Oral Session Abstracts

102nd Annual International Conference of the American Society for Horticultural Science Las Vegas, Nevada

Presenting authors are denoted by an astrisk (*)

Oral Session 1—Organic Horticulture

Moderator: Matthew D. Kleinhenz

18 July 2005, 2:00–4:00 p.m. Ballroom H

Weed Control in Organic Vegetable Production: The Use of Sweet Corn Transplants and Vinegar

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Weed control in organic vegetable production is a major challenge. During Summer 2004, we conducted field trials to manage weeds in organic sweet corn, carrots and onions. In sweet corn, we evaluated the efficacy of transplanting greenhouse-grown sweet corn seedlings. In carrots and onions, we tested vinegar and several concentrations of acetic acid. Studies were conducted in southwestern Minnesota at the Lamberton Research and Outreach Center and in eastern Minnesota at Foxtail Farm in Shaefer. Ten-day-old corn transplants were effective at both locations. Stand establishment was greater, less tillage was needed, and yield was greater than in the seeded plots. Straight vinegar was not very effective in controlling weed populations. Although there was greater damage to broadleaf weeds than grasses, straight vinegar did not reduce the need for tillage. Although 10% to 20% acetic acid did provide better weed control, it significantly damaged carrot and onion seedlings. These results suggest that using sweet corn transplants is time and cost effective for small acreage sweet corn production such as CSAs. Vinegar and acetic acid are problematic. Nonselectivity, potential danger in handling, and poor control at low concentrations were all considered significant disadvantages.

Fertility and Weed Management Effects on Crop Quality and Disease Variables in a Transitional-organic Processing Cabbage and Tomato System

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The influence of organic soil amendments (unamended control, composted dairy manure, or raw dairy manure) and weed treatments [critical period (CP) or no seed threshold (NST)] on diseases, growth parameters, yield, and postharvest quality was evaluated over 3 years in a transitional organic crop rotation of tomato, cabbage, clover, and wheat. More growth, yield, and postharvest quality parameters were affected by amendment treatments in cabbage than in tomato. Significant differences in yield among amendment treatments were found in 2001 and 2003 in cabbage, with higher marketable and total yields in amended vs. control plots. Soil management effects on cabbage varied annually, though amendments were required to maximize crop growth, as head weight, size, and volume and core volume of treatment plots exceeded the control plots in 2002 and 2003. Few differences were found between weed treatments, although in 2001 cabbage heads from the NST treatment were larger than heads from the CP treatment. Similar results were found in tomato in 2003. Also, the CP treatment had a higher Area Under the Disease Progress Curve than the NST treatment in tomato in 2003. Overall, disease pressure was highest in tomato in 2001. But disease levels within years were mostly unaffected by amendment treatments. In cabbage, disease was more common in 2002 than in 2003, although head rot was more prevalent in compost-amended plots in 2003 than in manure-amended or control plots. Tomato postharvest quality parameters were similar among amendment and weed treatments within each year. Soil amendment may enhance crop yield and quality in a transitional-organic system. Also, weed management strategy can alter weed populations and perhaps disease levels.

Consumer Sensory Evaluation of Organically and Conventionally Grown Spinach

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Consumers of organic food tend to believe that it tastes better than its conventional counterpart. However, there is a lack of scientific studies on sensory analysis of organic food. A consumer taste test was conducted to compare the acceptability of organically and conventionally grown spinach. Spinach samples were collected from organically and conventionally managed plots at the Kansas State University Research and Extension Center, Olathe. One hundred-twenty-two untrained panelists (80 female and 42 male) participated in this consumer study. Fresh and 1-week-old spinach leaves were evaluated by 60 and 62 consumers, respectively, using a 9-point hedonic scale (9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely). The ANOVA results showed that fresh organic spinach had a higher preference score than corresponding conventional spinach, although not at a significant level ($P = 0.1790$). For the 1-week-old spinach, the difference diminished, and instead, conventional spinach had a higher preference rating. Among 61 consumers who made comments regarding the sensory evaluation, 29 claimed that organic spinach was more tasty and flavorful; 19 consumers thought conventional spinach was better; 13 consumers could not tell the difference. Even though this consumer study did not reveal significant differences in consumer preference for organic vs. conventional spinach, further well-designed sensory tests are warranted given the trends indicated in our study. Assessment of sensory attributes of organic vegetables after storage also deserves further attention. Ideally, both consumer tests and descriptive analysis using trained panelists will be considered.

Organic Vegetable Yield and Economics Show Promise in a Mississippi Trial

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Yield, input, and economic data from research plots in central Mississippi are being used to test the economic potential of organic vegetable crop production. A six-part, multi-year rotation, including winter and summer cover crops, has been set up to generate yield, cost, and economic return data from vegetables produced in Mississippi using methods allowed by the U.S. Dept. of Agriculture National Organic Standards and accepted by local growers employing pesticide-free and other similar management methods. Data being collected include labor and input costs, yields, and market prices for harvested crops. Marketable produce is being sold through a grower-retailer at a farmer's

market. During 2004, the first full year of the rotation, 10 vegetable species were included in the plots. Pest pressure has generally been minimal. With one exception [one of two potato (*Solanum tuberosum*) cultivars failed to produce a good stand], all crops planted have produced fair to excellent yields. Crops generating high retail prices in this study include potatoes, snap beans (*Phaseolus vulgaris*), and leaf lettuce (*Lactuca sativa*). In the future, the yield and price data being generated will be combined with new and existing cost data to create enterprise and production budgets for use by perspective and existing organic vegetable growers.

Organic Transition Strategies for Vegetable Farms Near Urban Areas

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The risk : reward for a transition to organic vegetable farming near urban areas and changes in soil, crop, and economic parameters during transition are poorly understood. A 4-year study was initiated in 2003 at the Ohio State Univ.–OARDC to document the relative advantages of four transition strategies and their effects on major cropping system variables. Soil previously in a vegetable-agronomic crop rotation has been maintained fallow, planted to a mixed-species hay, used in open field vegetable production, or used in vegetable production under high tunnels, transition strategies with a range of management intensity and expected financial return. Each strategy was replicated four times within the overall experimental area. Half of the soil in each strategy unit was amended with composted dairy manure while the remaining soil was unamended. Field vegetable plots have been planted to potato, butternut squash, and green bean. High tunnels have been planted to potato, zucchini, and a fall–spring rotation of beet, swiss chard, mixed lettuce, radish, and spinach. Data describing the outcomes of the strategies in terms of farm economics, crop yield and quality, weed ecology, plant pest and disease levels, and soil characteristics (physical, chemical, biological) have been recorded. Inputs in the high tunnels have exceeded inputs in all other strategies; however, high tunnel production has widened planting and harvesting windows and increased potato yield, relative to open field production. To date, compost application has increased crop yield 30% to 230% and influenced crop quality, based on analytical and human panelist measures. Weed (emerged seedlings, seedbank) and nematode populations also continue to vary among the transition strategies.

The Effect of Several Organic Amendments on the Growth and Yield of Edible Ginger to Evaluate the Transition toward Organic Farming Production

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As many farmers transition toward organic farming, research-based information is required to determine the appropriate rates and timing for the application of available organic fertilizers. Four experiments were conducted over a 3-year period in Oahu, Hawaii, to evaluate the effect of five different organic amendments on the growth and yield of edible ginger. Fertilizer amendments, applied at a rate of 30–60 $t \cdot ha^{-1}$, included bone meal, a locally available commercial chicken manure-based compost, a commercial Bokashi compost, aged chicken manure, synthetic fertilizer (farmer's practice at 300 $kg \cdot ha^{-1}$ N), and a control. Each treatment plot consisted of a 10-m row with 15 plants per plot, and five replications per treatment. Ginger was planted in April of every year, and harvested from February to March of the following year. Data collected included soil fertility before initiation and after experiment completion, tissue nutrient levels, plant stands, plant height, and stem number, individual tops and root weight of 5–10 plants per treatment, as well as nematode counts before and after experiment completion. The data showed that similar or greater root weight yields and quality were obtained with the use of organic amendments compared to the use of synthetic fertilizer. Increased yields were obtained when organic amendment and fertilizer applications were split over the growing season. Data will be presented with regard to initial plant stands, tissue levels, and yield trends in response to the several amendments used in these experiments, and management considerations for farmers will be discussed.

Growth of Young 'Minneola' Tangelo Citrus Trees Fertilized with Banded Poultry Litter Overlaid with Wood Chips

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Soil incorporation of poultry litter can damage roots of citrus trees grown on shallow soils in southern Florida. Using an alternative application method, young 'Minneola' tangelo trees (*Citrus reticulata* Blanco × *C. paradisi* Macf.) on Cleopatra mandarin rootstock (*C. reticulata* Blanco) on bedded groves in southeast Florida were fertilized for 18 months after planting with surface-banded poultry litter (PL) overlaid with wood chips (WC). PL/WC was applied at 142, 284, and 425 $kg \cdot ha^{-1}$ N in two applications/year in one 0.6-m band within the dripline of trees planted at 278 trees/ha. Other treatments with different N rates included 220 $kg \cdot ha^{-1}$ N broadcast in the middle of the bed twice a year and 116 $kg \cdot ha^{-1}$ N as controlled release fertilizer applied within the dripline of trees in three applications per year. Eighteen months after planting, growth of trees receiving PL/WC treatments of 142, 284, and 425 $kg \cdot ha^{-1}$ N per year and 116 $kg \cdot ha^{-1}$ N per year was similar and greater than growth of trees receiving PL broadcast in grove middles at 220 $kg \cdot ha^{-1}$ N per year. Soil P, Ca, and Mg levels beneath the three banded PL/WC treatments were higher than in other treatments; in all treatments leaf N levels were optimum, but leaf P, K, Ca, Mg, and Fe levels were excessive. Banded PL/WC treatments applied at 142 $kg \cdot ha^{-1}$ N per year and even lower rates may be adequate for growth of young citrus trees, especially in terms of reducing excessive soil and leaf nutrient levels.

Tracking Papaya Pollen Movement with the GUS Transgene Marker

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Genetically engineered (GE), virus-resistant papaya cultivars in Hawaii are easily identified by a colorimetric assay for the β-glucuronidase (GUS) marker transgene. We used GUS to track pollen movement from a central 1-acre plot of gynodioecious GE 'Rainbow' plants into seeds on surrounding border rows of non-GE 'Sunrise' papaya. GUS evidence of cross-pollination occurred in 70% of female plants (43% of assayed seeds), compared with only 13% of the predominantly self-pollinating hermaphrodite plants (7% of seeds) segregating in the gynodioecious 'Sunrise' border rows. The percentage of GUS+ seeds in border row plants showed a weak negative correlation ($r = -0.32$) with distance from the nearest GE tree (30 m maximum). In a non-GE papaya field located less than a mile downwind from the 'Rainbow' source, no evidence of GUS was found in 1000 assayed seeds. In a separate study, the origin of GUS+ seed discovered in papaya fruits from an organic farm was investigated. Leaf GUS assays revealed that 70% of trees were GE, indicating that the grower had planted GE seed. The impact of pollen drift from GE trees in the same field was determined by screening seed samples from 20 non-GE hermaphrodites for GUS expression. Only three hermaphrodites (15%) showed GUS+ seeds, at low levels ranging from 3% to 6% of contaminated samples. These data indicate that the major source of GE contamination in organic fields is seeds of unverified origin, rather than pollen drift from neighboring GE fields. Organic growers are advised to: 1) plant only seed that is known to be non-GE, preferably obtained by manual self-pollination of selected non-GE hermaphrodites; 2) avoid open-pollinated seed; and 3) grow only hermaphrodite (self-pollinating) trees, removing any female or male plants from production fields.

Oral Session 2—

Water Utilization/Nutrition & Water Management

Moderator: Daniel I. Leskovar

18 July 2005, 2:00–3:45 p.m. Room 107

Physiological Responses of Apple Trees to Different Irrigation Practices

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New irrigation practices using controlled soil water deficits offer the opportunity of reducing tree vegetative growth and enhancing fruit quality without decreasing fruit size or yield. We tested partial root zone drying (*PRD*) and deficit irrigation in 'Golden Delicious' trees on M9 rootstock, at Summerland, B.C., Canada. There were four treatments: full irrigation (*100% daily ET replacement*), both sides irrigation (*50% daily ET replacement*), deficit irrigation (*1 side, 50% daily ET replacement*) and *PRD* (*alternating sides, 50% daily ET replacement*). The purpose of this study was to determine how deficit irrigation and *PRD* affect above- and below-ground physiology of apple trees where the amount of irrigation was the same. Soil water content, stem water potential, stomatal conductance and transpiration were significantly higher for deficit irrigation than *PRD* irrigation ($P < 0.05$) for both years (2003 and 2004). Root dynamics varied among years. For both years, root production was higher in trees under *PRD* than in trees under deficit irrigation. Root survivorship was significantly higher for trees exposed to *PRD* treatment than those exposed to deficit irrigation treatment in 2003 ($P < 0.0003$), but not in 2004 ($P > 0.662$). Stem growth, fruit yield, and fruit quality were generally not affected by treatments in 2003. In 2004, however, fruit yield was 37% higher in deficit irrigation than in *PRD* ($P < 0.05$). Soluble solids and sugar : acid ratio did not differ between these two treatments. For conditions where the amount of irrigation applied was the same, our results suggest that *PRD* may be less effective than deficit irrigation.

Effect of Reclaimed Water and Drought on Salt-sensitive Perennials

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Four species of salt-sensitive perennials (*Chilopsis linearis*, *Tecoma stans*, *Salvia greggii*, and *Verbena pulchella gracilior*) were grown in containers and were irrigated with potable or reclaimed water. Electrical conductivity (EC) was 0.3 $dS \cdot m^{-1}$ for potable irrigation water and 1.0 $dS \cdot m^{-1}$ for reclaimed irrigation water. After 12 weeks of growing plants with reclaimed vs. potable water, *C. linearis* leaf dry weight was reduced by 15%, *T. stans* root dry weight was reduced by 41%, *V. puchella gracilior* stem dry weight was reduced by 35%, and *S. greggii* total dry weight was reduced by 56%. The increase in canopy size was calculated 4, 8, and 12 weeks after treatments began and was not affected by water source for *C. linearis* and *T. stans*, but was reduced for *S. greggii* and *V. pulchella gracilior* treated with reclaimed water. Up to 12% dieback and reduced flowering were observed on *S. greggii* irrigated with reclaimed water. Within 4 weeks of treatments, EC in the root zone was 0.5 $dS \cdot m^{-1}$ for plants irrigated with potable water and 1.9 $dS \cdot m^{-1}$ for those irrigated with reclaimed water. When exposed to drought, *C. linearis* and *T. stans* grown with reclaimed water maintained a more negative water potential as soil moisture was depleted. Osmotic potential started to increase significantly for both irrigation treatments when more than 25% moisture from fully saturated containers were lost. In general, plants irrigated with potable water sustained more damage than those irrigated with reclaimed water after recovering from a drought cycle.

Determination of Crop Coefficients (Kc) and Water Use of Spinach and Onion

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Lysimeters are used to measure real-time water use during the growing season. By relating the water use of a specific crop to a well-watered reference crop, such as alfalfa or grass, crop coefficients (Kc) can be developed to assist in predicting accurate crop needs using available meteorological data. Reference evapotranspiration can be obtained from several weather networks; however, without crop coefficients for specific crops, this information is only useful for grass. Three weighing lysimeters, consisting of undisturbed 1.5 m × 2.0 m area by 2.2-m depth cores of soil, comprise the Texas A&M Research and Extension Center–Uvalde lysimeter facility. Two lysimeters, weighing around 15,000 kg, have been placed beneath a linear LEPA irrigation system and used in field production. A third lysimeter measures reference ET values (ETo) and is located in a grassed area near the field lysimeters irrigated by subsurface drip irrigation system. Spinach was grown in one of the two crop lysimeters while onion was grown in the second lysimeter. Daily water use was measured on 5-min intervals. Results show the possibility of saving ≈61 to 74 million m^3 of water per year in the irrigated farms of the Edwards aquifer region if proper irrigation management techniques are implemented in conjunction with the newly developed crop coefficients. Crop water requirements, Kc determination, and comparison to existing FAO Kc values will be discussed.

Deficit Irrigation and Plant Population Effects on Leaf Quality and Yield of Spinach

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A two-year experiment was conducted to determine yield, water use efficiency, and leaf quality responses to deficit irrigation and plant population of spinach (*Spinacia oleracea* L.). Three irrigation regimes were imposed with a center pivot system, 100%, 75%, and 50% crop evapotranspiration rates (ETc). Spinach seeds were planted on 11 Nov. 2003 at three plant populations: 494 (P-1), 618 (P-2), and 741 (P-3) thousand seeds/ha on cvs. DMC 16 and ASR 157, and on 15 Oct. 2004 at four plant populations: 655, 815, 988, and 1149 thousand seeds/ha on cv. DMC 16. Harvests were done on 3 Mar. 2004 and 26 Jan. 2005. In the first season, marketable yield was not reduced by deficit irrigation, but water use efficiency was significantly higher for 50% ETc compared to 100% ETc. The cv. DMC 16 had a significantly lower percentage of stem weight than ASR 157 (8.3 vs. 16.4%). The cv. ASR 157 had an excess of stem weight at 100% and 75% ETc compared to 50% ETc at P-1, but similar at P-2 and P-3. The cv. DMC 16 had a trend of reduced stem weight for P3 at 50% ETc. In the second season, marketable yield was reduced by deficit irrigation. However, water use efficiency was significantly higher for 50% ETc compared to 100% ETc, but similar to 75% ETc. Deficit irrigation also decreased the percentage of stem weight. Despite a slight increase in the percentage of of yellow leaves, but not in percentage of of stem weight, marketable yield and water use efficiency were significantly higher at 1149 thousand seeds/ha. This study showed that deficit irrigation in combination with increased plant population has the potential to increase yield and water savings, without adversely affecting leaf quality.

In Situ Probes for Direct Measurement of Substrate Soluble Salts: Effects of Substrate Moisture Content and Fertilizer Concentration

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Several probes have been been recently developed that can be inserted directly into the growing medium of container-grown crops to get electrical conductivity (EC) or pH measurements. However, for many floriculture and greenhouse crops, EC interpretation ranges are based

on substrate solution extraction methods such as the 1:2 v/v dilution, saturated media extract (SME), and more recently, the pour-through. We tested the sensitivity and accuracy of four in situ EC probes at a range of substrate moisture content and fertilizer concentrations. We also compared results from in situ probes with currently used methods of EC measurement. Concerning the effects of substrate volumetric water content (VWC) on the in situ probes, our results indicate little differences exist among probes when VWC exceeds 0.50, though drier substrates yielded differences depending on the measurement method. The SigmaProbe and W.E.T Probe measure the EC of the pore water specifically and show a decrease in EC with increasing water content, as the fertilizer ions in the pore water becomes more diluted as VWC increases. Results with the Hanna and FieldScout probes increased with increasing water content as the added water helps conduct the current of these meters. The EC measured with the various in situ probes differed slightly among the probes, but was highly and positively correlated with all three of the solution extraction methods over the range of fertilizer concentrations. It would be possible to convert substrate EC guidelines that have been established for any of the laboratory methods for use with the in situ probes, though our results indicate the substrate VMC must be above 0.35 for the interpretation to be valid.

Effect of Fertigation Strategy on Nitrogen Availability and Nitrate Leaching using Microirrigation

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Injection during the middle one-third or the middle one-half of the irrigation is recommended for fertigation using microirrigation. However, short fertigation events are commonly used by growers. This project investigated the effect of fertigation practices on nitrate availability and leaching. The first phase of the project (completed) determined nitrate distributions in the root zone for four microirrigation systems, three soil types, and five fertigation strategies using the HYDRUS-2D computer simulation model. Fertigation strategies included injecting for short time periods at the beginning, middle, and end of the irrigation cycle, respectively; injecting during the middle 50% of the irrigation cycle, and continuous injection. The second phase (ongoing) is investigating the distribution of nitrate, ammonium, urea, phosphate, and potassium around the drip line for selected Phase 1 scenarios. Phase 1 results showed less nitrate leached from the root zone for a 2-h injection time at the end of a long irrigation event compared to injection at the beginning and middle of a long irrigation event for surface drip irrigation. A more continuous fertigation resulted in a more uniform distribution of nitrate in the soil. The results were less conclusive for subsurface drip lines, due to upward movement of nitrate above the drip line. Little difference in nitrate leaching occurred for short irrigation events, regardless of fertigation strategy. Data analysis of the Phase 2 modeling is under way. The HYDRUS-2D model included partition coefficients for ammonium, phosphate, and potassium, and parameters for hydrolysis (conversion of urea to ammonium), nitrification, and denitrification.

Model-based Moisture Prediction of Root Medium and Irrigation Control in Potted Plant Production using Nutrient-flow Wick Culture (NFW) System

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The uptake of water and nutrient in potted plants is greatly affected by irrigation conditions, and it influences the plant growth. This study aimed to examine the correlations between basic environmental parameters and plant growth in potted plants (kalanchoe) and to develop the models for adequate irrigation control. Growth chambers were developed for the experiments, and four levels of photosynthetic photon flux (*PPF*) were treated by using different numbers of shading films and lamps. *Kalanchoe blossfeldiana* cv. New Alter, grown in the nutrient-flow wick culture (NFW) system, was used. The 7-cm pots were filled with a 7:3 mixture of peat moss and perlite medium (v/v). The initial water content was set at about 26%. A total of 150 pots and plants with different growth stage were prepared for 4 weeks. A wick [12 × 1 cm (L × W)] was used in each pot. Leaf areas of plants and surface areas of the medium were analyzed by a plant image analysis system. For measuring the water losses of plants and pots during the growth stage, the initial water content of the substrates was maintained at about 55%. Water losses were measured at 9, 11, 13, 15, and 17 hours for all experiment periods by using an electron balance. Two models were developed for estimating water losses by evapotranspiration and water intake by water absorption. Finally, a model for estimating water content in the medium was tried. Growth and environment parameters showed high correlations with transpiration and evaporation, respectively. There was an interactive effect of VPD and *PPF* on the change of evapotranspiration. The amount of absorption was increased by time and decreased with increase of initial water content.

