of certain varieties are important components of lei in Hawaii. Numerous cultivars have been developed, chiefly from either seedling selections of P. rubra, a Mexican species, and P. obtusa, broadly distributed in the Caribbean basin, or hybrids between these species and among older cultivars. Little is known of the breeding behavior of the species in nature or cultivation, but very few of the cultivars set an abundant number of fruits. We used 21 microsatellite DNA (SSR) loci developed in our lab from Plumeria rubra to investigate the genetic relationships of 83 cultivars of Plumeria from a germplasm collection at the University of Hawaii, now duplicated in Miami. All 21 loci were highly polymorphic, with three to 15 alleles observed across the cultivar population. Six of the 21 loci exhibit heterozygote excess across the cultivars; the majority of the remaining 15 have an excess of homozygotes, suggesting that the cultivars are largely inbred. Clustering with Bayesian analysis suggests that there are five main groups represented among the cultivars, with varying degrees of admixture among the five. The data also suggest that identical genotypes have received different cultivar names at times. We are also analyzing seedling populations from fruits spontaneously set on several cultivars to determine if they are predominantly the result of self-pollination or out-crossing.

A Phylogeny of Pelargonium Based on TRAP Markers

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Pelargonium is one of the priority genera collected by the Ornamental Plant Germplasm Center (OPGC). In order to protect future breeders from a loss of genetic diversity, the OPGC collects heirloom cultivars, breeding lines, and wild species. The current Pelargonium collection consists primarily of cultivars originating from P. xhortorum and P. ×domesticum. Our project was designed to analyze the current collection in order to facilitate the maintenance of a more-diverse core collection. We have expanded our TRAP (Target Region Amplified Polymorphism) analysis from 120 plants with one primer set to include 780 plants with four primer sets. Each primer set consists of a labeled arbitrary primer paired with a gene-specific primer, and two different fluorescent labels were used to allow multiplexed PCR reactions. We scored about 90 markers in each of the first two primer sets and about 60 markers in each of the second two. In comparisons between the phylogeny and the morphology and taxonomy of these plants, we show some matching clusters that may be explained by the breeding history of the plants.

Techniques to Evaluate Caladium Cultivars for Host Resistance to Fusarium Tuber Rot

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Caladiums, widely used in containers and landscapes as ornamental plants for their bright colorful leaves, are generally forced or grown from tubers. Commercial production of these tubers in central Florida is through dividing “seed” tubers and growing them in fields. Tubers quality is therefore of critical importance to success in container forcing, landscape use, and tuber production. Fusarium tuber rot (Fusarium solani) has been recognized as the most-destructive disease that affects caladium tuber quality. There is anecdotal evidence from growers indicating the existence of resistance in commercial caladium cultivars. To identify and confirm the source of fusarium tuber rot resistance in caladium, F. solani isolates have been collected from rotting tubers grown under different soil conditions and from different locations. The pathogenicity of these isolates has been tested through artificial inoculation of fresh harvested and/or stored tubers, and a number of highly virulent isolates
Determination of Seed Germination Requirements in Nolana sp.
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Nolana is a diverse genus native to coastal deserts of Peru and Chile, with great potential for developing new ornamental cultivars. Low germination rates have been an obstacle in the breeding efforts at the University of New Hampshire (UNH). Nolana species are comprised of unusual sclerified mericarps, each containing one or more embryos. Germination occurs through the tracheid tubes in the funicular plugs. Under normal greenhouse conditions at UNH, germination success in eight Nolana species (N. adansonii, N. aticoana, N. hemispheric, N. laxa, N. ivaniana, N. plicata, N. elegans, and N. rupicola) ranged from 0 to 0.05 seedlings/mericarp. We analyzed the effect of chemical and environmental germination treatments. SEM showed that soaking treatments create physical changes in mericarp morphology, exposing tracheid tubes in the funicular plugs. These treatments were unsuccessful in increasing germination: 0.1 N HCl, 0.2 KNO₃, conc. H₂SO₄, 10 mM or 1 μM etephon. Gibberelic acid (1000 ppm) effectively increased germination in some species (e.g., N. adansonii) to 0.47 seedlings/mericarp. Mericarps stored dry for 2 years had significantly higher germination than fresh mericarps (0.55 seedlings/mericarp). Mericarps of N. aticoana were subjected to after-ripening treatments. Mericarps stored for 7 weeks at 35 °C and 75% RH showed significantly higher germination (0.36 seedlings/mericarp) than mericarps stored dry, or stored moist for 1-6 or 8-12 weeks. Our findings facilitate development of larger hybrid populations, thus increasing the efficiency of Nolana breeding programs.

Fritillaria Species Are at Risk of Extinction in Iran: Study on Effective Factors and Necessity of International Attention
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The fascinating Fritillaria genus includes 100 species, of which 14 species are native to Iran. Iran is center of origin and genetic diversity of important species like F. imperialis and F. persica. Unfortunately, in recent years wild populations of these valuable plants, which have commercial value, are at risk of extinction in Iran. Effective factors on extinction of F. imperialis and F. persica were investigated in 2 years (2003 and 2004). The important factors were: 1) irregular grazing of Fritillaria stands (provenances); 2) in Iran, there is no protecting rule for saving Fritillaria from extinction; 3) changing of pastures to dry farms; 4) pest overflows that are related to destruction of pastures; and 5) Fritillaria are not commercially cultivated in Iran. Because of poverty, native people eradicate Fritillaria with their bulbs and transfer them to florists' shops. Prevention of this tragedy and conservation of Fritillaria require international attention. Because of these factors, Fritillaria will be removed rapidly from their place of origin.
Virtual Field Trips for Improving Undergraduate Education in Greenhouse Management

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Economics and logistics have greatly reduced or eliminated the ability of horticulture instructors to use field trips or on-site visits as educational tools. This is especially problematic in the field of greenhouse management and controlled environment agriculture, since the facilities and technologies used are essential to the discipline. To address this problem, we developed 15 DVD-based virtual field trips (VFTs) that instructors may use to demonstrate to the students the most up-to-date facilities, technologies, and management strategies used in greenhouse management (ornamental and food crops) and controlled environment agriculture (GCEA). Each VFT included a preface with background information about the company, a tour organized by subject chapters, self-examination, and a teacher’s guide with additional information and case studies. Each land-grant institution with an instructional program in greenhouse management of controlled-environment agriculture will be provided a free copy of each VFT, which will benefit all instructors of GCEA in the United States.

Using Active Learning to Teach Irrigation Concepts in Greenhouse Management

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In the past, horticulture students at the University of Maine have been taught to irrigate plants using only hand irrigation. It is becoming increasingly important to irrigate and fertilize efficiently in commercial greenhouses in order to reduce water waste and nutrient leaching. In 2004 and 2006, greenhouse management or plant production students were exposed to alternate methods of irrigating Dendranthema ×morifolium (chrysanthemum) in greenhouses to train students more effectively in irrigation techniques. In 2004, students measured the quantity of water applied to chrysanthemums once they reached the permanent wilting point from 26 Sept. until 30 Oct. The irrigation frequency generally increased as crops grew, but, the quantity of water applied was not significantly different. This experience provided students with a tangible idea of how irrigation frequency and timing change as crops grow, which could be applied to irrigation timing decisions in the future. In 2006, students grew a crop of chrysanthemums using alternate methods of irrigation (hand watering vs. drip irrigation) and fertilization. Student surveys in 2006 indicated that only 25% of students with previous experience working in a greenhouse or nursery had grown crops using drip irrigation, but all students with prior experience had irrigated by hand. Expanding student experiences with irrigation in the greenhouse uses active learning to instill students with more knowledge of irrigation and provide them with practical skills for irrigating efficiently and conservatively in the future.

Advanced Teacher Training on Air Pollution Effects on Plants at the Air Quality Learning and Demonstration Center at the Arboretum at Penn State

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1Penn State University, Horticulture; 2Penn State University, Institutes of the Environment; 3Penn State University, Plant Pathology

Penn State’s Air Quality Learning and Demonstration Center was completed and open to the public in 2003. The facility houses the State College air monitors for the Department of Environmental Protection and contains self-guided walkways through gardens of air pollution sensitive plants, innovative techniques for demonstrating the effects of air pollutants on plants, displays of recent research findings, industry-supported displays of pollution abatement technologies, and a teaching pavilion. One of our outreach projects, funded by the US EPA and the PA Department of Environmental Protections, is to provide enhanced teacher training on air pollution impacts on the regional and specific vegetation through an in-service training for local science school teachers utilizing on-site and archived data on weather conditions and plant injury symptom development. The picture archive began to be developed during Summer 2005 using video cameras that are permanently mounted for the growing season inside the open-top chambers and focused on a plant (and a specific leaf or set of leaves). Once the teachers are trained to utilize these data sets appropriately, they will be able to access the data during the school year through the Learning Center website and conduct the same analysis with their students in their classroom during the school year. This use of archival information is important because the school year does not coincide with optimum times for observing air pollution symptoms on vigorously growing field-grown plants in Pennsylvania (which is best during the summer).

Food and Nutrition Security and Horticulture

Prem Nath*
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The world produces adequate food for everyone, but unequal distribution has created a gap between the countries that produce more food than they consume and those countries with deficit production. About 815 million people suffer from hunger and malnutrition, mostly in the developing world. By 2020, the developing world is expected to face the overwhelming challenge of a 97.5% increase in population; moreover, developing countries will face serious challenges with the trend of a major shift in population from rural to urban areas, where 52% of the people will live in megacities—all asking for more food, land, and infrastructure. According to the World Health Organization, an estimated 334 million children in developing countries are malnourished. In 2020, one out of every four children in these countries will still be malnourished. It is recognized that modern agriculture must diversify production and achieve sustainable higher output to supplement food security. In order to reduce pressure on cereals as well as to improve human nutrition through the consumption of other nutritious crops, diversification in cropping patterns can provide better options. The increased production and consumption of fruits and vegetables, with their wide adaptation and providers of important nutrients (especially vitamins and minerals), offer promise for the future. Fruits and vegetables as food and diet supplements are gaining momentum in most countries. In addition, recent experimental evidence has shown the growing importance of fruits and vegetables in the prevention of noncommunicable diseases. Further, horticulture would play an important role in urban and peri-urban agriculture and development.

State Partnership Program: Mississippi and Bolivia

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The National Guard State Partnership Program seeks to link the National Guards of the United States with Ministries of Defense of emerging democratic nations in cooperative activities of mutual benefit. The Program aims to enhance those connections by bringing “Hometown America” onto the international stage through personal, sustained relationships. These associations could build a “Bridge to America,” establishing and nurturing bonds of mutual understanding at the grass roots level. The focus of the program has shifted rapidly to the “citizen” aspects of the National Guard, with instruction, orientation, and personnel exchanges in areas such as economic development, small business administration, and entrepreneurship. Mississippi’s program partner is Bolivia. Mississippi State University was called upon to participate in the program by providing Subject Matter Experts. Scientists spent seven days in Bolivia working with

the Bolivian military (made up of conscripted soldiers as young as 14 years of age), the Catholic University, and local villages, advising on greenhouse vegetable production and instructing program participants on cultural practices that would benefit their communities.

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**Oral Session 28—**

**Ornamentals, Landscape & Turf Management**

**30 July 2006, 10:30–11:30 a.m.**

**Oak Alley**

**Moderator: Jeffrey Norcini**

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**Effect of Provenance on Alkalinity Tolerance of Baldcypress**

Geoffrey Denny*, Michael A. Arnold, Donita Bryan

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Seedlings from 15 open-pollinated families of *Taxodium distichum* (L.) Rich. native to the Gulf Coast, central and south Texas, and Mexico, were evaluated for growth and foliar chlorosis development on field sites in Texas with acidic to alkaline soils. Forty seedlings per family were rated for level of chlorosis, height, and trunk diameter after two growing seasons in the field. Families grown on acidic soils did not differ in chlorosis ratings. Families from Mexico and south Texas had the lowest levels of chlorosis in the field, followed by those from central Texas, and then those from the Gulf Coast. Additionally, eight of the families were subjected to a greenhouse screening experiment with four levels of KHCO₃ (0, 4, 8, 12 mM). These were evaluated for height, trunk diameter, shoot and root dry mass, and level of chlorosis and leaf necrosis. Family differences were less apparent during greenhouse screening experiments than in the field. Mexican families were significantly less chlorotic than other families at higher levels of alkalinity in the greenhouse. There was also a trend for height and shoot dry masses of western populations to be less adversely affected by higher alkalinity levels than more eastern populations.

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**Mid-season Pruning Affects Cold Tolerance of Abelia Cultivars in Central Georgia**

Matthew Chappell*, Carol Robacker

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While the recommended time to prune abelia is before spring growth initiates, the actual pruning time is often variable and dependent upon labor and plant appearance. As abelia suffers from freeze damage north of zone 8A, pruning may have an impact on the level of freeze damage. Six *Abelia* genotypes were established in replicated field plots in Griffin, Ga., in 1999. On 3–4 July 2003, half the individuals of each genotype were severely pruned (75% of growth removed). Subsequently, 80 uniform-sized stem tips were randomly collected from plants of each genotype–treatment combination once per month from Oct. 2003 through Apr. 2004. Stem sections were exposed to pre-determined temperatures ranging from −3 °C to −27 °C in a temperature bath. The number of stem sections killed in each of two replications out of four possible stem sections was recorded (0 = none dead; 4 = all dead). Data were analyzed with SAS using the Genmod procedure to acquire seasonal results as well as with PROC GLM and means separation to acquire monthly results. Using the Genmod procedure, all genotypes with the exception of *Canyon Creek* were significantly more cold tolerant in unpruned compared to pruned treatments. In this study, Dec. 2003 was the first month with temperatures below freezing at the test site. Proc GLM analysis indicated a significant difference between the pruned and unpruned treatments in Dec. 2003–Feb. 2004. Results of the Proc GLM analysis for the months of Oct. and Nov. 2003 as well as Mar. and Apr. 2004 were nonsignificant (P < 0.05) due to an absence of cold acclimation. These results indicate that mid-season pruning of *Abelia* genotypes can significantly reduce cold hardiness and lead to serious stem dieback in pruned plants.

**Planting Technique Matters in Reducing Vinca Disease in Landscapes**

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Annual vinca, *Catharanthus roseus*, is exceptionally adaptive to the summer heat and the sandy loam or clay soil in the southeastern region and provides season-long blooms once established in landscape plantings. A wide variety of colors, sizes, and applications are available for landscape use. However, diseases such as alternaria leaf spot and phytophthora leaf blight are prevalent in this region in vinca plantings. Effective disease control requires frequent fungicide application that is expensive and may pose negative effects on the environment. Proper planting techniques including date of planting, fertilization rate and ET was equally high (83% to 100%). Also, CWF had 100% survival at the two northern sites, yet no CWF plants survived past week 16 in southeastern Florida. There was no short-term home region advantage to necessitate using local *G. pulchella* ecotypes in residential or commercial landscapes. CEF and CWF performed poorly in southeastern Florida, which was probably related to excessive June rain.