Oral Session 3—Pomology–Physiology

Moderator: Paolo Sabbatini

18 July 2005, 2:00–3:30 p.m. Room 101

Effect of Crop Load on Diurnal Leaf Photosynthesis, Stomatal Conductance, and Annual Carbon Isotope Composition of 'Imperial Gala' Apple Tree

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The naturally occurring carbon isotope composition (or 13C : 12C ratio, expressed with the notation d13C) of plant tissue may be used as an indicator of water use efficiency during plant growth. d13C has been shown to be an effective tool to study physiological response of plant to environmental conditions, especially water stress. The objective of this work was to test if d13C could be an indicator of carbon limitations or a low source : sink ratio. Trees of 'Imperial Gala'/Bud 9 (n = 12), 6-years-old, field grown at the Clarksville Horticultural Research Station (Clarksville, Miss.), were assessed with different crop load (LCL = Low Crop Load, 0.76 ± 0.44 fruit per trunk sectional area (TCA); NCL = Normal Crop Load, 7.25 ± 1.83 fruit/TCA; HCL = High Crop Load, 15.83 ± 1.76 fruit/TCA) and leaf : fruit ratio (LCL: 52.78 ± 8.55, NCL: 13.33 ± 3.06, HCL; 4.31 ± 0.68) immediately following June drop. Net photosynthetic rate of leaves were monitored during the season and elevated rates were observed in NCL and HCL and correlated with the fruiting process. Photosynthesis was inhibited in LCL more in the afternoon (from 20% to 42% in relation to NCL) than in the morning (from 5% to 20%) and this was positively correlated with crop sink strength. Variations of the stable carbon isotope composition of roots (fine and coarse), fruit, leaves, and current-year stems were examined. The d13C varied by tissue (fruit > shoot and leaf > root) and in relation to the level of crop load (d13C‰ in fruit: LCL –23.513 ± 0.248, NCL –24.891 ± 0.594; and HCL –24.935 ± 0.375). These results may have implications for analysis of isotopic signals in carbohydrate stress and fractionation steps will be discussed.

Native Variation in Bloom and Crop Density in Spur-type 'Delicious' and Effect of Ethephon Applied in High Crop Years

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For studies on blossom/fruit thinning in apple, tree selection is often based on uniformity of bloom/crop load, assuming that such trees exhibit greater uniformity to treatment. However, the literature is replete with data showing marked variation for a given treatment. We followed variation in bloom/crop density of spur-type 'Delicious'/MM.106 and effect of ethephon applied in high crop years on return bloom/yield. Uniform trees (n = 95), under identical cultural practices, were selected for varying crop load. Return bloom, yield and fruit size were monitored over six years. General mean (X) for yield was 94 ± 25 kg/tree

and bloom density, rated 1 to 10 (highest), was 5.4 ± 1.7. Annual yield deviated from X by +56 to –40% and bloom density by +49 to –42%. All trees were ranked (decreasing yield) and assigned to five percentile (PCTL) groups (1st, 81-100; 2nd, 61-80; 3rd, 41-60; 4th, 21-40; 5th, 0-20 kg/tree). Trees in each group were reassigned annually to the five PCPL groups for the next five years. Of trees in 1st PCTL (n = 19, X = 187 ± 10 kg/tree) in year one, 5, 5, 24, 0 and 63% placed in PCPL 1, 2, 3, 4, and 5, respectively, in year two. Of trees in 1st PCTL (5%) in year two, all placed in PCTL 2 in year three. Effect of ethephon [200 $mg \cdot L^{-1}$ at 3, 3 + 6, 3 + 6 + 9 weeks after full bloom (WAFB)] applied in on years to 'Redchief', with strong alternate bearing, were evaluated for six years. Ethephon at 3 WAFB had no effect. Yield from multiple applications differed from control (NTC) in off years, but not from each other. Total yield (3 on + 3 off years) for the NTC and ethephon at 3 + 6 WAFB was similar (479 vs. 471 kg/tree). However, 64% of the total yield was produced in the on years and 36% in the off years in NTC vs. 56 and 44% in 3 + 6 WAFB, respectively.

Regulation of Fruit Growth and Fruit Size in Apple

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Fruit development in apple cultivars varying in their ultimate fruit size was analyzed using cytology, flow cytometry (FCM), and semi-quantitative RT-PCR. Fruit size variation across cultivars was largely explained by variation in cell number. The cell division phase lasted for less than 30 days in all varieties, less than previously believed. A distinct overlap between the cell division and cell expansion phases was present. Analysis of the relative cell production rate (rCPR) showed a major peak about 10 days after full bloom (DAFB) after which it declined. Comparison of the rCPR across varieties suggested distinct patterns of cell production with 'Gala' having a low but sustained rCPR, 'Pixy Crunch' a short but high rCPR, and 'Golden Delicious' having a high and sustained rCPR. FCM analysis also showed similar patterns with a peak in the proportion of dividing cells about 10 DAFB followed by a decline. To further understand regulation of cell number, four cell cycle related genes were cloned from 'Gala'. Cyclin Dependent Kinase B (CDK B) and Cyclin B were found to be highly cell division phase specific in their expression. Analysis of gene expression by semi-quantitative RT-PCR indicated peak expression of these two genes at 5-10 DAFB, consistent with the peaks in rCPR and proportion of dividing cells. Comparison of gene expression across the varieties showed higher peak expression of the above genes in the larger-fruited 'Golden Delicious' than in the smaller-fruited 'Gala.' This study provides novel insight into the regulation of fruit development in apple and also suggests a role for the cell cycle genes in fruit size regulation.

Apple Fruit Growth and Cell Division in Relation to Embryo and Endosperm Development in Two Climates, New York State and Washington State

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In 2002 in New York State, we collected king fruit of 'Gala' and 'Red Delicious' on fruiting spurs from 0 to 66 days after full bloom (DAB). In 2003 in Washington State, we collected king fruit of these cultivars from 14 to 62 DAB. At each collection we determined radial cell number across the fruit cortex and developmental stage of the embryo and endosperm in seeds. Fruit diameter was slightly greater in Washington fruit than in New York fruit until about 40 DAB; thereafter, New York 'Delicious' outgrew Washington 'Delicious', while 'Gala' in the two climates (and two different years) grew identically. The New York fruits had a much earlier rise in fruit growth rate and maintained a slightly higher rate throughout the period. The cortex thickness of Washington fruit was greater than that of New York fruit for both cultivars. Most rapid cell division in the cortex occurred between 10 and 28 DAB and, by 40 DAB, most cell proliferation had ceased. The Washington fruit formed more cells across the radius than did New York fruit. Cortex thickness increased with respect to increase in cortex cell number about 30% to 40% faster in Washington fruit than in New York fruit. Developmental stages of embryos and endosperm followed a sigmoid time pattern for both cultivars in both states. By 60 DAB, embryos and endosperm reached their maximum stage of development. In both cultivars and states, cell divisions were nearly completed by the time the embryo and endosperm approached stage 3: for embryos this is the heart-shaped stage, for endosperm it is near completion of cell wall formation. The completion of wall formation in the endosperm, the near completion of cortex cell division, and the generation of the cotyledons and apical meristems in the embryo are highly correlated processes. We saw no evidence that endosperm development precedes embryo development.

ABA, Hydraulics, and Gas Exchange of Split-rooted Apple Trees

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Approach-grafted 1-year-old 'Gala'/M7 apple trees were grown with both tops for the remainder of the 2003 season in a greenhouse. Trees were supplied with >100% (control, PRD100) or 50% (PRD50, DI50) of daily ET_c either applied to one root compartment only (PRD100, PRD50) or divided evenly across both root compartments (control and DI50). ET_c was estimated from gravimetric measurements, and irrigation was switched between wet and dry root compartments several times throughout the experiment. Soil moisture was measured both gravimetrically (tripod) and volumetrically (time-domain reflectometry). Predawn leaf water potential (ψ_{pd}) and single leaf gas exchange (photosynthesis, stomatal conductance, and transpiration) were recorded daily, and sap flow in stems and roots was monitored continuously using the heat-pulse technique. Leaves were collected for abscisic acid (ABA) determination following gas exchange measurements. Regardless of irrigation placement (i.e., PRD or DI), both 50% ET_c treatments experienced similar declines in ψ_{pd} and single leaf gas exchange relative to control levels. In addition, ABA concentrations were similar for PRD50 and DI50, and were significantly higher than the control and PRD100 treatments. PRD100 trees had similar ψ_{pd} as control trees; however, gas exchange was reduced >25% compared to the control. Bulk leaf ABA concentration did not differ significantly from control levels and does not by itself explain the down regulation of stomata with PRD100.

Xanthophyll Cycle-dependent Thermal Dissipation and the Antioxidant System of 'Gala' Apple Peel in Response to Nitrogen Supply

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Four-year-old 'Gala'/M.26 trees were grown under low (2.5 mM), medium (12.5 mM), or high (25 mM) N supply with balanced nutrients in sand culture and the cropload was adjusted to 5 fruit/cm^2 trunk cross-sectional area at 10 mm king fruit. At about 100 days after bloom, exposed fruit on the south side of the canopy were chosen for monitoring chlorophyll fluorescence and fruit peel samples were taken for measuring xanthophyll cycle pigments, antioxidant enzymes, and metabolites. At noon, the efficiency of excitation transfer (Fv'/Fm') of the sun-exposed peel was higher in the low N treatment than in the medium or high N treatments. Photochemical quenching coefficient did not differ between fruits in different N treatments. The Photosystem II operating efficiency was higher in the peel of low N fruit compared with medium N or high N fruit. However, maximum quantum efficiency (Fv/Fm) of fruit peel after overnight dark adaptation was similar across the N treatments. The xanthophyll cycle pool size expressed on peel area basis was larger in the high N fruit than in the low N fruit. This corresponds well with the thermal dissipation capacity, as indicated by efficiency of excitation transfer. Over 95% of the xanthophyll cycle pool in the sun-exposed side was present in the form of zeaxanthin and antheraxanthin at noon regardless of N treatments. Activities of

superoxide dismutase and all the antioxidant enzymes and metabolites in the ascorbate-glutathione cycle were higher in the high N fruit than in low N fruit. The results indicate that apple fruit with a good N status have a higher photoprotective capacity in terms of xanthophyll cycle-dependent thermal dissipation and detoxification of reactive oxygen species compared with low N fruit.

Oral Session 4—Vegetable Breeding 1

Moderator: J. Brent Loy

18 July 2005, 4:00–5:30 p.m. Ballroom G

Development of Lettuce Breeding Lines Resistant to Bacterial Leaf Spot

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Bacterial leaf spot of lettuce caused by *Xanthomonas campestris* pv. *vitians* (Xcv) is an important lettuce disease in California. No adequate control measures have been found, although resistance exists in several heirloom cultivars. Deployment of cultivars resistant to bacterial leaf spot will reduce these periodic and costly disease events. The objectives of this research were to 1) identify new sources of resistance within modern crisphead cultivars and 2) select for resistance in 'Salad Crisp' × 'Iceberg' progeny. Field plots were established and grown with overhead irrigation, and a three-strain mixture of Xcv was applied until runoff 1 week after thinning at 1×10^9 CFU/mL. Twenty-six crisphead cultivars were tested in unreplicated field trials and rated on a 1 (susceptible) to 4 (resistant) scale. Selection was carried out between and within families from the F_2 to F_4 generation. Sixteen F_3 families were evaluated in unreplicated plots, and 12 F_5 families were tested in replicated plots for disease incidence and severity. No usable levels of resistance were identified in the modern crisphead cultivars tested to date. All F_3 families had resistance greater than 'Iceberg', and 19 plants from eight families were selected for further breeding. Subsequently, 12 plants from two F_4 families were selected. Replicated trials of 12 F_5 families indicated that all lines have disease severity comparable to both parents. Breeding lines from crosses to 'Salinas 88' are currently being developed.

Transfer and Mapping *Allium roylei* Derived *Botrytis* Leaf Blight Resistance in Onion

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All current onion cultivars are susceptible to *Botrytis squamosa* (BLB), in varying degrees. The wild onion relative *Allium roylei* possesses strong BLB resistance. To control this disease, BLB resistant onion populations are being created through backcross breeding using *A. roylei*. Interspecific sexual barriers reduce fertility and seed set, impeding gene transfer. It is relatively easy to make the interspecific F_1 between *A. roylei* and *Allium cepa*; however, sexual barriers severely limit seed production in subsequent generations. Nevertheless, we were able to select BC_1F_2 plants capable of generating high levels of BC_2F_1 seed. The BC_2F_1 plants had horticultural characteristics much closer to onion, and segregated for both BLB resistance and fecundity. One particular BC_2F_1 population gave the highest proportion of resistant plants in a field screen, and nearly all plants of this population produced true bulbs. 120 selected BC_2F_1 bulbs were retested for BLB resistance in a chamber assay and the most resistant plants were used to advance the transfer of BLB resistance. In 2004, BC_2F_2 and BC_3F_1 populations derived from the BC_2F_1 selections were screened for BLB resistance and used for seed production. 132 plants were selected in the field screen. The level of resistance in BC_2F_2 and BC_3F_1 is similar to BC_1F_2 and $BC2F_1$, with no evidence of reduction in level of resistance with generations. Molecular screens for markers associated with resistance are routinely used in vegetable crops to transfer resistance genes. The creation of a molecular assay for BLB resistance would accelerate its transfer and release of resistant varieties. We are using AFLP and SSRs in a search for DNA markers associated with BLB resistance in our materials.

Dissection of Linkage Drag in Breeding for Acylsugar-mediated Multiple Pests in Tomato

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The wild tomato *Lycopersicon pennellii* is resistant to numerous important pests of cultivated tomato, *L. esculentum*, including armyworm, fruitworm, aphids, leafminers, and whitefly. The pest resistance of *L. pennellii* is mediated by the presence of acylsugars, which constitute 90% of *L. pennellii* type IV trichome exudate. Transfer of the ability to accumulate acylsugars could result in pest-resistant tomato cultivars, and thus, a reduction in the dependence on synthetic chemicals for insect control for this crop. Initial tomato lines bred for acylsugar production possessed the desired insect resistance, but were of poor horticultural quality due to linkage drag. These tomato lines possessed seven or eight *L. pennellii* introgressions, some of which were quite large. As a result, about 25% to 30% of the genomes of these acylsugar lines were comprised of *L. pennellii* DNA. A set of 20 molecular markers was created, providing markers throughout each introgression. The acylsugar breeding program then combined use of a biochemical assay for acylsugars and genomic analyses using these molecular markers to determine which of the introgressions were involved in the linkage drag, and to select plants that either eliminated or shortened those introgressions. Introgressions on chromosomes 2, 3, 5, and 10 were found to be associated with negative characteristics, such as delayed germination, reduced fruit set or size, delayed maturity, or reduced seed set. New acylsugar lines that eliminate or reduce some of these introgressions were created. The new lines show marked improvement in some of the affected traits, while also producing acylsugars. Hybrids created using these lines show marked improvement in horticultural type.

Interpretation of Genotype-by-Environment Interaction for Carotenoid and Tocopherol Content in Broccoli

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Genotype-by-environment interaction (G×E) is a fundamental concern in plant breeding since it hinders developing genotypes with wide geographical usefulness. Analysis of variance (ANOVA) has been widely used to interpret G×E, but it does not elucidate the nature and causes of the interaction. Stability analysis provides a summary of the response patterns of genotypes to different growing environments. Two classes of phytochemicals with putative health promoting activity are carotenoids and tocopherols that are relatively abundant in broccoli. Growing clinical and epidemiological evidence suggests that vegetables with enhanced levels of these phytochemicals can reduce the risk of cancer, cardiovascular, and eye diseases. The objective of this study is to have better understanding of the genetic, environmental and G×E interaction effects of these phytochemicals in broccoli to determine the feasibility of the genetic enhancement. The ANOVA and Shukla's stability test were applied to a set of data generated by the HPLC analysis of different carotenoid and tocopherol forms for six broccoli accessions grown over three environments. The ANOVA results show a significant G×E for both phytochemicals that ranged from 22.6% of the total phenotypic variation for beta-carotene to 54.0% for delta-tocopherol while the environmental effects were nonsignificant. The genotypic effects ranged from as low as 1% for alpha-tocopherol to 31.5% and 36.0% for beta-carotene and gamma-tocopherol, respectively. Stability analysis illustrated that the most stable genotype for all

phytochemicals is Brigadier. The results suggest that feasibility of the genetic enhancement for major carotenoids and tocopherols. A second experiment that includes a larger set of genotypes and environments was conducted to confirm the results of this study.

Selenium Concentration of Broccoli Inbreds and Hybrids Is Largely Influenced by Environment

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Broccoli (*Brassica oleracea* L. Italica Group) can contain high levels of selenium (Se) in the form of selenium methyl selenocystine. This is a relatively unique Se compound that is found in certain plant species that accumulate this element. Several recent studies have shown that high Se broccoli can inhibit the development of certain cancers (e.g., colon and mammary) in rodents and this has led to increasing interest in broccoli as a vegetable that confers chemoprotective effects. The objective of this research was to determine the relative importance of genotype vs. environment in the expression of Se concentration in broccoli heads. A set of 15 broccoli inbreds and a set of 20 hybrids were evaluated in three different environments. Mature heads were harvested from plots, heads were dried and ground, and Se concentration was determined on a dry weight basis. Overall, Se levels measured in this study were low to moderate, typically ranging from about 20 to more than 100 ng/gdw of Se per head. For both inbreds and hybrids, the effect of environment on Se head concentration was highly significant and more than 10 times greater than the effect of genotype. When analyzed across all three environments, the genotypic effect on Se concentration was significant for hybrids only. However, when assessed for individual environments, the genotypic effect was significant in just one of three of the test environments with both inbreds and hybrids. Results indicate that genetic modification of broccoli to increase selenium concentration of heads will likely be difficult to achieve.

Improving Eating Quality and Storage Life in Acorn Squash

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Acorn squash (*Cucurbita pepo* L.) is one of the three major classes of squash consumed in North America. Breeding improvements over the past 30 years have focused on more compact cultivars, earlier maturity, darker rind color, and powdery mildew tolerance (PMT). Our observations from sampling acorn squash from local supermarkets at different times during the year show that eating quality is highly variable, and most often, not acceptable. Our taste tests indicate that for acceptable eating, quality acorn squash should have °Brix of 10 or higher, flesh %DW above 16, and a smooth, nonfibrous texture. Most commercial cultivars fail to meet the above minimum criteria for quality. Proper harvest time is a major determinant of squash eating quality. To obtain adequate °Brix levels, squash should not be harvested until at least 50 days after pollination (DAP). If squash are harvested between 25 to 40 DAP and then stored for two or more weeks, °Brix levels may increase to acceptable levels, but some mesocarp reserves will be remobilized to developing seeds, reducing mesocarp %DW and lowering eating quality. A major goal of the squash breeding efforts at the University of New Hampshire has been to increase mesocarp %DW for obtaining more consistent eating quality. We have evaluated several experimental PMT hybrids during the past 5 years, and in some of these, flesh DW has averaged 17% or higher, and eating quality has been rated consistently very good. The adoption of better quality acorn cultivars together with implementing proper harvest times and storage conditions could appreciably increase per capita consumption.

Oral Session 5—Floriculture-Growth and Flowering

Moderator: Erik S. Runkle

18 July 2005, 4:00–5:30 PM **Room 102**

Photosynthetic Daily Light Integral During the Seedling Stage Influences Subsequent Growth and Flowering of *Celosia*, *Impatiens*, *Salvia*, *Tagetes*, and *Viola*

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The photosynthetic daily light integral (DLI) dramatically increases during the spring, but effects of DLI on seedling growth and development have not been characterized for many species. We quantified the effects of DLI on growth and development of *Celosia*, *Impatiens*, *Salvia*, *Tagetes*, and *Viola* during the seedling stage and determined whether there were any residual effects of DLI on subsequent growth and development after transplant. Seedlings were grown in growth chambers for 18–26 days at 21 °C with a DLI ranging from 4.1–14.2 $mol \cdot mol \cdot m^{-2} \cdot d^{-1}$. Average seedling shoot dry weight per internode (a measure of quality) increased linearly 64%, 47%, 64%, and 68% within this DLI range in *Celosia*, *Impatiens*, *Tagetes*, and *Viola*, respectively. Seedlings were then transplanted to 10-cm containers and grown in a common environment (average daily temperature of 22 °C and DLI of 8.5 $mol \cdot m^{-2} \cdot d^{-1}$) to determine subsequent effects on plant growth and development. Flowering of *Celosia*, *Impatiens*, *Salvia*, *Tagetes*, and *Viola* occurred 10, 12, 11, 4, and 12 days earlier, respectively, when seedlings were previously grown under the highest DLI compared with the lowest. Except for *Viola*, earlier flowering corresponded with the development of fewer nodes below the first flower. Flower bud number and plant shoot dry weight at first flowering decreased as the seedling DLI increased in all species except for flower number of *Tagetes*. Therefore, seedlings grown under a greater DLI flowered earlier, but plant quality at first flowering was generally reduced compared with that of seedlings grown under a lower DLI.