**Growth, Flowering, and Survival of Gaillardia pulchella Foug. Based on Seed Source and Growing Location**

Jeffrey G. Norcini*,¹ Helen E. Danielson², Sandra B. Wilson¹, Rick Schoelhorn³, Deborah L. Miller⁴

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Containerized *Gaillardia pulchella* Foug. derived from seed of natural populations in east Texas (ET), northeast Florida (NEF), central west Florida (CWF), central east Florida (CEF), and southeast Florida (SEF) were transplanted in early April to field sites located in northwestern, northern central, and southeastern Florida. During the 22-week study, plants were irrigated only during the first 2 weeks after transplanting to aid establishment. Plant growth was assessed by calculating growth indices (GI, a gauge of plant size based on height and width) at first and second flowering peaks, and by recording shoot dry weight at first flowering peak. Growth index varied among ecotypes and sites but ecotype × site was nonsignificant. At 22 weeks, NEF and ET had GIs about 18% larger than CEF or SEF. Plants grew more at the two northern sites than in southeastern Florida, which was probably due to the loamy soils at the northern sites. Averaged over the entire study, visual ratings of vigor, flowering, and quality varied by ecotype; ecotype × site interactions were nonsignificant. All ecotypes except CEF exhibited equally high vigor, flowering, and quality. Plants in southeastern Florida had lower vigor and flowering ratings than those at the two northern sites. Survival varied by ecotype and site, and ecotype × site was significant. Within a site, survival of NEF, SEF, and ET was equally high (83% to 100%). Also, CWF had 100% survival at the two northern sites, yet no CWF plants survived past week 16 in southeastern Florida. There was no short-term home region advantage to necessitate using local *G. pulchella* ecotypes in residential or commercial landscapes. CEF and CWF performed poorly in southeastern Florida, which was probably related to excessive June rain.
Herbicide Drift Study on White Oak Seedlings
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In 2004 and 2005, potted white oak seedlings 0.6 m in height were treated with six herbicide treatments at three concentrations, 1/4, 1/10, and 1/100x of the standard field use rate. These herbicides and their standard field use rate of active ingredient (a.i.) included 2,4-D at 1.5 kg/ha, 2,4-D + glyphosate at 0.8 kg/ha + 1 kg/ha, acetochlor + atrazine at 3.5 kg/ha, dicamba at 0.7 kg/ha, glyphosate at 1.1 kg/ha and metolachlor at 2.0 kg/ha. The seedlings were treated at three growth stages: swollen buds, leaves unfolding, and expanded leaves. A compressed air spraying chamber delivering 187 L/ha was used to apply the herbicides. After treatment, the containers were placed in an open field plot in a completely randomized design. Oak seedlings were most susceptible to herbicide injury at all concentrations, at the leaves unfolding stage. Symptoms on seedlings treated with 2,4-D and dicamba at the leaves unfolding stage included leaf cupping and rolling, leaf curling, leaf rolling downward from leaf margin, and unusual elongation at leaf tip. Glyphosate + 2,4-D applications resulted in leaf cupping, yellowing, leaf rolling downward from leaf margin and abnormal leaf tips. Glyphosate symptoms ranged from leaf yellowing and browning, to slight browning of interveinal leaf tissues. Acetochlor + atrazine, or metolachlor alone caused the abnormality, referred to as “leaf tatters” where in severe cases, only the main veins are present with limited amounts of interveinal tissues. Detailed description of the injury symptoms, supplemented with photographs are posted on a web site: http://www.nres.uiuc.edu/research/herbicide_research/index.htm

Can Sunn Hemp Decrease Nitrogen Fertilizer Requirements of Vegetable Crops in the Southeastern United States?
Laura Avila1, Johannes Scholberg2, Nancy Roe1, Corey Cherr1
1University of Florida, School of Natural Resources and Environment; 2University of Florida, Agronomy; 1Farming System Research, Research

Increased dependency of conventional agriculture on inorganic fertilizers and fossil fuels may hamper long-term sustainability of agricultural production. Sunhemp (Crotalaria juncea) was tested during summer in a Community Supported Agriculture vegetable crop operation located in Southeast Florida. From 2003 to 2005, farm system components included sunhemp (SH) vs. a conventional fallow during summer, tomato (Lycopersicon esculentum) and pepper (Capsicum annuum) during winter and spring sweet corn (Zea mays). Tomato and pepper were fertilized with 0, 67, 133, 200 kg N/ha (2003) vs. 0, 100, 200 kg N/ha (2004/05). Sweet corn received 133 or 200 kg N ha (2003) vs. 100 kg N/ha (2004/05). Average SH biomass was 3.7 Mg/ha. In 2003 tomato yields following SH without supplemental N were similar to fallow, with 200 kg N/ha. By the third year, tomato and pepper yields in SH plots were 25% and 26% higher, respectively. Conventional pepper amended with 200 kg N/ha had only 8% higher yields than treatments amended with 100 kg N and CC. Overall, sweet corn had low yields, but yields increased if the preceding tomato/pepper crop received higher N rates. In 2003, sweet corn fertilized with 200 kg N/ha following a SH-fall vegetable crop produced 17% higher marketable yields compared to the fallow treatment. During 2004 and 2005, sweet corn within the SH-non-fertilized tomato system produced 29% higher yields compared to a similar conventional system. Results show that, in this rotation, both fall vegetable crops and sweet corn yield benefit from residual N fertilizer. Mineralization of SH may thus not only benefit the immediately following crop, but its effects can be seen later during the year.

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by plastic mulch on the timing of appearance of first TSW symptoms, vegetative top fresh weight (FW) and fruit FW in tomato. Under natural TSW infection as well as in artificially inoculated plants, vegetative top FW and fruit FW were both linearly related with number of days after transplanting (DAT) the plants were free from TSW symptoms. The plants grown on black mulch during the fall showed earlier appearance of TSW symptoms, and had significantly reduced vegetative growth and fruit yields. The mean RZT during the first 42 DAT—the time before the plants reached full canopy closure—significantly affected the timing of first appearance of TSW symptoms, tomato plant growth and fruit yield. Vegetative top FW (optimal RZT = 24.1 °C) and fruit FW (26.9 °C) fitted the quadratic relationships with the mean RZT during the first 42 DAT. In conclusion, utilization of plastic mulches that created conditions of RZT stress, particularly heat stress, resulted in reduced plant growth and yield and may predispose the plants to earlier expression of TSW symptoms compared to plants grown under RZTs more favorable to tomato plant growth.

Are Optical Tools Suitable to Manage Phosphate and Potassium Fertilization in Tomato Crops?
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Several experiments on multispectral radiometer showed its suitability in driving nitrogen fertilization in tomato crop. Nitrogen light ratio describes crop nitrogen status well, highlighting element deficiency or excess, which is a great help to farmers in choosing timing and intensity of fertilizer application. The scientific literature reports several studies about nitrogen management only, but not phosphorus and potassium. Because of the advantage obtained with N, it would be desirable to also adapt it to phosphorus and potassium management. For this purpose, a preliminary trial was carried out on the tomato cultivar Brigade grown in pots in a greenhouse. Four nutrient solution were supplied. Three were lacking in N, P, or K—the last had all elements needed for a balanced growth. Radiometer readings were taken once a week during the crop cycle, around noon. First results were encouraging. After some data elaboration, it appeared evident that an early divergence in the genus.”