Temperature Regulates Flowering of Two *Odontioda* Orchid Hybrids

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The production value of potted orchids has increased by 155% in the past decade, and they are now the second-most valuable potted flowering plant in the United States. Scheduling orchids to flower on specific dates requires knowledge of the environmental parameters that regulate flower induction. However, the flowering requirements of the vast majority of orchid species and hybrids have not been well described. *Odontioda* is a cool-growing, epiphytic genus originating from the Andes Mountains of South America, and several hybrids are commercially grown for their bright-colored flowers and compact habit. We quantified the promotion of inflorescence initiation and time from visible inflorescence (VI) to anthesis at constant and fluctuating day/night temperatures. *Odontioda* George McMahon 'Fortuna' and Lovely Penguin 'Emperor' were grown at constant temperatures of 14, 17, 20, 23, 26, or 29 °C, and day/night (12 h/12 h) temperatures of 20/14, 23/17, 26/14, 26/20, 29/23, or 29/17 °C. Plants were grown in glass greenhouses under a 12-h photoperiod, and shading was provided so that the maximum instantaneous irradiance was ≤300 $\mu mol \cdot m^{-2} \cdot s^{-1}$. After 6 weeks at the various temperature setpoints, heat stress symptoms were observed on plants grown at 26, 29, 26/14, 26/20, 29/23, and 29/17 °C. After 14 weeks, ≥60% of both hybrids had VI when grown at 14, 17, 20, or 20/14 °C. Data for time from VI to anthesis were converted to a rate and a thermal-time model relating temperature with inflorescence development was developed. This information could be used by commercial orchid growers to schedule flowering *Odontioda* orchids for specific market dates.

Coreopsis grandiflora 'Sunray' Flowers in Response to Short Days or Vernalization

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Coreopsis grandiflora 'Sunray' has been reported to flower under long days (LD) following vernalization or short days (SD). The objectives of this study were to characterize the effective duration of vernalization and SD and to determine if photoperiod during vernalization influences flowering. Vegetative cuttings taken from stockplants developed from one seedling were rooted for 2 weeks and grown for 5 weeks. Plants were provided with a 9-hour photoperiod for 2, 4, 6, or 8 weeks or were vernalized at 5 °C under a 16-hour photoperiod for 2, 4, 6 or 8 weeks or under a 9-hour photoperiod for 2 or 8 weeks. Following treatments, plants were grown in a greenhouse at 20 °C under a 16-hour photoperiod. Control plants were grown under constant 9- or 16-hour photoperiod. Leaf development, days to first visible bud (DVB), days to first open flower (DFLW), and height and total number of flower buds at FLW were recorded. No plants flowered under continuous SD. Under continuous LD, two plants flowered on axillary shoots but only after 95 days. All vernalized and SD-treated plants flowered on both terminal and axillary shoots. Photoperiod during vernalization did not affect subsequent flowering. DFLW decreased from 56 to 42 and from 50 to 42 after 2 to 8 weeks of vernalization and SD treatments, respectively. Following 2, 4, 6, and 8 weeks of vernalization, plants had 116, 116, 132, and 204 flower buds, respectively. Plant height at FLW of all SD-treated and vernalized plants was similar. Thus, 2 weeks of 9-hour SD or vernalization at 5 °C followed by LD was sufficient for flowering of our clone of *C.* 'Sunray', although longer durations hastened flowering and increased flower bud number.

Predictive Model for Scheduling Fowering of *Limonium sinuatum* (L.) Mill ×*Limonium perezii* (Stapf) Hubb.

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Weekly records of plant development, daily average temperatures (DAT), and light integrals (DLI) were used to develop a predictive model for time to flower, from seven successive plantings of the new *Limonium sinuatum* x *Limonium perezii* hybrid 'LSLP4' under two light regimes, full sun or 50% shade. Plantings occurred over the period covering fall through to late spring in a temperature-controlled glasshouse under long days. DLI was highly correlated with the time to visible flower, explaining in excess of 80% of the variation. When combined with the plant growth parameter describing the rate of increase in either leaf number (LNAR) or groundcover index (GCIR), a second model was developed that was able to predict the date of visible flowers of LSLP4 and account for more variation than DLI alone. As a result of the uniformity of temperatures between successive plantings, DAT did not significantly contribute to explaining time to visible flower, but was significant for the period from visible flower through to flower harvest maturity. It is recommended that growers of 'LSLP4' for cut flowers can use historical records of DLI to determine planting dates to schedule flowering. Once planting has occurred, by measuring actual DLI, DAT, and leaf number per plant, growers can use the second model to modify the predicted date for visible flowers and flower harvest.

Inheritance of Flowering without Vernalization in Seed-propagated *Lilium formosanum* Wallace

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A majority of commercial *Lilium* hybrids and species do not flower the first year from seed or scales due to an obligate vernalization requirement. The Formosa lily (*L. formosanum*) is a unique species within the genus *Lilium* because some genotypes flower from seed the first year without vernalization. The objective of this study is to determine the inheritance of stem emergence, which culminates in flowering, in seed-propagated families without vernalization. Nine *L. formosanum* genotypes, selected from six populations for obligate or non-obligate vernalization for flowering, were intermated to generate 23 families with 104 seedlings per family. Families were grown in a randomized complete-block design at 21 °C (day/night) and data collected were seedling mortality, stem emergence or rosetting without vernalization, and weeks to emergence. At the end of 44 weeks, rosetted genotypes were vernalized for 8 weeks (4 °C); 100% emerged. We propose this trait is controlled by two genes. For flowering without vernalization to occur, there needs to be at least one dominant allele at one of the loci. Locus *Ver*[2] has less penetrance than *Ver*[1]. Families segregating for dominant alleles at both *Ver*[1] and *Ver*[2] emerged sooner (34.2 weeks) than those segregating for a dominant allele at only *Ver*[1] (36.1 weeks) or *Ver*[2] (37.6 weeks). Identification of these genes can aid in the development of uniform, fast-flowering *L. formosanum* hybrids as well as aid in the introgression of this trait into standard commercial lily classes.

Echinacea purpurea 'Magnus': Is It an Intermediate-day or a Short-day/Long-day Plant?

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Echinacea purpurea Moench., or purple coneflower, has been classified both as an intermediate-day plant and a short-day/long-day plant by different research groups. We performed experiments to determine at what developmental stage *Echinacea* 'Magnus' became sensitive to inductive photoperiods, and identified photoperiods that induced the most rapid flowering. Seedlings were raised under continuous light in 128-cell plug trays, then were transplanted into 11.4-cm plastic pots. Plants were transferred to 10-hour short days (SD) once seedlings developed 3, 4, 5, 6, 7, or 8 true leaves. After 4 or 6 weeks of SD treatment (primary induction), plants were moved to 16- or 24-hour photoperiods until flowering (secondary induction). Plants were also grown under continuous 10-, 14-, and 24-hour photoperiods to serve as controls. At least 4 leaves were required for flower induction; flowering was delayed and the percentage was low when plants had 3 leaves at the beginning of primary induction. Plants under continuous 14-hour photoperiods had the highest flower percentage (100%) and flowered earliest (87 days). Plants under continuous 10- and 24-hour photoperiods did not flower. Four weeks of SD followed by 16-hour photoperiods induced complete flowering and in an average of 95 days. However, 6 weeks SD was required for 100% flowering when the final photoperiod was 24 hours.

Oral Session 6—Ornamental Plant Breeding

Moderator: Daniel F. Warnock

18 July 2005, 4:00–6:00 p.m. Room 107

Update on the Ornamental Breeding Program at the University of New Hampshire

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The Ornamental Breeding Program at the University of New Hampshire (UNH) was initiated in 1998, aiming to develop new or improved vegetatively propagated cultivars. Initially, breeding focused on *Anagallis monelli* (Pimpernel). At the time, only one blue and one orange cultivar ('Skylover Blue' and 'Sunrise') were grown commercially. Main breeding goals were to develop plants with more compact habit and earlier flowering in the spring. In 2002, the first two UNH cultivars were released as Proven Selections™: *Anagallis* 'Wildcat Blue' and 'Wildcat Orange'. We have also developed breeding lines with new pink, violet, lilac, and white flower colors that are currently in industry trials. Studies on genetics, biochemistry, and anatomy of flower color in *A. monelli* have been performed and molecular studies

are in progress. Breeding of *Nolana* and *Browallia* started in 2000 and UNH lines are currently in industry trials. *Nolana* is comprised of over 80 species native to desert areas of Peru and Chile. Only two cultivars, *N. paradoxa* 'Bluebird' and 'Snowbird', and interspecific hybrid 'Blue Eyes' are currently commercially available. We now have several *Nolana* species at UNH representing a wide germplasm base. Based on ornamental potential, some species have been selected for breeding, aiming to develop sterile interspecific hybrids. Studies to break seed dormancy to optimize germination rates are in progress, as well as research on floral development, which is being conducted in collaboration with Peruvian researchers. Interspecific hybridizations have been used in *Browallia* to develop breeding lines with new or improved traits than those available from seed cultivars.

Polyploidy in Stokes Aster (*Stokesia laevis*)

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Segregation analysis of two different F_2 families of stokes aster created by hybridizing two blue-flowered cultivars ['Peaches Pick' (PE) and 'Omega Skyrocket' (OSR)] with the yellow-flowered cultivar 'Mary Gregory' (MG) gave disparate results. The F_2 progeny of PE × MG segregated in the expected 3:1 (blue:yellow) ratio. In contrast, all 782 progeny from the MG × OSR F_2 family were blue-flowered. Flow cytometric analysis of the parents and F_1 hybrids was conducted to determine if ploidy differences existed among the parents, as such differences could account for aberrant segregation behavior in the MG × OSR F_2 family. Peak ratios suggested that MG and PE were diploid, OSR was tetraploid, and F_1 hybrids of MG × OSR were triploid. Chromosome counts from root tip squashes confirmed that MG and PE were diploid ($2n = 2x = 14$), OSR was tetraploid ($2n = 4x = 28$), and F_1 hybrid progeny of MG × OSR were triploid ($2n = 3x = 21$). Karyotype analysis also confirmed these results. We propose that the lack of recovery of yellow-flowered progeny in the MG × OSR F_2 family is due to differences in parental chromosome number. These results document the first report of polyploidy in stokes aster, and suggest the absence of a triploid block in this species.

Comparison of Gamete Selection for Heat Stress and Cool Temperature Tolerance in *Phalaenopsis*

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Gamete selection was examined as a breeding tool in developing *Phalaenopsis* hybrids that are more extreme temperature tolerant. Four pairs of hybrid cultivars were cross-pollinated, and then exposed to two temperature extremes, 30 °C/25 °C and 14 °C/9 °C, during initial pollen tube growth. One of each pollinated orchid cultivar was placed in either of two growth chambers and exposed to an 11-hour photoperiod with an irradiance of 180 $mmol \cdot m^{-2} \cdot s^{-1}$ and a relative humidity of 70% for 3–7 days. The capsules were collected after 150 days. Protocorm development was evaluated after 73 days on a thermogradient table ranging from 10 to 30 °C. For cold-pollinated seeds, protocorm development was optimum at 22 and 28 °C (means of 290 and 250 protocorms per plate, respectively), whereas the greatest protocorm development for warm-pollinated seeds occurred at 20 °C (103 protocorms/ plate). Protocorms were evaluated for leaf and root formation 125 days after initial plating. Transfer to warm or cold incubators occurred as seedlings matured. One year after the initial plating, seedlings were evaluated on the following criteria: weight, number of leaves, leaf width, leaf length, leaf area, number of roots, and root length. The pollination treatment significantly affected the number of roots per seedling, whereas table position during germination significantly affected weight. The weight, number of leaves, and average root length were significantly affected by the pollination treatment and incubator interaction. The interaction between pollination treatment and table position significantly affected weight, number of roots, and average root length. Additional replication is required to confirm the greater germinability of cold-pollinated seed at higher temperatures.

Novel Impatiens Genotype with Improved Resistance to Western Flower Thrips Feeding

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When breeding floriculture plants, one must have a targeted phenotype and genotype in mind before the initial cross-pollination event is performed. In the case of the floriculture breeding program at the University of Illinois, our initial goal was to develop a commercially acceptable, yet novel, *Impatiens wallerana* (bedding plant impatiens) phenotype with improved resistance to the western flower thrips, *Franklinella occidentalis*, a significant insect pest in production greenhouses. This study describes the process used to obtain a large impatiens phenotype (>61 cm tall and >125 cm wide) with acceptable branching, leaf color, flower size, flower number, flower display, and flower colors with improved resistance to western flower thrips. A reliable and simple evaluation technique, based on the number of leaves expressing western flower thrips feeding damage after inoculation, was developed and utilized to create more resistant impatiens genotypes based on generation means. Using a 1 to 9 scale, mean damage ratings for the original germplasm populations 1, 2, and 3 were 5.18, 6.02, and 6.11, respectively, with the trend for populations 1, 2, and 3 skewed toward susceptible plants. Germplasm with novel phenotypes were derived from crosses with plants in populations 1 and 3 with commercial cultivars. These novel phenotypes had improved levels of resistance with a mean rating of 5.06 and a normal shaped distribution. The potential for improving resistance to western flower thrips feeding exists within available germplasm and the tools necessary for proper evaluations are available.

Plant Regeneration from Protocorm-derived Callus of Five *Paphiopedilum* Hybrids

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Callus was induced from protocorms of five *Paphiopedilum* hybrids (Paph. 03-1, Paph. 03-4, Paph. 03-5, Paph. 03-6, and Paph. 03-7) on callus induction medium [MS inorganics (412.5 mg NH_4NO_3 instead of 1650 mg and 475 mg KNO_3 instead of 1900 mg) and vitamins plus (per liter) 0.1 g myo-inositol, 30 g sucrose, and 2.5 g Gelrite; pH 5.5] containing various concentrations and combinations of thidiazuron (TDZ; 4.5 and 45 μM) and 2,4-D (4.5 and 45 μM). Callus formation was greatest for protocorms of Paph. 03-1, Paph. 03-4, Paph. 03-6, and Paph. 03-7. Among the most competent hybrids, callus formation was greatest among protocorms induced in medium containing 4.5 μM 2,4-D and 4.5 to 45 μM TDZ. Induced calli were transferred to 100 × 15 mm petri dishes containing 25 mL of PLB and plant regeneration medium (similar to callus induction medium) containing various concentrations of either benzyladenine (BA; 0.5, 5, or 10 μM), TDZ (0.25, 2.5, or 5 μM) or no growth regulator (control). PLB and plant formation was greatest on medium containing BA.

Reproductive Development in Pink Tickseed, *Coreopsis rosea*, Nutt.

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Landscape and garden use of *Coreopsis rosea* has been growing recently. With the introduction of the new varieties of *Coreopsis rosea* 'Sweet Dreams' and 'Limerock Ruby', there are increased opportunities for commercial sales. While plants can be propagated by vegetative means, seed production is generally less expensive, seed can be stored, and hybrid development depends on seed production. As a result, it is beneficial to understand the reproductive process of the plant. The purpose of this research was to investigate the reproductive development of *Coreopsis rosea*. This research also seeks to identify, describe and record inflorescence morphological characters, which could be useful in plant systematic and phylogeny studies. To this end, the anthesis process of pink tickseed, *Coreopsis rosea* Nutt., was studied in 100 inflorescences from 10 plants. Inflorescences were tagged when they

were first visible and measured daily for a month. The following measurements were taken: number of ray flowers, inflorescence diameter, diameter of the disc floret cluster (head), timing of anthesis, presence of pollen, and the longevity of opened flowers. The inflorescence anthesis process was 19.8 (±1.6) days long and was subdivided into 13 stages of development. During the 20 days of inflorescence anthesis, the flower was open 27.5% of the time (5.4 days). When the disc florets started to open, they did so from the outer layer of the cluster to the center of the cluster; therefore, florets in the head did not mature at the same time. Micrographs were taken using a dissecting microscope (Cobra dynascope) to illustrate the entire process.

Genetic Study of Leaflet Number and Prickles in Roses

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Research with the Basye Rose Breeding and Genetic Program at Texas A&M University has developed rose populations to use to study the genetic nature of leaf, stem, and several other rose traits. The rose populations are from the backcross of *Rosa chinensis* 'Old Blush' to WOB (interspecific hybridization of the diploid parents *Rosa wichuariana* 'Basye's Thornless' and 'Old Blush'). The qualitative trait of presence of stem prickles and the quantitative traits of stem prickle density and leaflet number were observed in three field locations. Two locations are in College Station, Texas, and one location in Overton, Texas. The qualitative trait of presence of stem prickles supports the reported monogenic modes of inheritance. The presence of stem prickles (dominant) had a segregation ratio of 1:1 for prickles : no prickles. Prickle density and leaflet number demonstrated a quantitative mode of inheritance. For prickle density the genotype was significant and environment was nonsignificant. For leaflet number the genotype/generation was significant and environment was nonsignificant. This shows that genotype influences prickle density and leaflet number expression. The genotype by environment interaction was nonsignificant for all traits.

SSR Markers for Accelerated Hydrangea Breeding and Hybrid Verification

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Hydrangea popularity and use in the landscape has expanded rapidly in recent years with the addition of remontant varieties. Relatively little is known about the genetic background or combinability of these plants. We recently established microsatellite markers for hydrangea and evaluated their utility for estimating species diversity and identifying cultivars. We also verified an interspecific cross using these markers. Future research includes marker assisted breeding, particularly with respect to remontant flowering traits.

Oral Session 7—Weed Control and Pest Management

Moderator: William W. Coates

18 July 2005, 4:00–5:45 p.m. Room 108

Evaluation of Herbicides and Herbicide Application Timings for Carrot

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Few herbicides are available for weed control in carrot. Many of those that are available are old and are in danger of being discontinued. From 2000–04, field experiments were conducted on sandy loam soils at the Oakes Irrigation Research Site in North Dakota to evaluate some of the newer herbicides for possible use in carrot production. Herbicides were tested with preplant incorporated (PPI), preemergence (PRE), and/or several postemergence (POST) application timings. The major weed in this study was hairy nightshade. Cloransulam applied PRE severely injured carrot. Dimethenamid reduced carrot stand and isoxaflutole injured carrots when they were applied PRE. Neither controlled hairy nightshade when applied either PRE or POST, resulting in carrot yield reductions. Acetochlor reduced carrot stand when applied PRE and did not control hairy nightshade when applied either PPI or PRE, resulting in reduced carrot yield. Mesotrione killed carrots when it was applied PRE, but only slightly injured carrots when applied POST. Carrot yield was reduced in some years due to lack of hairy nightshade control when mesotrione was applied POST. Sulfentrazone reduced carrot stand and yield when applied PRE. It was less injurious to carrots when applied POST, but carrot yields were reduced in some years due to lack of hairy nightshade control. Flumioxazin severely reduced carrot stand when applied PRE. When it was applied after carrots were 8 cm tall, it slightly injured carrots, but did not reduce yield except in one year when it did not control hairy nightshade. None of the herbicides tested did consistently as well as the old standards of linuron, DCPA, and trifluralin, but flumoixazin, sulfentrazone, and mesotrione may hold some promise if applied POST.

Oryzalin Movement in One-gallon Containers from Spray and Oryzalin-treated Mulch Applications

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Herbicide-treated mulches can increase duration of efficacy; however, it is not known if the herbicide-treated mulches can reduce the amount of herbicide getting into the root zone or leachate water. The objective of this study is to examine herbicide movement and leaching potential using a bioassay between pine nuggets sprayed with oryzalin vs. a direct spray of oryzalin. Oryzalin-treated mulch and direct sprays were applied to 1-gallon pots at 2.0 lbs/acre a.i. (2.2 kg·ha^{-1} a.i.). The study was repeated in time, with trial 1 starting in Jan. 2004, and trial 2 starting in Nov. 2004. Both were conducted in a glass greenhouse in Columbus, Ohio. There were six dates of evaluation in each study: 0, 4, 8, 16, 32, and 64 DAT. An oat (*Avena sativa*) bioassay was conducted on three pot levels (0–2, 2–8, and 8–15 cm) and leachate to determine herbicide presence on each evaluation date. In trial 1, pots with direct sprays showed more herbicide presence in the top 2 cm than the oryzalin-treated mulch pots on each of the evaluation dates. In trial 2, results were much the same except for 32 DAT, where the oryzalin-treated mulch showed slightly more presence than the spray treatment at the 0-2 cm level. In both trials, there was a significant increase in herbicide presence in the oryzalin-treated pine nugget pots at the 0–2 cm level from 0 to 4 DAT, suggesting that the mulch does retain the herbicide. Also, results indicated more herbicide leaching into the 2–8 cm zone with the direct sprays compared to the pots containing oryzalin-treated pine nuggets. In trial 2, there was indication of the herbicide getting into the 8–15 cm zone from the direct spray treatment up to 8 DAT. There were no signs of herbicide presence in the leachates from any of the treatments.