Recent Developments in Primer Design for DNA Markers in Higher Plants
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Primers design is a critical step in the application of PCR-based technologies in genetic diversity analysis of horticultural plants. As more plant genomes have been sequenced in recent years, the emphasis of primer design strategy has shifted to genome-wide and high-throughput direction. This poster summarizes recent advances in primer design for profiling of DNA polymorphism in higher plants, including new primers for the classical plant DNA marker system such as simple sequence repeat (SSR) and single-nucleotide polymorphism (SNPs), as well as newly developed DNA marker systems such as sequence-related amplified polymorphism (SRAP), sequence-specific amplification polymorphism (SSAP), target region amplification polymorphism (TRAP), and universal rice primer (URP). Although most of these primers were designed for agronomical crops, they could be applied to horticultural plants because plant genomes are evolutionarily related. Also, these new primer design strategies could help horticultural researchers develop better primers specifically for profiling of polymorphism in a variety of horticultural crops, invasive weeds, or medicinal plants. We will present examples of their utilization in these diverse systems.

Construction of Antisense ACC Oxidase Gene of Lilium and its Genetic Transformation
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The enzyme ACC oxidase (ACO), encoded by a small multigene family in many plants, catalyzes the terminal step in the ethylene biosynthesis pathway. In this research, based on the total RNA isolated from the flowers of Asia hybrids ‘Pollyanna’ and Oriental hybrids ‘Sorbonne’, we obtained two cDNA fragments of ACO genes (Genbank accession DQ062133 and DQ062134) by RT-PCR technique. The two cDNA fragments were reversely inserted into plant expression vector pWR306 respectively, and constructed two antisense ACO gene expression binary vectors harboring hygromycin phosphotransferase (hptII), glucuronidase (uidA), and a green fluorescent protein (GFP) gene in the T-DNA region. We have developed a system to produce transgenic plants in Lilium via Agrobacterium tumefaciens-mediated transformation of calli. Transformants were subjected to GFP expression analysis, PCR assay, and Southern hybridization to confirm gene integration.
Gene identification and characterization can be utilized for the identification of respective functions and their relationship to flesh color inheritance. Phytoene synthase (PSY), which converts two molecules of GGPP into phytoene, is the first committed step of the pathway. Previous phylogenetic analysis of PSY has indicated that PSY duplication is common in Poaceae, but rare in dicots. Degenerate PCR and RACE were used for PSY cloning. Three members of PSY gene family (PSY-A, PSY-B and PSY-C) were identified. PSY-A shared higher identity with PSY-C than PSY-B. PSY-C shared 96% identity with melon PSY. PSY-C also showed a high homology with tomato PSY1, even higher than PSY-A and PSY-B. It showed a similar gene expression pattern, so we propose that PSY-C is a homologue to PSY1. RT-PCR analysis than PSY-A and PSY-B. It showed a similar gene expression pattern, the effects of girdling on shoot xylem sap mineral concentration were similar to trends in root mineral status; xylem sap from spring-girdled trees had about two times more sodium and about five times more chloride. Leaf chloride concentration measured 6 months after girdling was 74% higher in girdled trees and reached toxicity levels (0.65% vs. 0.37% dry mass, for girdled and nongirdled trees, respectively). The differences in leaf sodium, however, were nonsignificant (0.14% vs. 0.13% dry mass, for girdled and nongirdled trees, respectively). In autumn-girdled trees, the effects on leaf sodium and chloride concentration were more dramatic. Leaves from autumn-girdled trees (sampled 10 months later) had about two times more sodium and about five times more chloride in comparison to nongirdled trees (0.39% vs. 0.20% dry mass sodium and 1.02% vs. 0.22% dry mass chloride, respectively). The above results link root carbohydrate status and selective sodium chloride uptake in citrus roots. The effects on leaf sodium and chloride concentration were more dramatic. Leaves from autumn-girdled trees (sampled 10 months later) had about two times more sodium and about five times more chloride in comparison to nongirdled trees (0.39% vs. 0.20% dry mass sodium and 1.02% vs. 0.22% dry mass chloride, respectively). The above results link root carbohydrate status and selective sodium chloride uptake in citrus roots.

**Gene Expression Affecting Spider Mite Herbivory: A Comparison of Sulfur-dusted and Nondusted Grapevines**

Danielle Poor*

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Sulfur application is a common practice in viticulture fungus control. This application has been suspected to increase grape susceptibility to spider mites. We hypothesize that sulfur may initiate a pathway that increases spider mite infection. RNA was isolated from grape leaves with various sulfur applications. Evaluation of genes being expressed will allow us to determine if sulfur application is regulating grape leaf defense mechanisms.

**Genetics of the Star Mutation in Petunia ×hybrida**

Robert Griesbach*, Ron Beck

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Differences in structural gene expression are responsible for a wide range of responses from human cancer to patterned flowers. Gene silencing is one of the ways in which gene expression is controlled. We have developed a model system to study gene silencing using a gene silencing mutation in Petunia ×hybrida (Star mutation) and the ability of certain viruses to reverse the silencing mutation. This model system was used to characterize how the Star flower color pattern was controlled.
Effects of 5-chloro-3-methyl-4-nitro-1H-pyrazole and Ethephon on Citrus Leaf Function and Water Relations
Kuo-Tan Li*, Jackie Burns, Luis Pozo, Jim Syvertsen
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To determine the effects of abscission compounds 5-chloro-3-methyl-4-nitro-1H-pyrazole (CMNP) and ethephon on citrus leaf function and water relations, we applied CMNP at 0, 200, 500, 1000, or 2000 ppm, or ethephon at 400 or 800 ppm, to canopies of fruiting potted and field citrus trees during the harvest season. Both compounds induced fruit and leaf drop after 3 days of application, especially at high concentrations. Low concentrations of CMNP (0, 200, or 500 ppm) or either ethephon treatments did not affect leaf photosystem II efficiency, as indicated by leaf chlorophyll fluorescence (Fv/Fm). High concentrations of CMNP (1000 or 2000 ppm) immediately reduced photosystem II efficiency in leaves and fruit peel. However, Fv/Fm of leaves remaining on the trees was gradually restored and close to the level of control after 4 days of treatment. Both compounds had little effect on chlorophyll content, ratio of chlorophyll a to chlorophyll b, leaf water content, and mid-day leaf water potential. The results suggest that CMNP at recommended concentrations (200 to 500 ppm) effectively reduced fruit attachment force with little herbicidal effect on leaves.

Yield of Citrus Trees with Foliar Urea as the Only N Source
L. Gene Albrigo*, James P. Syvertsen
University of Florida, Citrus Research and Education Center, Lake Alfred, FL, 33850

In order to evaluate possible reduced nitrate leaching while maintaining yield, ‘Hamlin’ orange and ‘Flame’ grapefruit trees on ‘Carizzo’ or ‘Swingle Citrumelo’ rootstocks were grown from planting using only foliar urea or soil-applied nitrogen or ammonium N. An intermediate treatment of foliar and ground N was included also. From the 4th year, yields were recorded for 3 years. As previously reported, canopy growth was greater for the foliar urea treatment for the first 3 years. For 2 of the next 3 bearing years, the grapefruit trees in the foliar urea N treatment produced significantly less yield than the soil-applied treatment and the intermediate treatment was intermediate. The orange trees in the foliar urea treatment produced significantly less fruit than the soil N treatment in only 1 of 3 years, but the yields were numerically less every year. Results for fruit quality and nitrate leaching will be reported also. Foliar urea application alone was more costly and less productive than a soil N program.

Citrus Bioactive Limonoid Extraction using Environment-friendly Hydrotropy
Deepak Dandekar*, G.K. Jayaprakasha, Bhimanagouda Patil
Texas A&M University, Vegetable & Fruit Improvement Center, Department of Horticultural Sciences, College Station, TX, 77843

Citrus consumption has been shown to promote human health due to presence of several bioactive compounds. In the process of understanding the health benefits of citrus, we need to isolate and characterize these compounds. Limonoids are one of such prominent, but lesser-known phytochemicals that have been shown to prevent cancers of the mouth, skin, lung, breast, and colon. With the growing interest in the health-promoting properties of citrus limonoids, the demand for these bioactives has significantly increased. It has been critical to explore environment-friendly extraction methods rather than using hazardous organic solvents. A water-based hydrotropic extraction of limonoid aglycones from sour orange (Citrus aurantium L.) seeds was developed. Two hydrotropes, sodium salicylate (Na-Sal) and sodium cumene sulfonate (Na-CuS), were studied for extraction efficiency using the Box Behnken experiment design method. The extraction efficiency of prominent aglycone limonin was observed depending on hydrotrope concentration, extraction temperature, and percentage of raw material loading. Response Surface Analysis (RSA) of data predicted the optimum conditions for maximum yield. Recovery of aglycones from filtered extract is also easily achieved by mere dilution using water at pH 3 or 7 or by partitioning the extract with dichloromethane. At optimum conditions, limonin yield of 0.46 mg/g seeds in the case of Na-Sal extraction and 0.65 mg/g seeds in the case of Na-CuS extraction was achieved. The results demonstrated that the hydrotropic extraction process of limonoid aglycones has practical commercial importance. This project is based upon work supported by the USDA-CSREES IFAFS #2001 52102 02294 and USDA-CSREES #2005-34402-14401 “Designing Foods for Health” through the Vegetable and Fruit Improvement Center.

Oral Session 32—Ornamental/Landscape/Turf/Plant Breeding/Management
30 July 2006, 2:00–3:15 p.m. Oak Alley
Moderator: Timothy Rinehart

Intergeneric Hybrids between Weigela and Diervilla (Caprifoliaceae)
Darren Touchell, Zenaida Viloria, Thomas Ranney*
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Weigela Thunb. consists of 12 species distributed throughout Northeast Asia. Diervilla Mill. is a closely related genus containing three species endemic to North America. Taxa from both of these genera are important nursery crops. Hybrids between these genera could potentially combine the excellent cold hardiness and adaptability of Diervilla with diverse forms, foliage colors, and flower colors found in Weigela. Prior attempts to create intergeneric hybrids between these genera were unsuccessful and resulted in embryo abortion before seeds matured. To overcome this barrier, ovule culture and micropropagation procedures were used to develop intergeneric hybrids. Cleaved amplified polymorphic sequences (CAPS) analysis was used to verify hybrids. Intergeneric crosses, D. lonicera × W. middendorfiana, D. sessilifolia × W. florida (two clones), and D. lonicera × W. florida were attempted. Crosses of D. lonicera × W. middendorfiana did not produce viable hybrids. From the remaining three crosses, a total of 544 plants were obtained from 1278 ovules. About 85% of the 544 plants appeared very chlorotic or had low vigor, and senesced when transferred to multiplication medium. Only 80 of the 544 plants were successfully maintained in tissue culture, of which 10 have been successfully transferred ex vitro. CAPS analysis indicated that a majority of these plants were hybrids. Further studies are focused on improving tissue culture procedures and other methods to develop tetraploids to increase plantlet vigor and fertility.

Using SSR Markers to Verify Crapemyrtle Hybrids
Tim Rinehart*, 1, Brian Scheffler2
1 USDA-ARS, Southern Horticultural Laboratory, Poplarville, MS, 39470; 2 USDA-ARS, MSA Genomics Laboratory, JWDSRC, Stoneville, MS, 38776

Crapemyrtles (Lagerstroemia) are deciduous shrubs or trees with prolific summer flowers. Their popularity is due in large part to low maintenance requirements in sunny climates, wide range of growth habits, disease resistance, and bark characteristics, as well as having a long flowering period (up to 120 days). Once well-established, they are extremely tolerant to heat and drought. Lagerstroemia was first introduced to the southern U.S. from southeast Asia more than 150 years ago, and is comprised of at least 80 known species. Most modern cultivars are L. indica and L. fauriei hybrids. L. speciosa is a tropical crapemyrtle with very large flowers, but lacks cold hardiness. It is a vigorous plant, but only when grown in Hardiness zones 9 or 10. We recently established microsatellite markers for Lagerstroemia and evaluated their utility for verifying interspecific hybrids. Here we verify F1 hybrids between L. indica ‘Tonto’, ‘Red River’, and L. speciosa. We also genotyped two commercially available L. speciosa hybrids. Currently, we are using crapemyrtle SSRs for cultivar identification and germplasm conservation. Future research includes marker-assisted breeding to produce powdery
Determining Water Use and Crop Coefficients in Five Woody Ornamental Plants

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Relatively little work has been done to determine the water requirements of ornamental plants. To meet this need, five woody ornamental species including Abelia grandiflora ‘Edwards Goucher’, Buddleia davidii ‘Burgundy’, Ilex vomitoria ‘Pride of Houston’, Euonymus japonica, and Nerium oleander ‘Hardy Pink’ were investigated to determine their water use and crop coefficients. Parallel experiments were conducted by growing the shrubs both in 56-L (15 gal) drainage lysimeters and in aboveground 10-L containers. Water use per plant, crop coefficients, and overall growth parameters differed by species and culture system. Of the five species tested, Buddleia and Nerium had higher water use per plant in the lysimeters than in the containers. There was no significant difference in water use per plant for Abelia, Euonymus, and Ilex between the two culture systems. Crop coefficients and growth indices of Abelia, Euonymus, and Ilex were statistically similar between the two systems. The growth index of Buddleia and Nerium was much higher in the lysimeters than in the containers. Abelia and Euonymus had more growth in the containers than in the lysimeters while Ilex had slightly larger leaf area in the lysimeters than in the containers. The culture system did not affect the water use per unit leaf area of all species. Therefore, our results indicated that by quantifying the leaf area, the plant water use in the two culture systems is convertible.

Irrigation Requirements and Drought Response of Two Ornamental Grass Species

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Water use is the most important environmental issue facing the horticulture industry. As a result, many water management districts are recommending native plants for their putative low-water requirements. Numerous textbooks and trade journals claim native plants use less water than non-natives; however, previous research found no difference in water use efficiency in the field between native and non-native species. Furthermore, recommendations of ornamental grasses for use as low-maintenance and low-water-requiring landscape plants have recently escalated. This study evaluated non-native Miscanthus sinensis ‘Adagio’ and the native Eragrostis spectabilis for irrigation requirements and drought response in a landscape setting. To simulate maximum stress, both species were planted into field plots in an open-sided, clear polyethylene covered shelter. Each species was irrigated on alternating days at 0, 0.25, 0.5, or 0.75 L for a 90-day period. Growth index and height were recorded at biweekly intervals, and final shoot and root dry masses were taken at completion of the study. Significant treatment and species effects were found for height, growth index, shoot dry weight, and biomass. Plants receiving 0.75 L of irrigation had the greatest growth, and non-irrigated plants grew significantly less. Comparisons between species found growth was greatest among Eragrostis spectabilis plants for all parameters.