Cover Cropping and Cultivation Impacts on the Weed Seed Predator *Harpalus rufipes*

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Seed predators may significantly reduce the weed seedbank. In Maine, one ground beetle species, *Harpalus rufipes* DeGeer, can consume 90% of the epigeous seeds of certain weeds. *H. rufipes* is the predominant carabid seed predator in Maine agricultural systems. The mechanisms by which *H. rufipes* can be promoted are not well understood. Two weed management techniques used by diversified vegetable growers in Maine (cover cropping and cultivation) were evaluated in 2004 for their impact on *H. rufipes* movement and abundance. *H. rufipes* individuals (n = 200 plot) were marked and released into 180-m^2 plots that were either fallow or cover-cropped. Pitfall traps were installed in each plot to recapture marked beetles. The total recapture rate in fallow plots was 46% less than in cover crop plots. Movement of

fallow-released beetles into cover crop plots was 48% higher than movement of cover crop-released beetles into fallow plots. A second study evaluated the impacts of tillage on *H. rufipes*. Marked beetles (n = 25 plot) were released into 9-m^2 plots surrounded by raingutters. Plots were either tilled with a tractor-mounted rotovator to a depth of 15 cm or left undisturbed. There was no significant difference in beetle recapture rates in tilled (32%) vs. untilled (35%) plots, suggesting that beetles are capable of surviving even intensive tillage events. Variation in the number of *H. rufipes* across farming systems may not be due to tillage, as widely postulated in literature, but is instead a product of vegetative cover. Further research into the impacts of weed management on other life stages of *H. rufipes* is needed before firm conclusions can be reached.

Controlling Broad Mites [*Polyphagotarsonemus latus* (Banks)] Using *Neoseiulus californicus* McGregor and Sulfur After Transplanting Infested Bell Pepper (*Capsicum annuum* L.) Seedlings in the Greenhouse

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Pepper seedlings can be infested with broad mites prior to transplanting. Transplanted seedlings may not present visible mite damage symptoms and few microscopic mites will be undetected by growers. A rapid increase of the mite population can subsequently result in yield losses in greenhouse-grown crops. Control of broad mites based on biological (*N. californicus*) and conventional (sulfur) methods were evaluated after infested transplants were introduced into a production greenhouse. Seedlings were artificially infested with two broad mites, 3 days before they were transplanted in mid-September in a passively ventilated greenhouse in Florida. Plants had either two predatory mites released once [4 days after transplanting (DAT)], or twice (4 and 22 DAT), or were sprayed with sulfur (four weekly applications starting 13 DAT when first damage symptoms were noticed). Damage on plants was assessed by an injury scale transformed into percentage values, with 100% being total damage on untreated infested plants. Broad mites were absent in all plants 38 DAT but the damage caused to the plants at this time was negatively correlated ($r = –0.95$) with marketable yield at 90 DAT. Plants produced no marketable yield where broad mites were not controlled. One or two releases of predators led to respective damages of 56% and 45%, and fruit yields of 2.0 and 3.0 $kg \cdot m^{-2}$. Plants sprayed with sulfur had a damage of 7% after reaching a maximum of 74% at 18 DAT; however, yields were 4.3 $kg \cdot m^{-2}$, which was similar to the yield obtained in the uninfested control treatment (4.6 $kg \cdot m^{-2}$). Releases of predators prior to transplanting and/or higher predator release densities may be needed under similar conditions and will be evaluated in a subsequent experiment.

Effect of Soil Solarization and Methyl Bromide on Melon Wilt Caused by Fusarium on Cantaloupe in Western Mexico

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In the Pacific Central region of Mexico, 17,000 ha are cultivated with cucurbitaceous crops. Most are affected with wilt caused by *Fusarium oxysporum* f. sp. *melonis*. The use of fungicides, such as methyl bromide, for soil disinfecting is a common practice; however, this practice has adverse effects on beneficial microorganisms, and soil is rapidly infected again. Soil solarization is a sustainable alternative, and it is feasible to be integrated in production systems. It has been used to delay the establishment of symptoms and to reduce the incidence of fusarium wilt in watermelon fields. The objective of this study was to evaluate the effect of soil solarization and methyl bromide on control of fusarium wilt on cantaloupes in western Mexico. The experiment was conducted in the Ranch Fatima located in the municipality of Colima. Severe wilt incidence and damage were previously observed in the cantaloupe cultivar Impac. Dripping irrigation system was used. Treatments established were: 1) solarization; 2) solarization + vermicompost; 3) solarization + chemical products [methyl bromide + chloropicrine (98/2%)]; 4) methyl bromide; and 5) control (without solarization or chemicals). Soil solarization was done during the 6 months before planting using clear plastic mulching (110 thick). A completely randomized design with five treatments and four replications was used. Six beds, 10 m long and 1.5 m wide, were used as experimental unit. Variables registered were: leaf area, leaf number, dry and fresh weight, propagule number, soil temperature, number of diseased plants showing wilt symptoms, and yield. Treatments 1 and 3 exhibited the highest agronomic variable values, and best control of fusarium wilt and fruit yields.

Development of Organic Control Measures for Walnut Husk Fly in English Walnuts, Cultivar Susceptibility, and Impacts on Nut Quality from Infestation

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Walnut husk fly (*Rhagoletis completa*) is a major pest of English walnuts in California. Research was initiated in 1995 to evaluate reduced-risk pesticides. The first effective control measures were found in 2001—spinosad plus bait and kaolin (Surround). Spinosad was registered for organic use in 2003 as GF-120 NF (a formulation of spinosad and bait) and Entrust (a spinosad formulation to be mixed with existing baits). GF-120 is recommended for low to moderate populations while Entrust + bait is recommended for higher populations. Entrust + bait is price competitive with the standard malathion + bait. Kaolin is also effective for walnut husk fly control; however, control is dependent upon adequate coverage. In 2004, varietal susceptibility was assessed. The cultivars 'Payne', 'Serr', 'Pedro', and 'Hartley' were found to be highly susceptible while 'Chandler' and 'Howard' were somewhat resistant. Infestation in 'Chandler' began later in the season than in other cultivars. Quality parameters were also measured. Samples of 100 infested and uninfested 'Tulare' walnuts were compared at harvest. There were significant differences in adhering hull, percentage of edible yield, and relative value between infested and uninfested nuts. The relative value of infested nuts was 28% less than uninfested nuts. There were minimal differences in percentage of mold and kernel color. Walnuts sprayed with kaolin had larger nuts, fewer external defects, and an earlier harvest timing.

Impact of Anthracnose on Avocado Production in Kenya

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Avocado is the leading horticultural export in Kenya. In 2003, Kenya exported about 19,000 t, compared to 23 t in 1970. Most of the fruit is exported to the European markets. There are several constraints limiting production of avocado in Kenya, including limited superior varieties or planting material, poor infrastructure, poor market information, and poor tree crop management. Although several diseases infect avocado, the most important are fruit rot pathogens, such as anthracnose, cercospora, and scab. However, diseases and pests have not been important to avocado production in Kenya. Recently (2004), the constraint limiting avocado production in Kenya is anthracnose, caused by *Colletotrichum gloeospoirioides*. Little is known in Kenya on the impact of this disease on production and income realized by small- (<1 acre) or large-scale growers. The objectives of this research were to quantify losses attributed to anthracnose in Kenya, determine the current disease control measures, and recommend good agricultural

practice in conformance with EUREP-GAP. A survey was conducted in the avocado growing areas to identify and document constraints limiting avocado production in 2004. The highest losses were reported from central Kenya, where exporters reported up to 100% losses. Because all avocado varieties growing in Kenya are susceptible to anthracnose, it is recommended that good management, i.e., control of pests and diseases and good postharvest handling of fruit to minimize injury used as an entry point by anthracnose, should be enforced.

Oral Session 8—Plant Biotechnology 1

Moderator: Bipul Biswas

19 July 2005, 8:00–10:00 a.m. Room 102

In Vitro Propagation and Somatic Embryogenesis in Phalsa

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Phalsa [*Grewia asiatica* (L.) Tiliaceae] is an exotic fruit with good nutraceutical values. It cannot be grown in temperate climates with severe winters. Therefore, genetic improvement of phalsa for cold tolerance is essential. In order to apply biotechnology through genetic transformation to enhance cold hardiness, a reliable and rapid micropropagation system is needed. Thus, developing the most dependable micropropagation protocols for phalsa was the primary goal of this research. Phalsa explants prepared from different tissues, including leaf, nodes, internode, and zygotic embryos, were collected from mature trees growing in the specialty plants house, cultured on MS medium supplemented with various cytokinins alone or along with auxins and incubated under a 10-hour photoperiod at ambient temperature. In vitro propagation of phalsa tissues through both organogenesis and somatic embryogenesis was achieved. Of these, single shoots were developed from nodal explants as a result of budbreak on MS medium supplemented with BAP, kinetin, and zeatin separately. Somatic embryos were developed from the zygotic embryos when cultured on MS medium with 0.023 μM BA + 0.022 μM zeatin, for 2 weeks following a pulse treatment on NN medium supplemented with 5% sucrose, 0.11 μM BAP, 0.22 μM 2,4-D, and 29.20 μM L-glutamine. Somatic embryogenesis was also observed on modified basal medium supplemented with 13% sucrose, 58.40 μM L-glutamine, and 1.75 μM IAA. Enormous callusing was a major problem for in vitro studies with this species, irrespective of media composition. Further studies for multiple shoot development and higher frequency of SE induction are under way.

Embryo-rescue Culture in 'Galia' Male Parental Line Melon [*Cucumis melo* (L.) var. *reticulatus* Ser.]

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Embryo abortion and empty seeds after self-pollination occur in some transgenic (ACO antisense) 'Galia' male parental lines. An embryo-rescue system in this melon was developed to save potential viable embryos. To obtain the best and reliable embryo-rescue technique, several parameters were used including an improved (five new supplements) nutrient medium (named E-21) from the E-20A basic medium (Sauton and Dumax de Vaulx, 1987), an inoculation system (removing the embryo from the seed or intact seed), and the use of different fruit harvesting dates of the wild type and a transgenic 'Galia' male parental line. Fruits of wild type (WT) and transgenic (ACO gene in antisense orientation) 'Galia' male parental line were harvested at 4, 10, 17, 24, and 30 days after pollination (DAP). Fruits were surface sterilized by dipping in a 20% commercial bleach solution for 30 minutes. Subsequently, seeds were removed from fruit under sterile conditions. These seeds were either used to dissect the embryos or placed directly with the hilum facing E-20A or E-21 medium. Seedlings from all treatments were transferred to E-21 elongation medium, incubated 4 weeks, and transferred to soil to evaluate growth. The efficiency of this technique was greater when the time after pollination (4, 10, 17, 24, and 30 DAP) to rescue the embryos was increased. Thus, 30 DAP was the best time to rescue the embryos. The number of rescued embryos using E-21 medium was greater than with E-20A. We did not find any significant differences in survival efficiency rate between WT and transgenic embryos. We have obtained a competent embryo-rescue technique for WT and transgenic 'Galia' male parental line, which can be applied to rescue valuable GMO hybrid-melon embryos.

Recent Progress using Somatic Hybridization and Cybridization in Efforts to Develop High Quality Seedless Mandarin Hybrids

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The international fresh citrus market now demands high-quality, seedless fruit that must also be easy to peel for consumer convenience, especially when considering new mandarin varieties. High quality varieties that historically perform well in Florida are generally seedy. Florida is therefore losing market-share to 'Clementine' and other seedless varieties produced in Mediterranean climates, including Spain, Morocco, and California. In our ongoing program, somatic hybridization and cybridization via protoplast fusion are now playing a key role in strategies to develop competitive seedless mandarin hybrids adapted to Florida. Somatic hybridization is being used to combine elite diploid parents to produce high quality allotetraploid breeding parents that can be used in interploid crosses to generate seedless triploids. Several thousand triploid mandarin hybrids have been produced under the direction of F.G. Gmitter, Jr. Some of our allotetraploid somatic hybrids are producing fruit with direct cultivar potential, i.e., 'Valencia' sweet orange + 'Murcott' tangor. New somatic hybrids produced in our program will be discussed, including 'Page' tangor + 'Dancy' mandarin, 'Page' tangor + 'Kinnow' mandarin, and 'Hamlin' sweet orange + LB8-9 tangelo. Somatic cybridization is being used to transfer CMS (cytoplasmic male sterility) from the seedless 'Satsuma' mandarin to other seedy varieties via mtDNA transfer, in efforts to make them seedless. New somatic cybrids produced in our program that contain the 'Satsuma' CMS include 'Murcott' tangor and 'Kinnow' mandarin. Details of these results and other progress will be discussed.

Transgenic Grapevines Resistant to Pierce's Disease

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Pierce's disease (PD), caused by the xylem-limited bacterium *Xylella fastidiosa*, is endemic to the coastal plain of the southeastern United States. Although native southern grapevines are tolerant to *X. fastidiosa*, all varieties of *Vitis vinifera* grown in the region will succumb to PD. Genetic transformation to add disease resistance genes, while not disturbing desirable phenotypic characters, holds promise for expanding the southeastern U.S. grape industry by allowing use of established fruit and wine varieties. We utilize embryogenic cell cultures and *Agrobacterium* strain EHA105 to refine transformation systems for *Vitis* species and hybrids. *V. vinifera* 'Thompson Seedless' is employed as a model variety to test various transgenes for disease resistance, since as many as 150 independent transgenic plant lines routinely are produced from 1 g of embryogenic culture material. Transgenic plants are stringently screened for PD resistance in greenhouses by mechanical inoculation with *X. fastidiosa*. Transgenic plants are compared with both susceptible and resistant control plants by assessing typical PD symptom development and by assaying bacterial populations in xylem sap over time. Using these procedures, nine putative PD resistance genes have been inserted into grapevine and over 900 unique transgenic lines have been evaluated. A range of susceptible-to-resistant responses has been catalogued. Thus far, the best construct for PD resistance contains a grape codon-optimized hybrid lytic peptide gene

in a high-performance bi-directional 35S promoter complex. Certain transgenic plant lines containing this construct exhibit better resistance than that of resistant control vines.

Genetic Diversities within Camellia Species Confirmed by Random Amplified Polymorphic DNA (RAPD) Markers

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In this study research was conducted to evaluate the feasibility of characterizing genetic variation within camellia species using random amplified polymorphic DNAs (RAPD) markers. Eight varieties of species *Camellia japonica* and four varieties of species *Camellia reticulata*, provided by the America Camellia Society, Fort Valley, Ga., were investigated. RAPD profiles generated by five selected 10-based random primers (out of 20 primers) exhibited distinct patterns of amplified bands for all 12 tested varieties. A total of 344 bands were produced among the eight varieties of species *C. japonica*, with an average of 8.6 bands, ranging from 220 to 2072 bp in size, scored per primer. Among the 344 amplified bands, 74.4% of the bands presented polymorphic. The four varieties of species *C. reticulata* produced a total of 180 markers, with an average percentage of 57.8% polymorphisms. The amplified bands were in the range of 236–1760 bp. An average of nine amplified bands was generated per primer. The large percentages of polymorphisms displayed among 12 varieties within the two different species indicate that the expected genetic diversity among varieties within camellia species existed. It was concluded that the RAPD molecular markers are capable of revealing appreciable levels of genetic variation within camellia species.

Changes in Proteolytic Activity and Cysteine Proteinase Gene Expression during the Senescence of *etr1-1* Transgenic Petunias

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Corolla senescence in petunias was accompanied by a decrease in total proteins and a corresponding increase in proteolytic activity. Transgenic petunias that contain the mutated ethylene receptor (35S:*etr1-1*) have reduced sensitivity to ethylene and delayed flower senescence. Declines in total protein levels and increases in proteolytic activity were also delayed in *etr1-1* flowers and corresponded with corolla wilting. Experiments using class-specific proteinase inhibitors indicated that proteolytic activity in petunia corollas was largely due to cysteine proteinases. Total nitrogen levels within the corollas of both wild type and *etr1-1* flowers also decreased during senescence. Nine cDNAs encoding putative cysteine proteinases (CPs) were identified from a petunia EST database developed at the University of Florida. Six of these cysteine proteinases showed increased transcript abundance during corolla senescence (senescence-associated CPs) while three decreased in abundance. Of the six senescence-associated cysteine proteinases, only five showed delayed up regulation in *etr1-1* flowers that corresponded with corolla wilting. The role of ethylene in the regulation of protein degradation during flower senescence will be discussed.

DNA Methylation Polymorphisms in Somaclonal-derived Cultivars of Ornamental Aroids

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Plant tissue culture can induce a variety of genetic and epigenetic changes in regenerated plantlets, a phenomenon known as somaclonal variation. Such variation has been widely used in the ornamental foliage plant industry as a source for selection of new cultivars. In ornamental aroids alone, at least 63 somaclonal-derived cultivars have been released. In addition to morphological differences, many somaclonal aroid cultivars can be distinguished by amplified fragment length polymorphism (AFLP) analysis. However, a few cultivars have no detectable polymorphisms with their parents or close relatives by AFLP fingerprints. It is postulated that DNA methylation may be involved in the morphological changes of these cultivars. In this study, methylation-sensitive amplification polymorphism (MSAP) technique was used to study DNA methylation in selected somaclonal cultivars of *Alocasia, Aglaonema, Anthurium, Dieffenbachia, Philodendron,* and *Syngonium*. Results showed that polymorphisms were detected in the somaclonal cultivars, suggesting that DNA methylation polymorphisms may associate with tissue culture-induced mutation in ornamental aroids. This is the first study of methylation variation in somaclonal variants of ornamental foliage plants. The results clearly demonstrate that the MSAP technique is highly efficient in detecting DNA methylation events in somaclonal-derived cultivars.

Molecular Characterization of Photoperiodic Flowering in Cultivated Strawberry

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The molecular mechanisms governing photoperiodic flowering has been well defined in the model systems of *Arabidopsis thaliana* (a facultative long-day plant) and rice (a short-day plant). Photoperiodic flowering control is of great interest to strawberry (*Fragaria ×ananassa*) breeders and growers, and the genetics of photoperiodic flowering have been well studied, indicating that response to day-length is regulated by a small number of genetic loci. Cultivated strawberry is octoploid, so identification of these loci through forward genetic analyses is not practical. Since the componentry of the flowering response is generally conserved between monocots and dicots, we may assume that similar, if not identical, systems are functioning in strawberry as well. The goal of this work is to understand how cultivars likely containing identical photoperiod-sensing components are differentially sensitive to daylength. The expression patterns of genes relevant to the floral-transition were assessed under specific photoperiod conditions to assess similarities and/or differences to the model systems.

Oral Session 9—Ornamental/Landscape and Turf

Moderator: Jeffrey Adelberg

19 July 2005, 8:00–9:30 a.m. Room 108

A Comparison of Surface Mulch Type on Patterns of Above- and Below-ground Temperature and Surface Net Radiation in a Drip-irrigated Desert Landscape

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Mulches applied to landscape surfaces can moderate soil temperatures by changing the surface heat energy balance and conserve soil water by reducing evaporation rates. In the Southwest, decomposing granite is commonly used as landscape mulch. However, organic mulches, such as pine residue mulch and shredded tree trimmings, are becoming more available as industry by-products. Recent impetus toward water conservation and recycling forest and urban tree waste into urban landscapes has increased the need to better understand how such mulch types effect the temperature, moisture. and light quality of drip-irrigated landscapes typically found in the Southwest. We compared effects of three mulches, two organic (composted ponderosa pine residue and shredded urban tree trimmings) and one inorganic (Red Mountain Coral decomposing granite), turf grass, and bare soil applied to 14 drip-irrigated landscape research plots on below-ground soil temperatures at depths of 5 cm and 30 cm, temperatures at the mulch-soil interface, mulch surface temperatures, diel mulch surface net radiation, and albedo. Below-ground soil temperatures were more buffered by organic mulches, and mulch-soil interface temperatures

were lower under organic mulch than inorganic mulches. Inorganic mulch daytime surface temperatures were lower than organic mulch surface temperatures. Nighttime net radiation values were less negative over organic mulches than inorganic mulches and albedo was significantly higher for the inorganic mulch and bare soil treatments. These results provide evidence to show that organic surface mulches have higher resistances to heat transfer than inorganic mulches, which could improve landscape plant water and nutrient use efficiencies by lowering high summer root zone temperatures.

Cultivars of Invasive Japanese Barberry (*Berberis thunbergii*) Demonstrate Different Reproductive Potential and Seedling Traits

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While Japanese barberry (*Berberis thunbergii*) is an acknowledged invasive plant, the danger posed by its garden cultivars is unknown. This work analyzed the reproductive potential and seedling traits of wild type Japanese barberry and four important cultivars: 'Atropurpurea', 'Aurea', 'Crimson Pygmy', and 'Rose Glow'. The germination capacity of cleaned and stratified seeds was determined for all accessions in a greenhouse and seedling foliage color was noted. A subpopulation of seedlings from each accession was grown further in containers outdoors for a full season to ascertain seedling vigor. The average number of seeds produced per landscape specimen ranged from 75 and 90 for 'Aurea' and 'Crimson Pygmy' to 2967 for 'Atropurpurea', 726 for 'Rose Glow', and 1135 for wild type *B. thunbergii*. The vigor of 1-year seedlings—as measured by dry weight of top growth—for progeny derived from 'Aurea' (2.29 g) and 'Crimson Pygmy' (2.74 g) was less than 'Atropurpurea' (3.45 g), 'Rose Glow' (3.88 g) and wild type (3.73 g). Seedlings derived from purple-leaf cultivars displayed variable ratios of green and purple leaf phenotype correlated to the proximity and identity of likely Japanese barberry pollinators. 'Rose Glow' specimens located among other purple-leaf *B. thunbergii* produced up to 90% purple seedlings, while other samples growing in isolation or near green-leaf plants produced less than 10% purple progeny. This suggests that some invasive green-leaf Japanese barberry could be derived from cultivars. The results also show that these cultivars express disparate reproductive potential.

Miscanthus sinensis and *Panicum virgatum* Competition Study

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Many different vegetatively propagated cultivars of *Miscanthus sinensis* Anderss. are popular ornamental grasses sold at garden centers and nurseries. Large stands of the "wild type" or species (not ornamental cultivars) of this grass have self-seeded near Asheville, N.C.; Valley Forge, Pa.; and Washington, D.C. In order to document the competitive ability of this self-seeded naturalized species, a greenhouse competition study was conducted with *Panicum virgatum* L. 'Forestburg' (P), switchgrass, and several non-native, naturalized biotypes of *Miscanthus sinensis* (M) grown from seed collected from the above locations. Seedlings were transplanted into #1 (2.88 L) containers in nine different planting arrangements: 2M; 4M; 8M; 2M2P; 4M4P; 8M8P; 2P; 4P; 8P, and grown for 15 weeks. Growth measurements were taken during the 15 weeks. At harvest, shoot and root dry weights were calculated. *Panicum* had significantly larger root (0.50 g vs. 6.00 g) and shoot (6.96 g vs. 2.3 g) biomass, respectively, than *Miscanthus*. Intraspecific competition in monocultures was significantly higher for *Panicum* than *Miscanthus*. *Panicum* showed higher competitive ability than all *Miscanthus* biotypes, with one exception: root dry weights of one Pennsylvania biotype. *Panicum* increased in dry weight at the expense of *Miscanthus*. *Panicum* dominated *Miscanthus* during the 15 weeks and, in this study, proved to be a better competitor than *Miscanthus*. *Miscanthus* and *Panicum* did not fully share the common limiting resources and they showed partial resource complementarity. *Miscanthus* biotype variation was evident; the highest dry weights were from a Pennsylvania biotype and the smallest weights were from a Washington, D.C., biotype.

Provenance Affects Growth of *Taxodium distichum* in Containers

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Seedlings from 13 open-pollinated families of *Taxodium distichum* (L.) L.C. Richard from the gulf coast, central and south Texas, and Mexico were grown in a nursery in College Station, Texas. Forty seedlings per family were measured on three dates during the production cycle; 99, 109, and 133 days after sowing in Spring and Summer 2004. A two-step cluster analysis based on height and trunk diameter created 3 clusters of families. Cluster 1 had a mean height of 32 cm and a mean trunk diameter of 3.3 mm. Cluster 2 had a mean height of 33 cm and a mean trunk diameter of 3.4 mm. Cluster 3 had a mean height of 43 cm and a mean trunk diameter of 4.1 mm. Although clusters 1 and 2 are statistically significantly different, practically there is little difference between the two. The families from Mexico and central Texas were all in cluster 1 or 2 and the families collected from the gulf coast were all placed in cluster 3, with the exception of a single family from Biloxi, Miss., which was placed in cluster 1. Analysis of covariance revealed that family membership and days after sowing were both highly significant, as well as an interaction between family and days, for height. Families from Mexico and central and south Texas were 10 to 15 cm shorter than the families from the gulf coast, with the exception of the single family from Biloxi, Miss. Only days and the interaction between family and days were significant for trunk diameter. A pattern similar to the cluster analysis means was seen among the families for trunk diameter in the analysis of covariance.

Freezing Tolerance of Saltgrass (*Distichlis spicata*) Ecotypes

Hrvoje Rukavina*, Harrison Hughes, Yaling Qian

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Efforts are ongoing at Colorado State University to develop turf-type saltgrass cultivars. Prior freezing studies have indicated variation in freezing tolerance in saltgrass lines. Therefore, this study was made to examine relative freezing tolerance of 27 saltgrass clones as related to collection sites in three zones of cold hardiness. Furthermore, these lines were evaluated for fall color retention with the intent to determine if there is a correlation with fall color and freezing tolerance. Saltgrass rhizomes were sampled in mid-winter 2004 from lines established in Fort Collins, Colo., and then subjected to a laboratory-freezing test. Saltgrass freezing tolerance was highly influenced by climate zones of clones' origin ($P < 0.01$) and genotypes within zones ($P < 0.01$). There was a high negative correlation between color retention in the fall and freezing tolerance ($P < 0.01$). Average freezing tolerance of saltgrass clones within zones of origin significantly differed among zones. Ranking of zones for least square mean LT_{50} (OC) was: zone 4 (–17.2) < zone 5 (-14.4) < zone 6 (–11.1). LT_{50} values in zone 4 ranged from –17.8 (accession 72) to –17.0 (accession 87). Clones in zone 5 showed LT_{50} values from –17.8 (accession A29) to –11.9 (accession A137). Zone 6 clones had LT_{50} values that ranged from –9.5 (accession C92) to –12.6 (accession C12). Large intraspecific variation in freezing tolerance may be effectively used in new cold hardy cultivar development. Environmental adaptation inherited by origin of clone is useful in defining clones' adaptation range and may along with fall color retention serve as a selection criterion in saltgrass cold hardiness improvement.

Exploratory Factorial for Nutrient and Water Use in Liquid Culture Micropropagation of Diploid and Tetraploid Daylily (*Hemerocallis* sp.)

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Two tetraploid and two diploid varieties of daylily were micropropagated on a shaker in MS liquid medium containing high and low sugar levels (3% and 6% sucrose), 2 BA levels (0.32 and 3.2 μM), at two densities (57 and 171 explants/L), in the presence (0.32 μM) and absence of ancymidol. Biomass and media use were partitioned for the four genotypes and 32 cultural conditions with three replications (4 × 2 × 2 × 2 × 2 × 3). Genotype greatly effected f resh weight, dry weight, media, sugar and water use, but ploidy had little effect. Vessels at high density (171 explants/L) produced 1.8× more fresh weight, 1.4× more dry weight, used 1.6× more media and sugar than low density (57 explants/L). Plants from low density were 1.7× larger, 2× greater dry weight, and used 2× more sugar and media, than from high-density culture (per explant). Doubling the initial sugar level increased dry weight and sugar use 1.3×. There was a linear relation between sugar residual and percentage of dry weight ($R^2 = 0.55$, $P < 0.0001$), where a 1% increase in °Brix raised percentage of dry weight 1.8 units over the range of 9% to 22%. Ancymidol and BA had less effect on plant size, sugar and media use than genotype or plant density. Greenhouse survival was reduced by including ancymidol (90% to 30%) and increased BA concentration (85% to 35%). Lab plant density and initial sugar concentration had no apparent effect on greenhouse growth. 'Barbara Mitchell' had greatest mass, used more sugar and media than the other varieties, yet had least greenhouse growth. Nutrient use with 'Barbara Mitchell' was linearly correlated (R^2>80%) to lab growth for seven of 12 ions. P and Fe supply was inadequate to support optimal growth, as indicated by low residual in media (>1% of MS formulation).

Oral Session 10—Cross Commodity Nutrition I

Moderator: John M. Smagula

19 July 2005, 8:00–9:15 a.m. Room 106

Effects of Raising Lowbush Blueberry Leaf Cu Concentration on Growth and Yield

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Two experiments evaluated the Trevett (1972) Cu standard of 7 ppm by raising leaf Cu concentrations in a commercial blueberry field having low (~4 ppm) leaf Cu concentrations. A foliar spray of Cu Keylate (5% Cu) (Stoller Enterprises, Inc.) in a volume of 627 L·ha^{-1} applied 0, 0.56 1.12, 1.68, or 2.24 kg·ha^{-1} of Cu. Ammonium sulfate at 3.1 kg·ha^{-1} was added to the solutions to enhance Cu absorption. A preemergent soil application of Micromate Calcium Fortified Mix (Stoller Enterprises, Inc.), a micronutrient mixture containing Cu (0.3%), was also tested at 14 kg·ha^{-1}. These 6 treatments were replicated 7 times in a randomized complete-block design in 2001. Treatments were reapplied in 2003 in a split-plot design with Cu treatments as the main plots and an application of DAP at 448 kg·ha^{-1} as the split plots. In 2001, leaf Cu concentrations increased linearly, up to 12 ppm, with increasing rates of Cu, but Micromate had no effect. Leaf N and P concentrations were below the standards of 1.6% and 0.125%, respectively, and could explain why raising leaf Cu concentrations had no effect on growth or yield. In 2003, DAP corrected the N and P deficiency and leaf Cu concentrations were raised to above the 7 ppm standard with 2.24 kg·ha^{-1} of Cu, but again, no effect on growth or yield was found. The Cu standard appears to be too high.

Potassium Fertigation Improves Tomato Yield and Fruit Color

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The effect of K fertigation through buried drip irrigation on processing tomato (*Lycopersicon esculentum* Mill.) was evaluated in two California field trials in 2004, and soil K dynamics was investigated in greenhouse trials. Fertigation trials were conducted in fields with exchangeable soil K of 190 (site 1) and 270 mg·kg^{-1} (site 2), above the yield response threshold by traditional preplant or sidedress K application established by prior research. Two fertigation strategies were compared to an unfertilized control: continuous fertigation at 100 mg·L^{-1} K from early fruit set through early fruit color development, and weekly application of 40 kg·ha^{-1} K over the same period. In both treatments, a total of 200 kg·ha^{-1} K (from KCl) was applied. K fertigation significantly increased fruit yield at site 2, and improved fruit color at both sites. In the greenhouse experiments, fescue (*Festuca arundinacea*) was grown for 2 weeks atop columns of eight soils ranging from 120–380 mg·kg^{-1} exchangeable K; the columns were wetted from the bottom, by capillarity. The fescue roots were separated from the soil by a nylon fabric that prevented root penetration while allowing the penetration of root hairs, creating a two-dimensional root/soil interface. In all soils, fescue K uptake reduced soil exchangeable K only in the top 2 mm of the columns, suggesting that effective K diffusion was very limited. In columns of 200-mm height, applying 100 mg·kg^{-1} K in the water used to wet the soil had minimal impact on fescue K uptake. In columns of 15-mm height, this method of K application more than doubled fescue K uptake in all soils, suggesting that the effective limit of K movement was between 15-200 mm.

Phosphorus Fertilizer Calibration Studies with Three Mustard Cabbage Varieties in Tropical Soils with Initial High P Levels

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Regulatory agencies are concerned about the high levels of P fertilizers used in some agricultural areas because of potential runoff to aquatic habitats. Farmers in Hawaii traditionally make blanket P applications even in soils high in P. Many farmers, especially those growing leafy crops, claim to observe responses to P, especially during the cooler winter months. A series of 15 field experiments were conducted over a 2-year period to evaluate the response of three mustard cabbage varieties to five P fertilizer rates across three locations in the state, and across several planting seasons. All experiments were conducted in soils with P levels that the University of Hawaii determined to be high in P. The experimental design for each experiment consisted of three commercial mustard cabbage varieties, and five P application rates (from 0 to 400 kg·ha^{-1} of TSP). Each plot consisted of a 3-m double-row, with plants spaced 15 cm within the row, and 30 cm between rows, with four replications per treatment. Each experiment thus consisted of 60 plots (three varieties × five P rates × four replications). After the initial P applications were made on each site, three consecutive crops were planted on the same site without making any additional P applications. Data collected included soil fertility prior to initiation and after experiment completion, tissue nutrient levels, plant height during crop establishment, and individual head weight of 20 plants per treatment. Our data show that even in soils with initial high levels of P, mustard cabbage responded to P applications, especially at high elevations and during the cooler months of the year. From this data we recommend that the University recalibrate its P fertilizer recommendations for leafy vegetable production in Hawaii.

Papaya (*Carica papaya*) Transplant Growth and Quality as Affected by Nitrogen and a Soil-applied Seaweed Extract

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Experiments were conducted to assess the effects of rate combinations of nitrogen (N) and a soil-applied biostimulant based on seaweed (*Ascophyllum nodosum*) extract (SSE) on the growth of papaya seedlings

for transplant production. Seedlings were grown in 180-mL Styrofoam containers filled with a sphagnum/vermiculite/perlite growing medium. N (0 to 2 g per plant) and SSE (drench, 0 to 1 mL per plant) were applied at sowing and 15 days after emergence. N and SSE rates affected overall growth as well as time to attain adequate size for transplanting. In general, increasing N rates resulted in increased growth, and adding SSE enhanced N effects. In terms of increasing overall transplant growth and decreasing the time required from emergence to adequate transplanting size, the best results were found at the highest N and SSE rates.

Effects of High Nutrient Solution EC and Its Application Timing on Lycopene, Soluble Sugars, and Chlorophyll Concentrations of Tomato (*Lycopersicon esculentum* Mill.) Fruit

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Manipulation of the electrical conductivity (EC) of the hydroponic nutrient solution has been studied as an effective method to enhance flavor and nutritional value of tomato fruit. The objective of this research was to quantitatively understand the accumulation of lycopene, soluble sugars, and the degradation of chlorophyll in fruits as affected by EC and EC application timing relative to fruit ripeness stages. 'Durinta' tomato was grown hydroponically inside the greenhouse under two EC (2.3 and 4.5 $dS \cdot m^{-1}$). The high EC treatment began immediately after anthesis (HEC treatment) or 4 weeks later (DHEC treatment), when fruits had reached maximum size, but still were green. Fruits were harvested weekly beginning 2 weeks after anthesis, until they reached red ripe stage. The chlorophyll concentration in tomato fruits showed no difference between treatments when compared at the same ripeness stages. The lycopene concentration of red ripe tomato fruits in HEC and DHEC treatments was 29% greater than that in low EC control (LEC treatment). However, there was no significant difference in lycopene concentration between HEC and DHEC. Both DHEC and HEC increased total soluble solid concentration (TSS) of red ripe tomato fruits compared with those grown in LEC; while the DHEC showed an increase of fruit TSS of 12%, the HEC had a greater enhancement of TSS of 19%. In addition, the fruit ripeness was accelerated under high EC, regardless of the timing of treatment. High EC treatment at early and mature green fruit developmental stages enhanced both fruit TSS and lycopene concentration; however, the nutrient solution EC effect on lycopene concentration was not dependent on the time of application during fruit development.

Oral Session 11—Genetics and Germplasm 1

Moderator: Kim S. Lewers

19 July 2005, 10:00 a.m.–12:00 noon Room 102

Lemon Cultivar Selection Trials in Arizona

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Two lemon [*Citrus limon* (L.) Burm.] cultivar selection trials are being conducted at the Yuma Mesa Agriculture Center in Somerton, Ariz. Some selections in these trials include: 'Allen Eureka', 'Berna', 'Cook Eureka', 'Cascade Eureka', 'Cavers Lisbon', ' Strong Lisbon', 'Femminello Comune', 'Lapithkiotiki', 'Limoneira 8A Lisbon', 'Limonero Fino 49', 'Monroe Lisbon', 'Primofiori', 'Santa Teresa', 'Walker Lisbon', and 'Villafranca'. Selections that have had superior yields include 'Cascade Eureka', 'Cook Eureka', ' Strong Lisbon', 'Limoneira 8A Lisbon', 'Limonero Fino 49', 'Primofiori', 'Femminello Comune', and 'Villafranca'. Fruit size data suggest that 'Limonero Fino 49' has consistently good fruit size, and consistently larger fruit than 'Limoneira 8A', the industry standard. 'Cavers Lisbon' and 'Femminello Comune' also have good fruit size. 'Lapithkiotiki' also had large fruit size, but its shape was unacceptably elongated. We also found significant differences in peel thickness and juice pH among the selections. 'Santa Teresa' had significantly lower juice pH and a thinner peel than some of the other selections under evaluation.

Differential Response of Cushaw Squash (*Cucurbita argyrosperma* Huber) Lines, Hybrids, and Landraces in Spring versus Fall Culture in Sonora, Mexico

Heli Cain Nunez-Grajeda, Sergio Garza-Ortega*

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Cushaw squash is cultivated in northwest Mexico mainly during the fall and to a lesser degree in the spring season, in which a lack of fruit production in experimental and commercial materials has been observed. This work was done to test 12 lines, 16 hybrids and six landraces regarding fruit and seed weight, flesh color, and soluble solids content (SSC) in both spring and fall seasons in year 2002. Estimates of fruit and seed yield were done. The crop was established by direct seeding at 0.5-m spacing between plants, on both sides of furrow-irrigated beds measuring 15 m long and 4 m wide. In the spring, fruit weight changed from 2.7 to 4.7 kg and seed weight from 17 to 118 g/fruit; fruit yield varied from 3.2 to 38.8 $t \cdot ha^{-1}$ and seed yield from 18 to 1131 $kg \cdot ha^{-1}$. Thirty-two percent of the genotypes, including lines and hybrids, but not landraces, were fruitless. SSC and flesh color had values from 4% to 7.5% and from 5.22 to 6.94 Y, respectively. For the fall culture all the genotypes showed good fruit set. Fruit weight in this season changed from 0.8 to 3 kg and seed weight from 22.3 to 97 g/fruit; fruit and seed yield varied from 4 to 28 $t \cdot ha^{-1}$ and from 135 to 923 $kg \cdot ha^{-1}$, respectively. All of the landraces were severely infected with squash leaf curl virus and had very low yields. SSC and flesh color, in this season, had values from 3.6% to 10.4% and from 5.1 to 7.94 Y, respectively.

The Trouble with Genetic Mapping of Raspberry

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Researchers developing new cultivars of red raspberry (*Rubus idaeus* subsp. *idaeus* L.) and black raspberry (*R. occidentalis* L.) observe progeny of breeding populations for several seasons to identify those that perform reliably. If a portion of any breeding population could be eliminated based on a qualitative character or molecular marker, resources used for that portion could be used for other progeny. Our objective is to identify such molecular markers for red raspberry and black raspberry. A black raspberry × red raspberry cross was made to develop a map of each parent, and an F_2 population was generated to join the maps. Simple sequence repeat (SSR) markers derived from red raspberry and strawberry were used. The level of homozygosity for the red raspberry was 40%, and the level for the black raspberry was 80%. Severe segregation skewing was observed in the F_2 generation and indicates problems with transmission. Our findings help quantify the relative levels of homozygosity previously reported for red raspberry and black raspberry. In addition, the severe skewing observed in the F_2 generation provides a molecular perspective to the fertility problems previously reported for the black raspberry × red raspberry hybrids (purple raspberry). Since black raspberry is highly homozygous, purple raspberry has transmission and fertility problems, and black raspberry breeders have reported a frustratingly low level of diversity in this subgroup, development of a black raspberry map is expected to require twice the markers as for a red raspberry map, emphasizing the need for a black raspberry sequence from which to develop molecular markers.

Resistance to *Cucurbit Leaf Crumple Virus* in Melon

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Cucurbit leaf crumple geminivirus (CuLCrV) is transmitted by sweetpotato whitefly (*Bemisia tabaci*) biotype B (SPWF-B) and occurs on

cucurbits in Arizona, California, Texas, and Mexico. This virus is identical to *Cucurbit leaf curl virus*, and their symptoms are similar to *Squash leaf curl virus* on squash (*Cucurbita* sp.) and *Melon leaf curl virus* on melon (*Cucumis melo* L.). Melon has been reported to be either susceptible to CuLCrV, or to have the ability to recover from infection. Twenty-three melon cultigens were inoculated with CuLCrV in greenhouse tests using SPWF-B. Eighteen of the cultigens tested were highly susceptible to CuLCrV (≥60% infected plants) and generally exhibited pronounced CuLCrV symptoms: 'Amarillo', 'Edisto 47', 'Esteem', 'Fuyu 3', 'Impac', 'Moscatel Grande', 'Negro', 'Perlita', PI 234607, PI 236355, PI 414723, 'PMR 5', 'Seminole', 'Sol Dorado', 'Sol Real', 'Top Mark', 'Vedrantais', and WMR 29. Five cultigens were resistant to CuLCrV (<40% infected plants that exhibited restricted, mild symptoms): MR-1, PI 124111, PI 124112, PI 179901, and PI 313970. Symptoms abated with time in both groups although infected plants remained positive for the virus. Ten of the cultigens ('Edisto 47', 'Fuyu 3', 'Impac', MR-1, PI 124112, PI 313970, PI 414723, 'PMR 5', 'Top Mark', and WMR 29) were included in field tests in 2003 and 2004 that were naturally infected with CuLCrV. With the exception of PI 414723, the greenhouse and field data were consistent for reaction to CuLCrV.

New Sources of Lettuce Aphid Resistance in Lettuce

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Lettuce aphid (*Nasonovia ribisnigri* Mosley) is a recent insect pest to lettuce (*Lactuca sativa* L.) production in the United States. The single dominant gene, *Nr*, conditions resistance to the lettuce aphid in *Lactuca virosa* accession IVT280 from The Netherlands and is available in a limited number of commercial lettuce cultivars. New and genetically unique sources of resistance are sought to broaden the genetic base for resistance to the lettuce aphid. About 1200 lettuce PI lines were evaluated for resistance to lettuce aphid in greenhouse tests using a strain of lettuce aphid obtained from commercial lettuce in Salinas Valley, Calif. In 2002, plants were individually infested with five 24-hour nymphs per plant (controlled protocol), and the numbers of aphids per plant were counted 10–14 days post-infestation (dpi). Beginning in 2003, plants were mass-infested (mass protocol) with nymphs and alates of various ages and numbers. Using the mass protocol, the number of aphids per plant 10–14 dpi were estimated and categorized using a 1–5 scale where 1 = 0 aphids per plant, 2 = 1–10 aphids per plant, 3 = 11–20 aphids per plant, 4 = 21–30 aphids per plant, and 5 = >30 aphids per plant. 'Salinas' and 'Barcelona' were included as susceptible and resistant controls, respectively. Most of the accessions were susceptible. A few accessions had a few plants with very low numbers of aphids after repeated infestation, but their progeny were susceptible. Two accessions were highly resistant: PI 491093, a *Lactuca serriola* accession from Turkey, and PI 274378, a *L. virosa* accession from France. Inheritance of resistance in these two accessions and their allelism to *Nr* remains to be determined.