Drought Stress and Recovery in Green Ash

Greg Litus*, James Klett
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During Summer 2005, green ash (Fraxinus pennsylvanica ‘Patomore’) trees planted at the Colorado State University Agricultural Research Development and Education Center in 1996 were exposed to simulated drought by restricting irrigation for 33 to 41 days. During this period, predawn leaf water potentials in drought-stressed trees progressively dropped to a low of –2.04 MPa, while the control plot was maintained with full irrigation such that predawn leaf water potentials did not fall below –0.5 MPa. On 24 Aug. 2005, 31 days into this drought cycle, mid-day leaf water potentials and stomatal conductance were measured at –3.0 MPa and 22.63 mmol·m⁻²·s⁻¹, respectively. Measurements in control trees collected at about the same time were –2.0 MPa and 169 mmol·m⁻²·s⁻¹. The dramatic reduction in stomatal conductance in the drought-stressed trees began at about 10:30 a.m. and continued into the evening. Once irrigation was resumed, drought stressed trees rebounded from depressed predawn leaf water potentials and mid-day leaf water potentials and stomatal conductance and reached levels similar to control trees in 2 to 5 days. Stem flow gauges indicate that, during this period, fully hydrated control trees used about 250 liters/day.

Mechanism of Up-regulation of Starch Synthesis in Mature Leaves of Transgenic Apple Trees with Decreased Sorbitol Synthesis

Rui Zhou1, Lailiang Cheng*,1 Abhaya Dandekar2
1Cornell University, Horticulture, Ithaca, NY, 14853; 2University of California, Plant Science, Davis, CA, 95616

The reaction catalyzed by ADP-glucose pyrophosphorylase (AGPase) to form ADP-glucose is a regulatory and rate-limiting step in starch synthesis in plants. In response to decreased sorbitol synthesis, starch synthesis was up-regulated in the transgenic apple plants. In this study, we examined both redox and metabolite regulation of AGPase to understand the mechanism responsible for the up-regulation of starch synthesis. No difference in the monomerization/dimerization of apple leaf AGPase small subunits was observed between the transgenic plants and the untransformed control. NADP-dependent malate dehydrogenase, indicative of chloroplastic redox status, did not show significant change in the transgenic plants either. Determination of key metabolites with nonaqueous fractionation indicated that concentrations of hexose phosphates (mainly glucose-6-phosphate and fructose-6-phosphate) were higher in both the cytosol and chloroplasts of the transgenic plants than in the control, whereas 3-phosphoglycerate (PGA) concentration in the chloroplast was not higher in the transgenic plants. We conclude that accumulation of hexose-phosphates results in a decrease in inorganic phosphate (Pi) concentration and an increase in PGA/Pi ratio in the chloroplast, leading to up-regulation of starch synthesis via activating AGPase.

Regulation of Starch Degradation in Mature Leaves of Transgenic Apple Trees with Decreased Sorbitol Synthesis

Rui Zhou*, Lailiang Cheng1, Abhaya Dandekar2
1Cornell University, Horticulture, Ithaca, NY, 14853; 2University of California, Plant Science, Davis, CA, 95616

Considering starch synthesis was enhanced in leaves of transgenic apple trees with decreased sorbitol synthesis, we hypothesized that starch degradation must be up-regulated correspondingly to maintain carbon supply to sink tissues. Compared with the untransformed control, mature leaves of the transgenic plants had a larger drop in carbon supply to sink tissues. Compared with the untransformed control, mature leaves of the transgenic plants had a larger drop in carbon supply to sink tissues.
leaves to study the fate of starch breakdown products in the synthesis of sorbitol and sucrose. Under light, a larger proportion of both 14C-maltose and 14C-glucose were converted to sorbitol than to sucrose in the untransformed control, whereas conversion of 14C-maltose and 14C-glucose to sucrose predominated over that to sorbitol in the transgenic apple leaves. The leaf samples fed with 14C-maltose and 14C-glucose in the dark are still being analyzed, but it appears that sucrose is the main product in both the untransformed control and the transgenic plants. These results support the hypothesis that starch degradation is up-regulated in the transgenic plants.

**Yield, PFD Interception, and Crop Load Relationships in ‘Royal Gala’ Apples**

Victor Garcia de Cortazar*1, Gabino Reginato2

1Universidad de Chile, Ingenieria y Suelos, Santiago, Chile; 2Universidad de Chile, Producción Agropecuaria, Chile

Three different parameters were tested to estimate yield in ‘Royal Gala’ apples. These are: a) parameters related to crop load—fruits per tree, fruits per cm² of branch cross-sectional area, and fruits per hectare; b) parameters related with PFD interception: average fraction of PFD intercepted, total PFD intercepted during the season; and c) combination of the parameters a) and b). The data set was composed of measurements of PFD interception once a month and of yield components on various commercial apple orchards of the variety ‘Royal Gala’ in the central zone of Chile between 2003 and 2006. The orchards were managed for high production, but there were differences of plantation distance, age, and size between them. Also, inside the orchard there were differences between trees. For the trees studied, there were variations of a factor of 10 for crop load, branch cross-sectional area, and tree size estimated as fractional interception of PFD at the beginning of the season. In spite of the big differences between trees, simple equations were fitted between yield and load parameters with coefficients of determination >0.95. Research funded by FONDECYT-Chile grant 1930695.

**Observations on the Relationship Between Crop Load and Return Bloom in ‘Honeycrisp’ Apple**

Philip G. Schwallier*1, Paolo Sabbatini2, Martin J. Bukovac2

1Michigan State University, Department of Horticulture, Clarksville Horticultural Experiment Station, Portland, MI, 48815; 2Michigan State University, Horticulture, East Lansing, MI, 48823

The ‘Honeycrisp’ apple has unique characteristics favored by consumers that has provided exceptional return to growers. This cultivar also has some traits that challenge plant management. There appears to be a strong inhibitory effect of crop load on flower initiation and thus annual cropping. We studied the relationship between fruit load, established by post-bloom hand and chemical thinning, and effect of ethephon and gibberellin (GA₃) on flower initiation and thereby annual cropping. Initially, return bloom (RB) was related to previous season’s crop load in three thinning studies on 3- and 9-year-old ‘Honeycrisp’ / M 9, Pajam 1 trees. The RB density was rated 1–10 on trees (n=172), which produced 0-60 kg of fruit/tree. Return bloom ratings (RBR) on the 3-year-old trees ranged from 0–9. Percentage of trees with RBR >5 for previous season’s yield of <5 kg, 5–10, 10–15, and 15–20 was 70, 2, 2.5, and 0, respectively. There was dramatic inhibition of flowering at a crop load of >5 kg/tree. In the second study (9-year-old trees), crop load ranged from 15–60 kg/tree (n=24). RB for trees in the 30–40 kg/tree class ranged from 0–8 with high variability. Thirty-one percent of trees with crop load between 20–30 kg had RBR of 5–8, and 26% between 0–5. Twenty-one percent of trees in the 30–40 kg/tree class flowered and all but one had a RBR of 5 or less. Yields ranged from 22–81 kg/tree in the third study (n=60); crop load was normally distributed among trees. Flower initiation was almost completely inhibited. Fifty percent of the trees did not flower; the remainder had a RBR of <1, i.e. <10%. In the ethephon/GA Study, RBR ranged 8–10 on trees producing <12 kg/tree, then decreased rapidly to <2 for yields of 25–50; greatest variation at 20–40 kg.