Identified Resistance in Lettuce Germplasm to Verticillium Wilt Caused by *Verticillium dahliae*

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Since its appearance in 1995, Verticillium wilt of lettuce has spread through the Salinas River Valley, where nearly 60% of California's lettuce acreage is located. A replicated field trial was conducted to assess various modern and heirloom lettuce (*Lactuca sativa*) cultivars, plant introductions, and *L. virosa* lines for resistance to Verticillium wilt. Based on horticultural type, lettuce plants were destructively sampled at harvest maturity and assessed for the incidence of Verticillium wilt. Of the *L. sativa* cultivars, only the iceberg type displayed pronounced foliar symptoms of stunting and wilting. Disease incidence based on root symptoms ranged from 0% to 100%, with continuous variation found across and within lettuce types. Most cos, crisphead, and leaf cultivars exhibited 20% or greater disease incidence. Butter cultivars exhibited the lowest disease incidence among the major lettuce types examined, and Latin and Batavia type cultivars exhibited the lowest disease incidence overall. Disease progression was further monitored for 10 select lettuce cultivars for 2 weeks past harvest maturity. Disease intensity increased over the 2-week period for some cultivars, demonstrating the need to assess plants for Verticillium wilt past harvest maturity to avoid misclassifying plants. The *L. sativa* plant introduction lines tested, predominantly stem and oil-seed horticultural types, were quite susceptible and exhibited distinct symptoms of wilt and defoliation, possibly due to their elongated growth habit. The variation in disease incidence among the *L. virosa* lines tested was discontinuous, with discrete differences in susceptibility. Overall, the results reflected trends found in previous greenhouse and field trials.

New Gene Candidates for the Regulation of Winter Dormancy in Perennial Plants

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'Evergrowing' (*evg*) peach is a naturally occurring mutant unable to enter winter dormancy in response to dormancy inducing conditions. The *evg* mutant is one of only two described mutants affecting winter dormancy in woody perennial trees. The *evg* mutation segregates as a single recessive gene and previous work by our group has fine mapped the trait between flanking markers separated by 3.3 centiMorgans. This region was physically mapped using a bacterial artificial chromosome (BAC) library from and a contig of overlapping genomic fragments identified. We have utilized several approaches to complete the sequencing of a 132 kilobase region of the peach genome derived from three overlapping BACs that encompass the complete EVG gene containing region. We present here our analysis and annotation of the genomic region, including putative and experimentally verified gene coding sequences. A primary feature of the region is a large tandem duplication of a region containing a MADS-box type DNA binding transcription factor resulting in six similar copies of the gene, all of which appear to be expressed at the mRNA level in wild-type germplasm. Hybridization analysis revealed the presence of a large deletion in the mutant genome. Five of the identified genes fall within the *evg* mutation and represent new candidates for the control of entrance into winter dormancy.

Collection and Preliminary Evaluation of Turkish Strawberry Germplasm

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Fragaria species are in different plodiy levels (from 2n = 2x = 14 to 2n = 8x = 56) and distributed in almost all parts of the arable areas of the world. The flora of Turkey has wild strawberries, some of which are harvested for their small, but very aromatic berries. There are also old cultivars found in Turkey that are known for their aromatic fruits. We made collection trips to the Marmara and Black Sea areas to collect both wild strawberries and old cultivars in Summer 2004. During these trips, we sampled 50 populations from the altitudes of 6 to 2007 m, lat. 35°91'N to 41°76'N latitudes, and long. 26°81'E to 42°65'E. The samples were propagated in a greenhouse and evaluated in a replicated trail for both taxonomic and horticultural traits in an unheated greenhouse. The chromosome numbers of the genotypes were also determined. The results indicate that Turkish strawberry germplasm consists of both diploid and octoploid species. The principal components and cluster analysis separated the genotypes into three groups: octoploid cultivars and/or derivatives (e.g., 'Madame Moutot'), and two diploid *Fragaria* species, *vesca* and *viridis*. Further relationships of the genotypes will be discussed.

Oral Sesssion 12—Vegetable Crops Culture & Management 1

Moderator: Albert Sutherland

19 July 2005, 10:00 a.m.–12:00 p.m. Room 106

Influence of Tillage Method and Insecticide on Asian Eggplant Production

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Many growers in the St. Louis metro east area in Illinois are growing a diversity of vegetable products to satisfy local market demand, including many Asian vegetables. In 2003 and 2004, an experiment was conducted at a grower location in Belleville, Ill., to evaluate the effect of tillage method (tillage vs. no-tillage) following no-tillage corn (*Zea mays*) and insecticide treatment (imidacloprid, carbaryl, and none) on growth and productivity of three Asian eggplant (*Solanum melongena*) cultivars ('Ichiban', 'Little Fingers', and 'Millionaire'). Regardless of cultivar, imidacloprid resulted in greater plant growth for most of the growing season, resulting in higher early and total-season yields compared to the other insecticide treatments. Flea beetle (numerous species, including *Epitrix fuscula* and *Epitrix cucumeris*) damage to eggplants can be severe during the early part of the growing season in southern Illinois, which can drastically reduce plant growth and subsequent yields. Although carbaryl was applied at 10-d intervals for most of the growing season, flea beetle damage was similar to the no insecticide treatment and resulted in significant growth reduction and yield loss compared to imidacloprid. Tillage methods did not differ ($P > 0.05$) for Asian eggplant productivity or flea beetle damage. Cultivar performance was similar over the tillage method and insecticide treatment as no significant interactions ($P > 0.05$) were detected. However, cultivars differed for productivity with 'Millionaire' and 'Ichiban' generally providing higher marketable and total yields than 'Little Fingers'.

Fall Cover Crops for Reducing Nitrate Leaching in Cool Season Vegetable Production in the Salinas Valley

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Lettuce growers in the Salinas Valley are often not able to rotate to other crops due to economic pressure, such as high land rent. Winter-grown cover crops (October to March) provide a short-term rotation from lettuce and have been shown to reduce nitrate leaching by 75%. However, the use of winter-grown cover crops is low due to the extended time these cover crops tie up the ground. As a result, growers are interested in the potential of fall-grown cover crops (September to October) to reduce nitrate leaching through the winter. Fall-grown cover crops are incorporated into the soil prior to the onset of winter rains and leave the soil bare over the winter; however, during fall growth, the cover crop has the potential to capture excess nitrate that may leach during the fallow period, but how much has not been previously measured. A long-term trial was established in Fall 2003 using treatments of Indian mustard (*B. juncea*) 'ISCI 61', White mustard (*S. alba*) 'Ida Gold', Cereal rye (*Secale cereale*) 'Merced', and a no cover crop control. All cover crops contained ≈224 kg·ha^{-1} N upon incorporation. Anion resin bags were installed 90 cm deep in the soil following incorporation to trap leaching nitrate; they were left in place until planting of the lettuce the following spring. First-year results indicated that the mustard cover crops and 'Merced' rye all reduced nitrate leaching to the 90-cm depth by 67% to 82% over the bare fallow treatment. These results indicate that fall-grown cover crops have the potential to reduce nitrate leaching in lettuce production systems in the Salinas Valley.

Using Polyacrylamide (PAM) for Reducing Sediment and Nutrient Losses from Cool Season Vegetable Fields

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Agricultural runoff is a source of nutrients and sediments in surface water on the central coast of California. Treating soils with high molecular weight anionic polyacrylamide (PAM) may reduce sediments and P lost from furrow and sprinkler irrigated fields by maintaining infiltration and stabilizing soil aggregates. We conducted column and field studies to quantify the effect of PAM on infiltration rate, run off, and sediment and nutrient (ortho and total P, NO_3, K) loss from cool season vegetable fields. Column studies demonstrated a reduction in infiltration for 10 soil types when PAM was continuously applied in the irrigation water at 10 ppm. Recirculating infiltrometer studies showed that in furrow systems, PAM, applied only in the initial water at 10 ppm, had no significant effect on infiltration at four of six sites evaluated. Turbidity and total suspended solids were significantly reduced in the PAM treated water. Across all sites, treatment with PAM reduced suspended solids by 85% compared to the untreated control. Additionally, soluble and total P, and total N were reduced in the PAM treated water. PAM had no effect on nitrate or salt levels in the runoff. PAM applied through sprinklers at a 5 ppm concentration was able to significantly reduce the turbidity and the suspended solids in the tailwater. Similar to the results obtained with the recirculation infiltrometer trials, PAM reduced soluble and total P and total N in the runoff, but had no significant effect on NO_3-N. Total sediment loss under sprinklers was reduced by as much as 95% using PAM.

Improving IPM Decision Support in Vegetable Crops through Weather-based Disease Advisories

Albert Sutherland*[1], John Damicone[2], Rafal Jabrzemski[3], Stdrovia Blackburn[3]

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Weather-based disease advisories have allowed vegetable producers to optimize their fungicide applications. These models typically use only past weather data to identify times of potential disease outbreak. The Oklahoma Mesonet has developed a new Spinach White Rust Advisory that improves grower disease decision support by combining forecast, current, and past weather data in calculating infection periods. The decision-support component issues initial spray advisories, based on infection hour accumulation from the first true-leaf stage or from a previous fungicide application date for subsequent sprays. The advancement in this model in relation to traditional weather-based disease advisories are: incorporation of an 84-hour forecast, hourly model recalculation, cultural practice customization, user site selection from any of 110+ statewide sites, and immediate access to detailed historical data. The model is available on the Oklahoma Mesonet AgWeather website (http://agweather.mesonet.org).

Use of Compost as an Alternative to Methyl Bromide for Vegetables

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We evaluated the influence of three compost sources and compost amended with T382 with fumigant Telone C-35 and various combinations of compost and Telone C-35 on the yield and pest management of cucumber, pepper, tomato, collard, southern pea, and summer squash in a multicrop rotational system. In the first year, there were few differences between the compost treatments and Telone C-35, but all treatments resulted in more yield than the control. In the second year, all compost treatments and/or Telone C-35 improved total and marketable yield of cucumber, pepper, tomato, southern pea, and summer squash. Furthermore, in the second year, Telone C-35 treat-

ments produced more yield than some of the compost treatments in tomatoes. Combining Telone C-35 with compost did not differ from either treatment alone. Nematode and disease assessments were not consistent and will be discussed in further detail.

Tomato Yield Stability during Five-year Transition to Conservation Tillage and Cover Cropping

Jeffrey P. Mitchell*[1], William R. Horwath[2], Karen K. Klonsky[3], Randal J. Southard[2], Rich DeMoura[3], Daniel S. Munk[4], Kurt J. Hembree[4]

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Eliminating tillage passes is a means to reduce production costs and dust emissions in California's San Joaquin Valley tomato production region. Inserting winter cover crops between summer crops may be a way to add organic matter to the soil and thereby improve soil quality. From 1999, we evaluated conservation tillage (CT) and cover cropping (CC) in a tomato/cotton rotation in Five Points, Calif. During the course of the study, tillage operations were reduced an average of 50% in the CT system relative to the standard tillage (ST) approach. Yields in the CT no cover crop (NO) system matched or exceeded yields in the STNO system in each year. Tomato yields in the CTCC and STCC systems were comparable to the STNO except in the first year, when stand establishment and early season vigor were problems. Weed management and machine harvest efficiency in high surface residue systems are issues requiring additional work in order to make CT adoption more widespread.

Biofumigation and Soil Conditioning Effects of Cover Crops in Processing Tomato

P.R. Johnstone*[1], T.K. Hartz[1], E.M. Miyao[2], R.M. Davis[3]

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Mustard cover crop residue has been reported to have a "biofumigant" action when incorporated into the soil, potentially providing significant disease suppression and yield improvement for the succeeding crop. Such activity could be particularly useful in processing tomato rotations, where consecutive cropping invariably results in yield decline. Agronomic and environmental effects of growing over-winter mustard cover crops preceding tomato production were investigated in three field trials between 2002 and 2004. Two mustard cover crops ['Pacific Gold', a brown mustard (*Brassica juncea*), and 'Caliente', a blend of brown and white mustard (*Sinapis alba*)] were compared to a legume cover crop mix, a fallow bed treatment (the standard grower practice in this region), and, in two of the three trials, a fumigation treatment using metam sodium. No suppression of soil populations of *Verticillium dahliae* or *Fusarium* spp. was observed with the mustard cover crops, nor was there any visual evidence of disease suppression on subsequent tomato crops. In these fields, the mustard either had no effect, or reduced tomato yield, when compared to the fallow treatment. At one of two sites, metam sodium fumigation significantly increased tomato yield. The presence of a cover crop, whether mustard or legume, reduced winter runoff by an average of 50% over two years of trials. No benefit of mustard cover cropping beyond this reduction in winter runoff was observed.

Vegetable Science International Network (VEGINET)

Prem Nath*

P.N. Agricultural Science Foundation (PNASF), Chairman, Convener, VEGINET, #9, 1st Cross, 1st Main, 1st Block, Rajmahal Vilas (RMV) Extension 2nd Stage, Bangalore, Karnataka, 560 094, India

At the International Conference on Vegetables held 11–14 Nov. 2002 in Bangalore, India, about 700 participants from 37 countries across the globe discussed more than 600 papers and posters presented on its 13 theme areas of scientific, technological, and economic importance. It was recognized that this phenomenal knowledge and much more of it that is globally available and will be available in the future should be collected, consolidated and easily retrieved and shared for appropriate use by the stakeholders. Therefore, the General Assembly of the Conference ICV-2002 decided to establish the Vegetable Science International Network (VEGINET). The goal of VEGINET will be to strengthen partnership and inter-institutional cooperation among the member organizations of the vegetable sector toward improved production and utilization of vegetables. The main objectives will be to strengthen/promote vegetable research and development by facilitating inter- and intra-regional and inter-institutional cooperation; promote partnership between public and private sectors for improving vegetable production; facilitate development of human resources; promote improved and sustainable production of vegetables for food; develop a collaborative network for dissemination of information among the member organizations; and facilitate building of a sustainable infrastructure from the farm to the consumer and processor. The rising challenge, structure and membership, partnership, human resource development, mandate and strategy, activities, and resource generation of the VEGINET will be explained during the presentation.

Oral Session 13—Nursery Crops 1

Moderator: James S. Owen, Jr.

19 July 2005, 10:00–11:00 a.m. Room 107

Whole-plant Photosynthesis of Containerized Hydrangeas and Abelias as Affected by Substrate Moisture Content

Marc W. van Iersel*, Sue Dove

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Efficient water use in nurseries is increasingly important. In recent years, new soil moisture sensors (ECH_2O probes) have become available, making it possible to monitor the moisture content of the growing medium in containers. One piece of information that is lacking for fully-automated irrigation systems is how much water actually needs to be present in the growing medium to prevent detrimental effects of drought on plants. We determined the effect of substrate moisture on photosynthesis and plant water relations of hydrangea and abelia. Growth rates of these species were measured during two subsequent drying cycles to determine how drought affects the growth rate of these species. Whole-plant photosynthesis, an indicator of growth rate, of both species remained stable as the volumetric moisture content of the substrate dropped from 25% to 15%, with pronounced decreases in photosynthesis at lower substrate moisture levels. Abelias and hydrangeas wilted when the substrate moisture level dropped to 6.3% and 8.3%, respectively. At wilting, abelias had lower leaf water potential (–3.7 MPa) than hydrangeas (–1.8 MPa). After the plants were watered at the end of the first drying cycle, the photosynthesis of the plants did not recover to pre-stress rates, indicating that the drought stress caused a long-term reduction in photosynthesis. Despite the more severe drought stress in the abelias (both a lower substrate water content and lower water potential at wilting), abelias recovered better from drought than hydrangeas. After the plants were watered at the end of the first drying cycle, the photosynthetic rate of abelias recovered to ≈70%, while the photosynthetic rate of the hydrangeas recovered to only 62% of the pre-stress rate.

Border Patrol: Epicuticular Leaf Wax Mediates Resistance of Azalea Genotypes (*Rhododendron* spp.) to Azalea Lace Bug [*Stephanitis pyrioides* (Scott)]

Matthew Chappell*, Carol Robacker, Sherrod Baden, Allen Byous

University of Georgia, Horticulture, Griffin, GA, 30223

Azalea lace bug (ALB) is a significant pest on azalea, with feeding injury causing speckling and discoloration on affected leaves. Feeding damage also results in a reduction of stomatal gas exchange and leaf chlorophyll content, postulated to diminish growth and flowering rates.

In azalea, specific lipid components of the plant cuticle have been implicated in ALB resistance of *R. canescens*. In this study, epicuticular leaf wax was extracted from the leaves of four azalea genotypes, divided into two groups: a resistant group including *R. periclymenoides* and 'Fourth of July' and a susceptible group including *R. austrinum* and 'My Mary'. Leaf wax was extracted and resuspended in solution for application to all entries in a full diallel manner, including controls of solution only and no treatment. Each genotype–solution treatment included 10 replications. The leaf wax solution was applied to each replication (leaf) by painting the solution on one side of the midrib, yet on both abaxial and adaxial surfaces. Two leaves attached to a stem and four female adult ALB were placed in separate 32-mL sealed cups. Experimental conditions were 24 °C and 12-hour daylength for 96 h, at which time the number of live adults, frass spots, and eggs were counted. Data revealed that application of leaf wax solution had an impact on the level of frass and egg deposition by ALB in both resistant and susceptible genotypes. The effect was most pronounced when a solution of resistant genotypes was placed on susceptible genotypes, as the application resulted in lower numbers of frass spots and eggs compared to the nil control. However, an increase in frass and eggs was observed when extract of susceptible genotypes was applied to resistant genotypes.

Development of Water Need Indices for Irrigation Permits for Three Container Sizes of *Ligustrum japonicum* Thumb.

Richard Beeson*

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

In Florida, ornamental nurseries and other agricultural entities have been required to obtain volume-limited permits for irrigation water since 1992. Since then, volumes permitted for nurseries have declined. This project set out to establish maximum annual irrigation quantities for *Ligustrum japonicum* Thumb. grown in three common container sizes. Plants were scheduled and grown such that every 4 months, beginning 1 Jan., plants 2 months from marketable size would be available to place in suspension lysimeters with accompanying border plants. Once in lysimeters, plant weights were recorded every half-hour for 4 months. At that point, plants were 2 months larger than marketable size, thus averaging marketable size over the 4-month period. Data were collected through six 4-month cycles (2 years), along with daily calculation of reference evapotranspiration and monthly canopy measurements. Irrigation was applied overhead and based on a minimum 30% reduction in plant available water within a container. Daily actual evapotranspiration was used to calculate a water need index for each plant. These water need indices, normalized by different surface areas, will be discussed, along with comparisons of cumulative actual evapotranspiration to irrigation depth applied.

Water and Phosphorus Efficiency in Containerized Crop Production of *Cotoneaster dammeri* 'Skogholm' with an Industrial Mineral Aggregate Amended Pine Bark Substrate

James S. Owen, Jr.*[1], Stuart L. Warren[1], Ted E. Bilderback[1], Joseph P. Albano[2]

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The physical and chemical properties of pine bark yield low water and nutrient efficiency; consequently, an engineered substrate altering the substrate properties may allow greater water and nutrient retention. Past research has focused on controlling the quantity and rate of water and nutrient inputs. In this study, pine bark was amended at 8% (by volume) with a Georgiana palygorksite-bentonite blended industrial mineral aggregate with a particle size of 850 µm-4.75 mm or 300 µm-710 µm to improve water and nutrient efficiency. Each particle size was pretreated at temperatures of ≈140 °C (pasteurized) or ≈390 °C (calcined). The study was a 2 (particle size) × 2 (heat pretreatment) factorial in a randomized complete-block design with four replications. The control was a pine bark substrate amended with 11% sand (by volume). Containers (14 L) were topdressed with 17–5–12 controlled release fertilizer. A 0.2 leaching fraction was maintained by biweekly monitoring container influent from spray stakes and effluent volume measured daily. An aliquot of the daily collected effluent was analyzed for phosphorus (P). After 112 days, tops and roots were harvested, dried, and weighed for dry weight comparisons. Compared to pine bark amended with sand the 300 µm-710 µm particle size mineral decreased mean daily water application by ≈0.4 L/day per container. The calcined mineral reduced P leaching by ≈10 mg of P per container or 60% over the course of the study compared to pine bark : sand. Top and root dry weights were unaffected. These results suggest 300 µm–710 µm calcined mineral provided the most significant decreases in water use and P leaching while growing an equivalent plant.

Oral Session 14—Consumer Horticulture and Master Gardeners

Moderator: Cynthia Haynes

19 July 2005, 10:00–11:15 a.m. Room 108

High and Dry Research in the Front Range, Colorado

Kerrie B. Badertscher*, Irene Shonle, Larry Vickerman, Gary Hall

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The purpose of this study was to gain knowledge about the establishment of drought-tolerant species at high elevations and with no irrigation. Colorado State University Cooperative Extension (CE) had no research-based information about the establishment of no-water gardens, a topic of much relevance in times of drought and for mountain communities with watering restrictions. Research-based information about plant establishment at 7500 feet elevation and above is extremely limited. Test gardens were planted with a standardized planting pallet and in such a way as to be aesthetically pleasing. Each plot was approximately 400 square feet and contained shrubs, perennials, grasses, seeds, and bulbs. A review of the first full year and second growing season will be given along with outreach strategies.