**Effect of Varying Crop Load on Leaf Photosynthesis and Carbon Isotope Discrimination of ‘Imperial Gala’ Apple Tree**

Paolo Sabbatini*, James Flore

Michigan State University, Horticulture, Plant and Soil Science Bldg., East Lansing, MI

Crop load (CL) is a critical regulator of production and quality on apple. It affects leaf photosynthetic rate and usually an increase is detected in leaves close to developing sinks. The objective of this work was to test if 13C discrimination during photosynthesis could be an indicator of carbon sink limitation. The natural plant carbon isotope composition (δ13C/δ12C ratio: d13C) is an indicator of water use efficiency and it is an effective tool to study environmental stresses in plants. Seven-year-old trees of Imperial Gala/Bud 9 (n=30), field-grown at the Clarksville Horticultural Research Station in Michigan, were hand-thinned to five levels of CL manipulating the leaf to fruit ratio (LFR: 4, 8, 16, 32, 64) after June drop. Net photosynthetic rate (A) of leaves was monitored daily during the season and elevated rates were observed in low LFR. The A was inhibited in low CL trees (LFR 32 and 64) more in the morning (from 20% to 42% in relation to normal CL: LFR 16) than in the morning (from 5% to 20%), and stomatal conductance declined over the afternoon. Shoot and fruit growth were affected (fruit size –11/+11%, shoot length +13/+18% from normal CL; LFR 16). Variations of the stable carbon isotope composition of leaves show a significant reduction of 13C discrimination in low CL trees (~3.2%; d13C –25.82) and an increase of 13C discrimination (+2.7%; d13C –27.38) in relation to normal CL trees (LFR 15.63). The results were similar to those reported in 2004, which imply isotopic discrimination in relation to source limitation. This is the opposite of what you would expect under water stress conditions. Although trees were well-watered during the season, the effect of water stress on apple trees and its interaction with source limitation will be discussed.

**Modeling Fruit Tree Architectural Growth, Source–Sink Interactions, and Physiology with L-PEACH**

Ted M. DeJong*, 1 Romeo Favreau1, Mitch Allen1, Przemyslaw Prusinkiewicz2

1University of California, Davis, Plant Sciences, Davis, CA, 95616; 2University of Calgary, Computer Science, Canada

Modeling source–sink interactions and carbohydrate partitioning in plants requires a detailed model of plant architectural development, in which growth and function of each organ is modeled individually and carbohydrate transport among organs is modeled dynamically. L-PEACH is an L-system-based graphical simulation model that combines supply/demand concepts of carbon partitioning with an L-system model of tree architecture to create a distributed supply/demand system of carbon allocation within a growing tree. The whole plant is modeled as a branching network of sources and sinks, connected by conductive elements. An analogy to an electric network is used to calculate the flow and partitioning of carbohydrates between the individual components. The model can simulate multiple years of tree growth and be used to demonstrate effects of irrigation, crop load, and pruning on architectural development, tree growth, and carbon partitioning. Qualitative model outputs are viewed graphically as the tree “grows” on the computer screen while quantitative output data can be evaluated individually for each organ or collectively for an organ type using the MatLab software.

**The Photoperiod Pathway in Fragaria (Rosaceae)**

Philip J. Stewart*, Ashley R. Winslow, Kevin M. Foltz

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The transition from vegetative growth to reproductive growth is carefully controlled by a number of independent signal transduction systems, one of which interprets photoperiod. Photoperiodic control of flowering time has been well-described in Arabidopsis and rice,
revealing the presence of a generally common network of regulatory proteins. Timely and appropriate progression to flowering is critical to profitable production of cultivated strawberry (*Fragaria x ananassa*), a species that includes long-day, short-day, and day-neutral cultivars. In an effort to characterize the photoperiodic flowering control mechanism in strawberry, the *Fragaria* orthologs of the photoperiod pathway genes were cloned and sequenced. Strawberry versions of *Constans, Constans-like, Leafy, Flowering Locus T*, and *Suppressor of Constans Overexpression 1* were identified by screening cDNA libraries and through degenerate PCR approaches. Expression of these transcripts in short-day and day-neutral cultivars was tested under long and short photoperiods. Functional complementation of Arabidopsis mutants was performed where appropriate, alleles were identified, genetic linkage was determined where possible, and relationships between the strawberry genes and homologs from other species were studied. These trials define the mechanistic elements of an agriculturally important pathway in this valuable crop, and lays the foundation for transgenic studies in strawberry to manipulate the floral transition.

**Oral Session 34—**

**Viticulture and Small Fruit—Culture & Management**

30 July 2006, 2:00–4:00 p.m.  
Edgewood A/B

Moderator: Fumiomi Takeda

**Spatial Variability of Grape Yield and Quality: Using GIS as a Precision Viticulture Tool to Optimize Vine Yield and Quality**  
Said Ennahli*, Sorkel Kadir  
Kansas State University, Horticulture, Forestry, and Recreation Resources

Variability due to soil types, topography, and climate within a vineyard influences grapevine physiological parameters and fruit quality. Technical feasibility of using precision Geographic Information System (GIS) as a viticulture tool to improve vineyard management and increase wine quality will be investigated. The study was conducted in an experimental vineyard where rows consist of plots with 24 cultivars and selections randomly planted and managed similarly. Monitored vineyard parameters collected by Global Positioning System (GPS) location include soil characteristics, soil moisture, vine growth, crop load, and fruit characteristics. Geospatial maps are used to differentiate yield between the cultivars and selections as high, medium, or low. Production was determined from each variety/selection within the vineyard. Yield parameters were number of clusters, cluster weight, and weight of 50 berries; fruit composition (such as pH), titratable acidity, soluble solids concentration, and anthocyanins were measured. Maps for each factor will be derived via GIS tools and spatial analysis will be conducted to assess which spatial variability factor has more effect on grapevine physiology, yield, and fruit quality. This type of analysis can be used by grape growers to achieve specific vine characteristics in a large or small vineyard by controlling all sources of variability, leading to the ability to perform precision viticulture in the future, with low cost.

**Effect of Cropload on Eastern European Grapevine Cultivars**

Joseph Masabni*, S. Kaan Kurttural, Dwight Wolfe, Chris Smigell  
University of Kentucky, Horticulture, Lexington, KY, 40546-0091

The effect of cropload (kg yield/kg pruning weight) on yield components and fruit composition of 17 eastern European grapevine cultivars was evaluated from 2000 to 2004 in a vineyard, at the research station in western Kentucky, characterized by a long and warm season. There was a cubic relationship between number of clusters retained per vine and the cropload ($R^2 = 0.6374$, $P < 0.0001$). Similar relationship was evident between yield per vine and cropload ($R^2 = 0.5908$, $P < 0.0001$). Of the observed variation in cluster weight, 28% was attributed to variation among predictions, based on the value of cropload in a quadratic relationship ($P < 0.0001$). As cropload increased, pruning weight per meter of row decreased ($R^2 = 0.4513$, $P < 0.0001$). However, there was very little effect of cropload on the percentage of total soluble solids and juice pH measured at harvest. Optimum cropload values fell in between 13–18 (kg yield/kg pruning weight) depending upon cultivar evaluated, based on optimum ranges for pruning weight per meter of row for optimum vine balance in the lower Midwest.

**Physiological Responses of Three Grapevine Cultivars to Partial Root Drying**

Said Ennahli*, Sorkel Kadir  
Kansas State University, Horticulture, Forestry, and Recreation Resources

Partial root-zone drying (PRD) irrigation management has been developed for grapevines as an efficient method to control excessive growth, improve fruit quality, and save water without compromising yield. PRD is based on knowledge of the mechanisms that control transpiration and requires slow dehydration of half of the plant root system, whereas the other half is irrigated. A study was conducted in the field to evaluate the effect of PRD on physiological characteristics, growth, yield, and fruit quality of three grape cultivars. The wetting and drying cycle of the PRD-vine root system is alternated on a 10–14 day schedule. Significant reduction in vigor was observed in treated plants compared with control plants. Root biomass was not affected, but fine roots significantly increased in PRD-treated plants, compared with that of the control. This contributed to the ability of PRD-treated plants to maintain leaf water potential similar to that of the control. Stomatal conductance of PRD plants was significantly reduced when compared with that of the control plants. Abscisic acid (ABA) concentration in leaves of PRD vines increased significantly when compared to the control vines. PRD treatment significantly increased yield and fruit quality when compared with the control treatment. PRD significantly increased water use efficiency (pruning weight per unit of water applied). This study shows that PRD stimulated ABA production in the drying roots, which caused reduction in stomatal conductance and transpiration rate, leading to a substantial reduction in vegetative growth without compromising yield and fruit quality.

**A Winter Protection Method for Blackberries**

Fumiomi Takeda*, David Handley  
1USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV, 25430; 2University of Maine, Agricultural Research Center, Monmouth, ME, 04259

A combination of simple cultural practices, a modified rotatable cross-arm (RCA) trellis system, and covering plants with insulation material in winter overcame the lack of cold hardiness in trailing blackberries that have been established at Kearneysville, W.Va. After tying canes to trellis wires and rotating the cross-arms to below horizontal, tied canes were close to the ground, allowing them to be covered with protective materials, such as floating rowcover and polyethylene plastic during winter. Covers were removed in early spring and the canes remained in the horizontal orientation until bloom, which promoted flowering laterals to grow upright. After bloom, the cross-arm was rotated beyond vertical to position the fruit on one side of the row and improve harvest efficiency. In Jan. and Feb. 2005, the daily minimum temperatures under the FRC+PE covers were about 3 °C higher than in the open. The covers also provided protection against the wind. Tissue damage in protected trailing blackberries was significantly less than for unprotected plants. ‘Siskiyou’ plants in covered plots produced 3 to 5 times more fruit than plants in the open. Harvesting of ‘Siskiyou’ fruit occurred during the red raspberry harvest season or 2 to 3 weeks earlier than for eastern blackberries. Our findings suggest that trailing blackberries can grow satisfactorily and produce fruit if the adverse effect of low temperatures and winds is mitigated with our trellis system and winter protection method. If practical cultural techniques for improving their winter survival become available, there is a potential for early-season high-quality blackberry production in the mid-Atlantic coast region.
Pre-plant Dipping of Strawberry Transplants for Control of Colletotrichum acutatum
Oleg Daugovish1*, Doug Gubler2
1University of California, UCCE, Ventura, CA, 93003; 2University of California, Plant Pathology, Davis, CA, 95616

Strawberry anthracnose caused by Colletotrichum acutatum may kill strawberry plants or reduce plant vigor and marketable yield, resulting in multimillion dollar losses to strawberry industry. The fungus is often carried with transplants from nurseries to production fields undetected. The studies in one summer and two winter seasons near Oxnard, Calif., evaluated 30-second pre-plant dipping in ten fungicide solutions or water washing of transplants inoculated with C. acutatum as a means of reducing infection and improving fruit yield. In summer-plantilled ‘Baeza,’ the pathogen caused severe die-back and reduced marketable fruit yield 89% in inoculated, untreated controls compared to non-inoculated plants while plants dipped in Switch (cyprodinil + fludioxonil) at 0.38 g/L had 33% yield reduction. Other fungicides provided even less protection, resulting in 53% to 89% yield losses. During cooler winter seasons the pathogen remained latent and lesions appeared on ‘Camarosa’ when the day-night air temperatures reached 16 °C or more, 7–14 days after rain. None of the treatments reduced fruit fungicides only 3% had C. acutatum symptoms (including early die-back) as opposed to 26% in inoculated, untreated controls. Plants dipped in Switch, Quadris (azoxystrobin), or Pristine (pyraclostrobin + boscalid) yielded similar to non-inoculated, untreated controls in 2003 and 10% to 12% more in 2005. These studies showed that strobilurin fungicides did not prevent fruit infection (indicating need for foliar spraying). Results for the 2005 treatments will also be presented.

Drip Irrigation Configuration Influences Growth in Young Highbush Blueberries
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A study was done to determine the effects of irrigation with different drip configurations on growth of newly planted highbush blueberries (Vaccinium corymbosum L. ‘Duke’). Plants were grown on raised beds mulched with sawdust. Different configurations included two laterals of drip tubing placed on the soil surface on each side of the plants, two laterals buried 0.1 m deep on each side of the plants, and one lateral suspended 1.2 m above the plants. Each treatment was irrigated three times per week (when needed) with enough water to replace 100% of the estimated crop evapotranspiration requirements. During the first 2 years after planting, plants irrigated by buried drip were larger and produced significantly more whips than those irrigated by drip placed at the soil surface. The size and whip number of those irrigated by suspended drip were intermediate. Subsurface drip eliminated water runoff and bed erosion observed with both surface drip configurations. It also maintained lower soil water content near the plant crown. Since plants tested positive for phytophthora and pythium root rot, lower soil water content may have reduced problems with the disease. As plants mature, the next objective will be to determine the effects of each drip configuration on fruit production.

Suppression of Flowering in ‘Bluecrop’ Highbush Blueberry
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Precocious varieties of highbush blueberry may over-crop during the first few seasons in the fruiting field, adversely affecting plant establishment. Reducing or preventing bloom in the nursery and during establishment would be beneficial in preventing early cropping and reducing the risk of infection by pollen-borne viruses. We investigated the efficacy of foliar applications of ProVide® (Valent BioSciences), a commercial GA4,7 formulation, for suppressing flower bud initiation in blueberry. One-year-old rooted cuttings of ‘Bluecrop’ were obtained from a commercial nursery and established in 11-L pots at the Blueberry and Cranberry Research Center, Chatsworth, N.J. Dilute foliar applications of ProVide® were made at concentrations ranging from 50 to 400 mg L-1 a.i., ranging from 7 July to 1 Sept., 2004, with 10 replicate plants per treatment. Floral and vegetative buds were counted the following spring. A separate experiment was initiated in 2005, with concentrations of 200 and 400 mg L-1 a.i. applied in August and September. For the 2004 study, the greatest flower bud suppression resulted from repeat applications at 400 mg L-1 a.i. Weekly applications from 7 July to 1 Sept. resulted in a 70% reduction in flower bud number, whereas three weekly applications from 18 Aug. to 1 Sept. reduced flower bud number by >80%. Neither treatment significantly reduced total bud numbers (vegetative + floral) compared to untreated and water-sprayed controls, indicating that the treatments did not reduce plant growth. Results for the 2005 treatments will also be presented.

Evaluating Hornfaced Bees (Osmia cornifrons) as Pollinators of Highbush Blueberry
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The objective of this study was to investigate the use of hornfaced bees (Osmia cornifrons Radoszkowski) as a successful sustainable alternative for pollination of commercial highbush blueberry (Vaccinium corymbosum L.). The hornfaced bee is native to Japan and introduced to the United States in 1977 by the USDA. Hornfaced bees have been shown to be 300× more efficient in pollinating apples than honey bees. Hornfaced bees are active for 4–6 weeks (April to June), and then the adults die. The rest of the year (10 months), dormant hornfaced bees exist inside nest cells located in cardboard straw stored away from berry production areas. Currently, there are no reports on hornfaced bee use available for blueberry farmers. Five pollinator treatments were compared in 2005 including: hornfaced bees; honey bees; bumble bees; natural pollinators; and no pollinators. Enclosed pollination cages were constructed around mature field-grown highbush blueberry plants to prevent mixing of pollinator treatments. Each cage contained a single pollinator treatment except for the natural pollinator treatment. The five pollinator treatments were replicated three times inside separate netted cages on the farm. Three branches per plant were randomly selected that had a minimum of five fruiting buds and blossom number recorded. After pollination occurred the cages were removed to allow the berries to ripen. Ripe fruit were picked weekly over the season (July to August), with the fruit from each sample being counted and weighed. Blossom number was compared to fruit number and weight to determine efficiency of pollination as a result of the pollinator treatments. The results showed that hornfaced bees pollinated blueberries as well as or better than the other pollinators.