Interactive Web-based Technology Has Wide Applications for Extension Programs

Bodie Pennisi*

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The Internet has become a valuable tool in education in the traditional classroom. Although electronic publications and other visual information in the form of PowerPoint presentations, with or without streaming video, have proven very effective in disseminating information, these forms lack interaction with clientele. Horizon Wimba software circumvents this limitation by allowing interaction between presenter and remote audience as well as between individual students while the lecture is in progress. This Web-based tool was evaluated in two Extension programs, Master Gardener and county agent trainings. With both types of audience, evaluations showed high satisfaction and effectiveness of the delivery of information. Evaluations also showed that Master Gardeners who use the Internet on a regular basis considered the Web-delivered interactive lecture format similar to face-to-face interaction. Master Gardeners who do not use the Internet on a regular basis listed that Web-delivered interactive training could be used as a supplement to traditional face-to-face interaction. County agents were very comfortable with the format and indicated high interest in participating in future trainings via the Internet.

Acceptable Risks—In Science vs. Farming

Mike Murray*[1], Bill Ashcroft[2], B.M. Top[3], G.R. Ashburner[4]

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University of California Extension field staff are well educated and highly trained to conduct sound applied research. Part of this training

includes statistical classes. Data that fail to attain a 95% confidence level are considered "risky." This is inconsistent with "risk" assumed in almost every other aspect of our lives. There are ample examples of people willingly taking "high" risks. Examples include legalized gambling, marriage, insurance actuarial tables, etc. Most of us are willing to take calculated risks, depending on the importance and cost of making an incorrect assumption. This is directly applicable to agricultural production enterprises. While the comfortable level of risk will vary among producers, there is interest in technologies that have confidence levels below 95%. Australian processing tomato researchers have developed a Residual Maximum Likelihood (REML) analysis tool to address this issue. REML was designed to simplify interpretation of a relatively complex data set, including statistics, so a farmer can make choices at a risk level they find appropriate. The model incorporates pairwise *t* tests, an interactive computer program, and a gambling analogy in its analyses. Multiple variables can be entered and the model provides odds that the desired result will be attained. The user can determine the relative importance of each variable as part of the determination. This model, and implications for adoption by producer clientele, will form the basis for the presentation.

A Marketing Feasibility Study of Incorporating Worm Castings into a Substrate Mix for Home Gardening

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Ferry-Morse Seed Company is trying to market worm castings to their customers. Murray State University was asked to compare different percentages of worm castings for use with both bedding plants/vegetables and houseplants. Recommended application rates for worm castings was not to exceed 30%. Two plants were chosen to represent the plant categories deemed important to the consumer: tomato (*Lycopersicon esculentum* 'Rutgers') and spider plant (*Chlorophytum comosum*). Treatment percentages for worm castings were 0% for a control and 10%, 20%, and 30% were incorporated into a soilless media substrate. Treatment 1 consisted of worm castings/soilless media alone and Treatment 2 consisted of worm castings/soilless media with the addition of Peters Professional All-Purpose 20–20–20 fertilizer at 100 ppm nitrogen. Tomatoes were grown from seed and the spider plant propagules were harvested from greenhouse stock plants and sized into small, medium, and large depending on weight. Tomatoes were harvested at 6 weeks and spider plants at 10 weeks. All tomatoes in Treatment 1 had poor visual consumer quality. Visual quality for Treatment 2 tomatoes was best in 20% and 30%. No significant differences were found in Treatment 1 regarding shoot and root weights. Treatment 2 showed significant differences in dry and fresh weight between the control and 20% and 30%. There were visual quality differences with spider plants in Treatment 2 and also significant differences in shoot and root weights between control and all percentages of worm castings in Treatment 2. Based on plant performances, a recommendation to Ferry-Morse Seed Company was to market worm castings in conjunction with a regular fertilizer schedule for maximum plant quality.

Gardening in the Zone: Educational Programming using Mass Media Outlets

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The 2004 report from the National Gardening Association showed that 84 million people (78% of the U.S. population) participated in one or more types of do-it-yourself lawn and garden activities. This creates a substantial consumer group, and an important audience for Cooperative Extension to reach with educational programming. In 2003, a collaborative project between the Iowa State University (ISU) Extension Service, a regional gardening magazine, and regional television stations began as a new avenue to deliver educational programming related to horticulture. Gardening in the Zone is a series of 35 two-minute segments that are broadcast weekly March through October during local morning and evening news programs. Currently, the segments are shown on television stations across the state, resulting in over 95% coverage and reaching viewers in southwestern Wisconsin, northwest Illinois, southern Minnesota, and eastern Nebraska. In just 1 year, the number of stations carrying the segments has doubled. The segments are hosted by a broadcast professional and done in a question and answer format with an introduction, content on the particular topic, and a close. To close the segment the host refers viewers to the ISU Extension Gardening in the Zone website (http://129.186.89.193/gardening/) and the magazine website, which appear on the screen. This format provides a minimum of three potential contacts with the viewer including the real time broadcast, reference to the website, and ultimately, links to Extension publications from the website. These segments provide research-based information to a large audience that traditional Extension programming methods might not otherwise reach.

Oral Session 15—Vegetable Breeding 2

Moderator: Majid R. Foolad

19 July 2005, 2:00–3:30 p.m. Room 101

Classification and Identification of *S*-haplotypes Using PCR-RFLP and Measuring the Self-incompatibility Activity in Radish (*Raphanus sativus* L.)

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Self-incompatibility (SI) in Brassicaceae vegetables prevents self-pollination by recognizing self-pollens and rejecting them at the stigmatic surfaces. The *S*-haplotypes of 47 hybrid radish cultivars that are commercially available in Korea were classified and identified using the polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP). Twelve kinds of *S*-haplotypes were identified from the cultivars: S_1, S_8, S_{11}, S_{17}, S_{18}, S_{30}, and S_{31} haplotypes in class-I *S*-haplotype and S_4, S_5, S_{13}, S_{21}, and S_{26} haplotypes in class-II *S*-haplotypes. Even though the class-II *S*-haplotypes are supposed to exhibit weak and/or leaky SI activity, the class-II *S*-haplotypes showed the same allele frequency of class-I *S*-haplotypes in 38 fully classified commercial cultivars. The SI activity was examined using the pollen tube germination test, flower pollination test, and the seed set ratio analysis. The pollen tube test showed low correlation (R^2 = 0.13) with the flower pollination test, a conventional method. The results of seed set ratio analysis varied from 0% to 159%, and thus could distinguish the weak and strong SI activity clearly and showed high correlation with the flower pollination test (R^2 = 0.69). The seed set ratios of the cultivars possessing the class-I/class-I, class-I/class-II, and class-II/class-II genotypes were 0.6%, 17.4%, and 38.1%, respectively. Among the eight class-II/class-II cultivars, three cultivars showed strong SI activity. The SI activity of the S_4S_{17}, S_5S_8, and S_4S_{26} genotypes varied among cultivars, but the S_1S_{17}, S_5S_{17}, and S_8S_{26} genotypes showed constant strong, intermediate, and strong activity, respectively, among the cultivars. Results indicate that the SI activity of Brassicaceae vegetables depends not only on the *S*-haplotypes, but also on the genetic background of cultivars.

Molecular Marker Development and High Throughput with Microarrays using Diversity Array Technology (DArT)

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Recently, a technology known as DArT (diversity array technology) has been developed to increase throughput in marker assisted selection (MAS). DArT utilizes microarray technology as a method to

potentially compare thousands of molecular markers in one test to a single DNA sample. We used DArT on two sets of interspecific tomato [*Solanum lycopersicum* (Fla 7613) × *S. pennellii* (LA 716 or LA 2963)] segregating populations (BC, F_2, and F_1). We compared over 300 segregating plants to 3840 random tomato genomic fragments. After the 3840 markers were prepared, it took about 2 weeks of laboratory time to perform the experiments. With experience, this time can be reduced. We identified a total of 654 polymorphic markers usable for developing a DArT tomato genetic map. Depending on the particular cross, 13 to 17 linkage groups were identified (LOD 3) per population. Most recently, the amplified polymorphic DNA (AFLP) technique has been used for rapid genetic mapping of large numbers of anonymous genomic fragments. Besides the additional effort and reagents using AFLPs compared to DArT, a desired AFLP polymorphic band is often difficult to clone and process into a PCR based marker, whereas in DArT all markers are already cloned and immediately available for such experiments. A drawback to DArT is that it requires specialized software and equipment and is technically demanding. However, once the equipment and software are secured, techniques are optimized, and segregating populations developed, marker throughput is increased by orders of magnitude. Although challenging, the application of DArT can dramatically increase MAS throughput, thus facilitating quantitative trait and saturated mapping research.

Deployment of Molecular Markers and Marker-assisted Selection in Tomato Breeding

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In tomato, *Lycopersicon esculentum* Mill., currently there are >285 known morphological, physiological and disease resistance markers, 36 isozymes, and >1000 RFLPs, which have been mapped onto the 12 tomato chromosomes. In addition, currently there are >162,000 ESTs, of which ~3.2% have been mapped. Several tomato genetic maps have been developed, mainly based on interspecific crosses between the cultivated tomato and its related wild species. The markers and maps have been used to locate and tag genes or QTLs for disease resistance and other horticultural characteristics. Such information can be used for various purposes, including marker-assisted selection (MAS) and map-based cloning of desirable genes or QTLs. Many seed companies have adopted using MAS for manipulating genes for a few simple morphological characteristics and several vertical disease resistance traits in tomato. However, MAS is not yet a routine procedure in seed companies for manipulating QTLs although it has been tried for a few complex disease resistance and fruit quality characteristics. In comparison, the use of MAS is less common in public tomato breeding programs, although attempts have been made to transfer QTLs for resistances to a few complex diseases. The potential benefits of marker deployment to plant breeding are undisputed, in particular for pyramiding disease resistance genes. It is expected that in the near future MAS will be routine in many breeding programs, taking advantage of high-resolution markers such as SNPs. For quantitative traits, QTLs must be sought for components of genetic variation before they are applicable to marker-assisted breeding. However, MAS will not be a "silver bullet" solution to every breeding problem or for every crop species.

Genotype Analysis of Fruit Color using a Molecular Marker in Watermelon [*Citrullus lanatus* (Thunb.) Matsum & Nakai]

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Fruit color and carotenoid composition are important traits in watermelon. Watermelon fruit color inheritance has revealed that several genes are involved in color determination. Carotenoids are known to have various functions in plants and animals, such as providing antioxidant activity and other health benefits for humans, and UV protection and pigmentation for plants. Differential gene activity in the carotenoid biosynthetic pathway may result in different color determination of mature fruit. Eight genes encoding enzymes involved in the pathway were isolated and their structures were characterized. While obtaining full-length cDNA of these enzymes, two single-nucleotide polymorphisms were detected in a coding region of lycopene β-cyclase (LCYB). These SNP markers showed cosegregation with red and canary yellow fruit color based on the genotyping of two segregating populations. This will lead to development of a codominant molecular marker for the selection of LCYB allele, which may allow breeders to distinguish between red and canary yellow watermelon fruit colors at the seedling stage.

Genetics and Breeding of Early Blight Resistance in Tomato

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Early blight (EB), caused by the fungus *Alternaria solani*, is a destructive disease of tomato (*Lycopersicon esculentum*) worldwide. Sources of genetic resistance have been identified within related wild species, including green-fruited *L. hirsutum* and red-fruited *L. pimpinellifolium*. We have employed traditional protocols of plant breeding and contemporary molecular markers technology to discern the genetic basis of EB resistance and develop tomatoes with improved resistance. Backcross breeding has resulted in the development of germplasm with improved resistance; however, linkage drag has been a major obstacle when using *L. hirsutum* as a donor parent. To identify and map QTLs for EB resistance, we used several filial and backcross populations derived from interspecific crosses between *L. esculentum* and either *L. hirsutum* or *L. pimpinellifolium*. In each population, an average of seven resistance QTLs were detected. While similar QTLs were detected in different generations of the same cross, generally different QTLs were identified in populations derived from different crosses. The results suggested stability of QTLs across environments and generations but variation in QTLs in different interspecific populations. It is expected that marker-assisted pyramiding of QTLs from different sources results in development of germplasm with strong and durable resistance. Further inspection of the results led to the identification and selection of six QTLs with stable and independent effects for use in marker–assisted selection (MAS). However, to facilitate "clean" transfer and pyramiding of these QTLs, near-isogenic lines (NILs) containing individual QTLs in a *L. esculentum* background should be developed.

Screening and Breeding for Leafminer Resistance in Spinach

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Leafminer (*Liriomyza* spp.) is a major insect pest of many important vegetable crops, including spinach (*Spinacia oleracea*). Chemical control is not long lasting, and it is well documented that leafminers can develop a high degree of resistance to insecticides. Resistant varieties remain the most economical means of insect control. The purposes of the present experiments were to evaluate differences in spinach genotypes to leafminer damage, to compare results obtained from insect cages and from the field, and to study the association among different resistant traits. We screened 345 spinach genotypes from the USDA germplasm collection and 441 genotypes from CGN (Holland) and IPK (Germany) spinach collections for leafminer resistance in an outdoor insect cage and in the field. Significant genotypic differences were found for leafminer stings per unit leaf area, mines per plant, and mines per 100 g of plant weight. The sting result from the field was highly correlated ($r = 0.770$) with the result from the insect cage, demonstrating that a cage test could be used to screen for leafminer resistance in the field. Mines per plant were not correlated with plant weight, suggesting that leafminer flies did not lay their eggs randomly and oviposition-nonpreference occurred in these plants. Stings per unit leaf area was not correlated with mines per plant or per 100 g plant weight, which suggests that feeding-nonpreference does not necessarily mean oviposition-nonpreference for a spinach genotype and these

two traits can be improved independently. These findings suggest that genetic improvement of spinach for leafminer resistance is feasible. A phenotypic recurrent selection method is used to increase the level of leafminer resistance in spinach.

Oral Session 16—Floriculture–Crop Physiology

Moderator: Robert H. Stamps

19 July 2005, 2:00–3:15 p.m. Room 106

Quantifying the Thermal Tolerance of Nonrooted Petunia Cuttings and Their Subsequent Performance

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In 2003, commercial greenhouse growers in the United States imported 724 million nonrooted cuttings valued at $53 million. During transit and storage, cuttings can be exposed to environmental stresses (e.g., low or high temperature), which can consequently decrease quality, rooting, and subsequent plant performance. We performed experiments to quantify how temperature and storage duration of cuttings influence root initiation, root number, lateral branch count and length, and time to flower of Tiny Tunia 'Violet Ice' petunia (*Petunia ×hybrida* hort. Vilm.-Andr.). Dry or wet cuttings were harvested and packaged into perforated bags within small, ventilated boxes and then into traditional shipping boxes. The boxes were placed in environmental chambers with temperature setpoints of 0, 5, 10, 15, 20, 25, or 30 °C for 0, 1, 2, 3, 4, or 5 d. Cuttings were then rooted in a propagation house at 26 °C with a vapor pressure deficit of 0.3 kPa under ambient photoperiods. The visual quality rating of dry packaged cuttings decreased with increasing temperature and shipping duration. After 2 d at ≥25 °C, cuttings were horticulturally unacceptable due to water stress and chlorophyll degradation and they never fully recovered. Dry- or wet-packaged cuttings held at temperatures of 0 to 30 °C formed significantly fewer roots and lateral branches as duration increased from 1–5 d. Although cuttings held for 5 d at 0 °C produced 60% fewer lateral branches, they subsequently flowered 5 d earlier than plants held at 0 °C for 1 d. Therefore, exposure to temperatures >15 °C for ≥3 d can reduce petunia cutting quality, delay rooting, and decrease plant size at flowering.

Small Heat Shock Proteins, Morphological and Physiological Characteristics Associated with Heat Tolerance in Salvia (*Salvia splendens*)

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Small heat shock proteins (sHSP) are a specific group of highly conserved proteins produced in almost all living organisms under heat stress. These sHSP have been shown to help prevent damage at the biomolecular level in plants. One of the greatest impediments to production of marketable herbaceous plants and their longevity is high temperature stress. The objectives of this experiment were to study the plant responses in terms of sHSP synthesis, single leaf net photosynthesis, total water-soluble carbohydrates (WSC), and overall growth for two *S. splendens* cultivars differing in performance under heat stress. 'Vista Red' (heat tolerant) and 'Sizzler Red' (heat sensitive) were exposed to short duration (3 hours) high temperature stresses of 30, 35, and 40 °C in growth chambers. Increasing the temperature to about 10 to 15 °C above the optimal growth temperature (25 °C, control) induced the synthesis of sHSP 27 in *S. splendens*. Expression of these proteins was significantly greater in the heat-tolerant vs. the heat-sensitive cultivar. Soluble carbohydrate content was greater in 'Vista Red', and in both the cultivars raffinose was the primary soluble carbohydrate in heat-stressed plants. Overall growth of plants was significantly different in the two cultivars studied in terms of plant height, stem thickness, number of days to flower, and marketable quality. The better performance of 'Vista Red' under heat stress was attributed to its morphological characteristics, including short stature, thicker stems and leaves. sHSPs and WSC are also found to be associated with heat tolerance and heat adaptation in *S. splendens*.

The Effect of Short Days on Cold Acclimation in *Gaura*

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Cold acclimation has been extensively studied in woody species such as *Cornus sericea* and *Malus ×domestica*. These studies have shown that cold acclimation is initiated by short days and completed with the addition of a cold treatment. It is unknown whether herbaceous perennials respond in a similar manner to these environmental cues. Our research objective was to examine short day photoperiod effects on cold acclimation in herbaceous gaura populations collected at different latitudes. *Gaura drummondii* collected in Texas, and *Gaura coccinea* collected in Minnesota and Texas were clonally propagated, grown under a 16-hour long day photoperiod and 25/20 °C [day/night (D/N)] temperature for 8 weeks. Plants were then subjected to 0, 1, 2, 3, 4, or 5 weeks of 8-hour short days at 20/15 °C (D/N) temperatures. Cold acclimation was determined using electrolyte leakage (freezing stem pieces from –1 to –9 °C) and measuring electrical conductivity after treatment and tissue death. Mean separations showed two distinct statistical groupings of 0-2 weeks and 3–5 weeks of short days for Minnesota gaura, whereas Texas gaura overlapped for 0–5 weeks of short day treatments. It is unknown what environmental cue(s) initiate cold acclimation in *Gaura* native to southern latitudes such as Texas.

Water Requirements and Drought Tolerance of Bedding Plants

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Optimal substrate volumetric water content (θ) and drought tolerance of impatiens, petunia, salvia, and vinca were investigated by growing plants under four constant levels of θ (0.09, 0.15, 0.22, and 0.32 $m^3 \cdot m^{-3}$). Gas exchange, quantum efficiency (ΦPSII), electron transport rate (ETR), non-photochemical quenching (NPQ), and leaf water potential (Ψ) were measured for all species, and response of photosynthesis (Pn) to internal CO_2 concentration (Ci) was studied in petunia and salvia. Leaf photosynthesis (Pmax) was highest at a θ of 0.22 $m^3 \cdot m^{-3}$ for all species and did not differ between a θ of 0.15 and 0.22 $m^3 \cdot m^{-3}$ for vinca and petunia. The Pn-Ci response curves for petunia were almost identical at a θ of 0.22 and 0.15 $m^3 \cdot m^{-3}$. Regardless of species, ETR and ΦPSII were highest and NPQ was lowest at a θ of 0.22 $m^3 \cdot m^{-3}$. Based on these results, a θ of 0.22 $m^3 \cdot m^{-3}$ for salvia and impatiens and a slightly lower θ of 0.15 $m^3 \cdot m^{-3}$ for vinca and petunia, is optimal. Mean osmotic potential in all treatments was lower in vinca and salvia and resulted in higher turgor potential in these species than other species. Analysis of Pn-Ci response curves indicated that Pn at a θ of 0.09 $m^3 \cdot m^{-3}$ was limited by both gas phase (stomatal and boundary layer) and non-gas phase (mesophyll) resistance to CO_2 transfer in salvia. At the lowest θ level, Pn in petunia was only limited by gas phase resistance, indicating that absence of mesophyll resistance during drought may play a role in the drought tolerance of petunia.

Effects of S-ABA on Water Loss and Desiccation of Containerized *Hibiscus rosa-sinensis*

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Desiccation of containerized plants at retail outlets due to inadequate watering is a recurring problem. Water stress can decrease plant quality and survivability. Treatments that could reduce plant transpiration without lowering plant quality could be beneficial in maximizing the likelihood that plants would not become water stressed between waterings at retail outlets. Abscisic acid (ABA) is known to be involved in the regulation of stomatal aperatures, the major control mechanism for transpirational water loss. Containerized plants of four cultivars of hibiscus were thoroughly sprayed with S-ABA at concentrations

of 0, 125, 250 or 500 mg·L^{-1}. Plants were held under simulated retail conditions and were not watered until visible wilting occurred. Transpiration and pot weights were monitored over time. Transpiration rates and weight loss percentages were negatively correlated with S-ABA concentrations. Effects on transpiration rates lasted for at least 30 hours after treatment. For mean hours to wilt, there was interaction between S-ABA treatments and cultivars. For the most sensitive cultivar ('Double Apricot'), treatment with S-ABA at 500 mg·L^{-1} almost doubled the time to plant wilt (130 h) compared to the control treatment (72 hours). Hours to wilt was increased 24% for 'Double Pink' treated at the highest rate. For 'Double Red' and 'Single Pink', hours to wilt was not affected by treatments. For some hibiscus, S-ABA treatments prior to placement of plants at retail outlets might decrease the chances that the plants would become severely water stressed.

Oral Session 17—Crop Physiology

Moderator: Rebecca Darnell

19 July 2005, 2:00–4:00 p.m. Room 108

Effect of Drought Stress on Growth and Ginsenoside Content of American Ginseng

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American ginseng (*Panax quinquefolium* L.) contains pharmacologically active secondary compounds known as ginsenosides, which have been shown to be affected by both genetic and environmental factors. In this greenhouse experiment, we tested the hypothesis that ginsenosides would behave as "stress metabolites" and be associated with osmoregulation in response to drought stress. Two year-old seedlings, grown in 5-inch pots, were well watered for 40 days prior to the initiation of treatments. Plants in the drought stress treatment were watered every 20 days while the controls were watered every 10 days, and the experiment was terminated after 4 and 8 dry down cycles (80 days), respectively. Predawn leaf water potential and relative water content (RWC) of drought-stressed plants during a typical dry down cycle were lower than control plants. The diameter and weight of primary storage roots were decreased in the stressed treatment. The length of the main storage root and the longest secondary (fibrous) root were significantly increased by the drought stress treatment. Leaf chlorophyll content of drought-stressed plants was lower than controls. The osmotic potential of the drought-stressed ginseng was not lower than the control, indicating that ginsenoside is not involved in osmoregulation in response to drought stress. Furthermore, ginsenosides Rb1 and Rd, and total ginsenosides were significantly lower in primary roots of drought-stressed plants compared to control plants.

Salinity Tolerance of Cleopatra Mandarin and Carrizo Citrange Rootstock Seedlings Is Affected by Higher Growth and Lower Water Use under CO_2 Enrichment

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Two-month-old citrus rootstock seedlings of Cleopatra mandarin (CM) and Carrizo citrange (CC) were fertilized with nutrient solution, with or without additional 50 mM NaCl, and grown under either ambient CO_2 (aCO_2, 360 ppm) or elevated CO_2 (eCO_2, 720 ppm) for 8 weeks. Elevated CO_2 increased plant growth, shoot : root ratio, net assimilation of CO_2, leaf chlorophyll, and water use efficiency (WUE), but decreased plant water use. Salinity decreased growth, shoot : root ratio, net gas exchange and water use. Neither salinity nor eCO_2 affected leaf chlorophyll fluorescence (Fv/Fm), but CC had higher Fv/Fm, leaf gas exchange, chlorophyll, N and Ca than CM. Although salinity increased leaf Cl and Na in both genotypes, CC had higher leaf Cl, but lower Na than CM. Salinity-induced decreases in leaf osmotic potential increased leaf turgor, especially at eCO_2. There were no interacting effects of eCO_2 and salinity on plant growth, but salinity decreased WUE more at eCO_2 than at aCO_2 in CM; but not in CC. Elevated CO_2 decreased leaf Cl and Na in CC, but tended to increase both ions in CM leaves. Patterns of Cl and Na responses in roots generally were in opposite direction to their respective responses in leaves. Thus, the modifications of citrus seedling responses to salinity by higher growth and lower water use at eCO_2 were not only species dependent, but also involved whole plant allocations of Na and Cl.

Effect of External Nitrate Concentration on Nitrate and Iron Uptake and Assimilation in *Vaccinium* Species

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Most *Vaccinium* species, including *V. corymbosum*, have strict soil requirements for optimal growth, requiring low pH, high iron, and nitrogen, primarily in the ammonium form. *V. arboreum* is a wild species adapted to high pH, low iron, nitrate-containing soils. This broader soil adaptation in *V. arboreum* may be related to increased efficiency of iron or nitrate uptake/assimilation compared with cultivated *Vaccinium* species. To test this, nitrate and iron uptake, and nitrate reductase (NR) and ferric chelate reductase (FCR) activities were compared in two *Vaccinium* species, *V. arboreum* and the cultivated *V. corymbosum*. Plants were grown hydroponically for 15 weeks in either 1.0 or 5.0 mM NO_3 with 0.09 mM Fe. Root FCR activity was greater in *V. arboreum* compared with *V. corymbosum*, especially at the lower external nitrate concentration. However, this was not reflected in differences in iron uptake. Nitrate uptake and root NR activity were greater in *V. arboreum* compared with *V. corymbosum*. The lower nitrate uptake and assimilation in *V. corymbosum* was reflected in decreased plant dry weight compared with *V. arboreum*. *V. arboreum* appears to be more efficient in acquiring nitrate compared with *V. corymbosum*, possibly due to increased NR activity, and this may partially explain the wider soil adaptation of *V. arboreum*.

Photoassimilate Regulation of Sorbitol and Sucrose Metabolism in Peach Fruit

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Along with sucrose, sorbitol represents the major photosynthetic product and the main form of translocated carbon in peach. The objective of the present study was to determine whether in peach fruit, sorbitol and sucrose enzyme activities are source-regulated, and more specifically modulated by sorbitol or sucrose availability. In two separate trials, peach fruit relative growth rate (RGR), enzyme activities, and carbohydrates were measured 1) at cell division stage before and after girdling of the shoot subtending the fruit; and 2) on 14 shoots with different leaf to fruit ratio (L:F) at cell division and cell expansion stages. Fruit RGR and sorbitol dehydrogenase (SDH) activity were significantly reduced by girdling, whereas sucrose synthase (SS), acid invertase (AI), and neutral invertase (NI) where equally active in girdled and control fruits on the fourth day after girdling. All major carbohydrates (sorbitol, sucrose, glucose, fructose and starch) were reduced on the fourth day after girdling. SDH activity was the only enzyme activity proportional to L:F in both fruit developmental stages. Peach fruit incubation in sorbitol for 24 hours also resulted in SDH activities higher than those of fruits incubated in buffer and similar to those of freshly extracted samples. Overall, our data provide some evidence for regulation of sorbitol metabolism, but not sucrose metabolism, by photoassimilate availability in peach fruit. In particular, sorbitol translocated to the fruit may function as a signal for modulating SDH activity.

The Involvement of Lipid Signaling in Citrus Fruit Abscission

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Abscission is a natural plant process that culminates in the removal of organs from the parent plant. Control of abscission remains an

important goal of agriculture, but events that initiate and transduce abscission signals have not been well defined. An understanding of these events may reveal pathways that can be targeted to control abscission. The compound 5-chloro-3-methyl-4-nitro-1*H*-pyrazole (CMNP) is a pyrazole-derivative that induces abscission selectively in mature citrus (*Citrus sinensis*) fruit when applied to the canopy. Peel contact is essential for efficacy. Previous work identified CMNP as an uncoupler. Timing of CMNP-induced events in citrus flavedo indicated that increased reactive oxygen species and electrolyte leakage occurred within 30 minutes and 2 hours after application, whereas reduced ATP content was measured 3 hours after application. Phospholipase A2 (PLA2) and lipoxygenase (LOX) activities, and lipid hydroperoxide (LPO) levels increased in flavedo of citrus fruit peel treated with CMNP, indicating that the lipid signaling pathway was activated. A specific inhibitor of PLA2 activity, aristolochic acid (AT), reduced CMNP-induced increases in PLA2 and LOX activities and LPO levels in citrus flavedo and greatly reduced abscission, suggesting that production of phospholipid-derived signals influence abscission process. However, AT treatment failed to halt the reduction in ATP content, indicating that reduction in ATP preceded the increase in PLA2 activity and the biological response. The results demonstrate a link between lipid signaling and abscission in citrus.

The Study of Pollen Development in Nine Cultivars of Hazelnut (*Corylus avellana*)

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Pollen development is an important event in plant reproduction. Hazelnut (*Corylus avellana*) male flower differentiation starts in summer and pollen shed is in the winter. Hazelnut pollen shed can vary up to 3 months between early to late flowering genotypes. Microsporogenesis and microgametogenesis of hazelnut is not well understood. Pollen development and differentiation of nine genotypes, representing early to late blooming cultivars from the National Clonal Germplasm Repository in Corvallis, Ore., were studied. Catkins were collected weekly from Aug. to Nov. 2002. Tissue sections were examined under the light microscope. Microsporogenesis was divided into five stages: archesporial cells, sporogenous cells and parietal layers, pollen mother cells (PMC), tetrads, and microspores. Microgametogenesis was distinguished between young pollen grains (uninucleate) and mature pollen grains (binucleate). On 4 Aug., cultivars were at different developmental stages of microsporogenesis. Early blooming cultivars had PMCs present. Later-blooming cultivars only contained archesporial cells. PMCs were present in all cultivars by 22 Aug. Microspores were observed on 26 Sept. in all cultivars. This study contributes to a better understanding of male gametophyte development in hazelnut, which has increased our ability to correlate hazelnut pollen development with bloom phenology.

Alternatives to Fish Oil for Thinning Apples with Lime Sulfur

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A tank mix of fish oil plus liquid lime sulfur has proven to be an effective chemical thinner for apples in the bloom and postbloom periods. This combination was labeled for use as a chemical thinner in Washington State in 2003. There are several concerns with fish oil when used in this thinning mixture. Phytotoxicity is one concern. Apple growers have a reluctance to utilize this oil because of its expense and repulsive odor. Research to date has been conducted using oil from a single small source in Washington State. Shipping fish oil across the country is expensive and the consistency and purity of fish oil from other sources is unknown. Fish oil may function as a surfactant and penetrant, and it may also have a direct thinning effect. The objective of these studies was to evaluate the efficacy of several surfactants and oils in combination with lime sulfur for thinning apples. Lime sulfur has been less effective as a thinner when used alone than when used with oil in our studies. Regulaid, LI-700, and Silwet L-77 were shown to be less effective than oils for achieving thinning. Vegetable oil has been very effective in the thinning combination, while petroleum oils have been effective in some eastern U.S. trials, but less effective in the west. Tank mixing fish oil with lime sulfur has remained among the best treatments in our trials, while vegetable oil also shows promise.

Mechanism and Underlying Physiology Perpetuating Alternate Bearing in Citrus

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Alternate-bearing trees produce a heavy on-crop followed by a light off-crop. Whereas climatic events initiate alternate bearing, it is perpetuated by endogenous tree factors. For citrus, the mechanism and underlying physiology by which fruit influence floral intensity the next spring was unresolved. To determine whether reduced return bloom of on-crop trees was due to inhibition of vegetative shoot production and, thus, a lack of "wood" on which to bear next spring's inflorescences or, alternatively, to inhibition of phase transition and inflorescence development on an adequate number of vegetative shoots, fruit were removed from individual shoots monthly or from entire on-crop 'Pixie' mandarin trees during periods critical to shoot initiation (summer) and phase transition (winter). Fruit removal provided clear evidence that the on-crop exerted a significant effect on return bloom during the summer by reducing summer–fall shoot growth and, hence, the number of flowers borne on these shoots as well as on old wood of fruit-bearing shoots. The on-crop had less effect in winter on phase transition and return bloom. Buds collected during the summer from on-crop 'Pixie' mandarin trees were characterized by high indoleacetic acid and low isopentenyladenosine concentrations compared to buds from off-crop trees. The starch level of the buds was not affected. No differences in hormone concentrations were detected for buds collected during winter from on- and off-crop trees, but buds of on-crop trees had less starch. The results demonstrate that the on-crop reduces return bloom predominantly by inhibiting summer-fall vegetative shoot growth by a mechanism similar to apical dominance, not a lack of available carbohydrate.

Oral Session 18—Vegetable Crops Culture & Management 2

Moderator: Dean A. Kopsell

19 July 2005, 2:00–3:45 p.m **Room 107**

Developmental Changes in Cucumber Fruit Susceptibility to Infection by *Phytophthora capsici*

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Phytophthora capsici, a soil-borne oomycete pathogen causing fruit rot in cucumber, has become a limiting factor for cucumber production in the Midwest. In the process of screening plant introductions (PIs) for resistance to *P. capsici*, it appeared that degree of susceptibility might decrease as fruits develop. To examine this more carefully, detached, greenhouse-grown, hand-pollinated 'Vlaspik' fruits aged 2–18 days post-pollination (dpp) were inoculated with *P. capsici* mycelium and evaluated for symptoms. There was a reproducible decrease in susceptibility with increasing fruit age. The fruits that sporulated were usually younger and smaller (2–9 dpp), 10-3 dpp fruit tended to develop water-soaked symptoms, while the fruits that remained symptom-free were usually older (>14 dpp) and oversized for pickling cucumber. The transition from susceptible to more resistant appeared to occur at the end of the period of rapid fruit elongation. Detached field-grown 'Straight Eight' fruits showed similar size-related trends. Candidate resistant genotypes identified from the PI screening

were re-screened using 7 and 14 dpp fruits. Again an age-dependent difference in response was observed, indicating that the increase in resistance is not genotype-specific. Furthermore, field observations suggest a gradation of susceptibility within the fruits as the blossom end was most frequently infected. Preliminary tests of detached greenhouse-grown, hand-pollinated fruits suggested that as the fruits grew older, the blossom end remained susceptible longer than the stem end. These findings could have implications for appropriate screening methods, the stage of fruit likely to become infected in the field, and appropriate spray practices.

Changes in Gluconasturtiin Content in Chinese Cabbage with Increasing Cabbage Looper Density

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Gluconasturtiin (2-phenylethyl glucosinolate), an aromatic glucosinolate, was used to evaluate the response of Chinese cabbage (*Brassica campestris* L. ssp. *pekinensis*) cv. Green Rocket to three and five cabbage looper (*Trichoplusia ni* Hubner) larvae per plant. Plants were harvested 0, 10, and 17 days after infestation. The change in gluconasturtiin content due to decreased light and leaf area removed was also studied. All samples were assayed for gluconasturtiin content using high performance liquid chromatography (HPLC). The gluconasturtiin content of plants subjected to five larvae/plant had a 59% increase, compared to noninfested plants 10 days after infestation. The effect of larval feeding was also dependent on harvest time. The levels of gluconasturtiin increased by 52% from the first harvest (prior to infestation) to the second harvest (10 days after infestation) in both larval feeding densities. Seventeen days after infestation (final harvest), gluconasturtiin content experienced a nonsignificant 6% decrease, compared to the previous harvest.

Biological Control of Crucifer Crop Pests and Participatory IPM in Thailand

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Larvae of the diamondback moth (DBM), *Plutella xylostella* L. (Lepidoptera: Ypeunomutidae) and other crucifer pests cause severe economic damage to cabbage, *Brassica oleracea* L. var. *capitata* (Brassicaceae) and related vegetables in Thailand and elsewhere in Southeast Asia. Overuse of pesticides is a serious problem in most vegetable growing areas of the country. Six species of parasitoids were reared from DBM larvae and pupae collected in northern Thailand in 1989–90 and 2003–04. The larval parasitoid *Cotesia plutellae* Kurdjumov (Braconidae) appears to be the most important parasitoid of DBM in Thailand; other native or naturalized parasitoids may play supplementary roles. These natural enemies can and should be conserved in well thought out, participatory IPM programs. Field experiments comparing local farmer practice (weekly sprays of synthetic pyrethroid insecticides) to a simple IPM protocol using Bt and neem demonstrated superior control and higher yields of undamaged cabbage from the IPM treatment. This information on DBM parasitoids and other natural enemies of crucifer pests has been developed into a poster and other extension materials currently used in national "training of trainer" (for vegetable IPM) programs throughout Thailand. Farmer-centered IPM programs focused on conservation of local DBM parasitoids and on greater implementation of biological control will help alleviate growing public concerns regarding the effects of pesticides on vegetable growers and consumers.

Influence of Honey Bee Pollination on Triploid Watermelon Fruit Set and Quality

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Cucurbit vegetable crops, such as watermelon (*Citrullus lanatus*), require insect pollination for fruit set, which is usually achieved by placing honey bee (*Apis mellifera*) colonies in a field or relying upon natural bee populations. Pistillate (or female) watermelon flowers require multiple honey bee (or other bee) visitations after visiting staminate (or male) flowers for fruit set, and pollination is even more of a concern in triploid watermelon production since staminate flowers contain mostly nonviable pollen. Six honey bee visitation treatments, 1) no visitation control, 2) two visits, 3) four visits, 4) eight visits, 5) 16 visits, and 6) open-pollinated control, were evaluated to determine the effect of honey bee pollination on 'Millionaire' triploid watermelon fruit set, yield, and quality utilizing 'Crimson Sweet' at a 33% pollinizer frequency. No differences ($P > 0.05$) between honey bee pollination treatments were observed for 'Millionaire' quality characters (hollow heart disorder or percent soluble solids). The lowest pistillate flower abortion rate (20%) and subsequently the greatest triploid watermelon yields (fruit numbers and weights per hectare) occurred with the open-pollinated control compared to all other honey bee visitation treatments. Fruit abortion rates decreased linearly, while fruit numbers and weights per hectare increased linearly as number of honey bee visits to pistillate flowers increased from 0 (no visit control) to the open-pollinated control (≈24 visits). This study indicated that >16 honey bee visits are required to achieve maximum triploid watermelon fruit set and yields, which is twice the number of honey bee visits required by diploid watermelons to achieve similar results.

Changes in Kale Pigment Profiles during Leaf Ontogeny

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Chlorophyll and carotenoid pigments were measured with high-performance liquid chromatography (HPLC) during leaf development in kale (*Brassica oleracea* L. var. *acephala* D.C). Lutein and β-carotene are two plant-derived carotenoids that possess important human health properties. Diets high in these carotenoids are associated with a reduced risk of cancer, cataracts, and age-related macular degeneration. Kale plants were growth-chamber grown in nutrient solution culture at 20 °C under 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of irradiance. Pigments were measured in young (<1 week), immature (1-2 weeks), mature (2-3 weeks), fully developed (3-4 weeks) and senescing (>4 weeks) leaves. Significant differences were measured for all four pigments during leaf development. Accumulation of the pigments followed a quadratic trend, with maximum accumulation occurring between the first and third week of leaf age. The highest concentrations of lutein were recorded in 1- to 2-week-old leaves at 15.1 mg per 100 g fresh weight. The remaining pigments reached maximum levels at 2-3 weeks, with β-carotene at 11.6 mg per 100 g, chlorophyll *a* at 251.4 mg per 100 g, and chlorophyll *b* at 56.9 mg per 100 g fresh weight. Identifying changes in carotenoid and chlorophyll accumulation over developmental stages in leaf tissues is applicable to "baby" leafy greens and traditional production practices for fresh markets.

Sensory Quality Ratings and Mineral and Glycoalkaloid Concentrations in Organically and Conventionally Grown Redskin Potatoes (*Solanum tuberosum*)

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Sensory evaluations (triangle tests) were used to determine if panelists could distinguish, by tasting, cooked wedges of potatoes grown organically, either with or without compost, and conventionally. Mineral and

glycoalkaloid analyses of tuber skin and flesh were also conducted. When the skin remained on the potatoes, panelists detected differences between conventional potatoes and organic potatoes, regardless of soil treatment. However, they did not distinguish between organic treatments (±compost) when samples contained skin or between any treatments if wedges were peeled prior to preparation. Glycoalkaloid levels tended to be higher in organic potatoes. In tuber skin and flesh, potassium, magnesium, phosphorus, sulfur, and copper concentrations were also significantly higher in the organic treatments, while iron and manganese concentrations were higher in the skin of conventionally grown potatoes.

Nitrogen Level and Form Influence Kale Growth and Leaf Pigment Concentrations

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Kale (*Brassica oleracea* L.) ranks highest among vegetable crops for lutein and beta-carotene carotenoids, which function as antioxidants in disease prevention. Nitrogen (N) rate and N form influence plant growth and alter pigment composition and accumulation. The objectives of these experiments were to investigate the effect of N rate and form on biomass and accumulation of plant pigments in the leaf tissues of kale. Three kale cultivars were grown using nutrient solution culture. In the first study, N treatment rates were 6, 13, 26, 52, and 105 mg·L^{-1}, at a constant NH_4-N:NO_3-N ratio. Kale biomass increased linearly in response to increasing N rate. On a fresh weight basis, lutein and beta-carotene were not affected by N rate. However, carotenoids calculated on a dry weight basis increased linearly in response to increasing N rate. In a second study, kale was grown under: 100% NH_4-N:0% NO_3-N, 75% NH_4-N:25% NO_3-N, 50% NH_4-N:50% NO_3-N, 25% NH_4-N:75% NO_3-N, and 0% NH_4-N:100% NO_3-N, at a N rate of 105 mg·L^{-1}. Linear increases in biomass were observed for each kale cultivar as percentage of NO_3-N increased. Lutein concentrations increased 155%, 73%, and 39% for 'Toscano', 'Winterbor', and 'Redbor' kale, respectively, as N form changed 0% NO_3-N to 100% NO_3-N. Concentration of leaf beta-carotene increased linearly in response to increasing NO_3-N in each cultivar tested. Nitrogen management should be considered in crop production programs designed to increase the concentrations of nutritionally important carotenoids.

Oral Session 19—Herbs, Spices, and Medicinal Plants

Moderator: Karen L. Panter

19 July 2005, 4:00–6:00 p.m. Room 101

Chemical Analysis of Cultivated *Hypoxis hemerocallidea* using Thin Layer Chromatography

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Hypoxis hemerocallidea (African potato) is in high demand as a medicinal plant and therefore it is becoming scarce in its natural habitat. Thus, the objective of this study was to investigate the effect of cultivation practices on the active ingredients of the corm over a 12-month period. Different TLC (Thin Layer Chromatography) methods were also investigated when separating the different compounds. Plants were grown under a tunnel in plastic bags containing bark or sand growing media. The planted corms were treated with different fertigation frequencies and harvesting took place during four seasons. The harvested material was sliced, freeze-dried, and ground into a fine powder. Different solvents, namely methanol, acetone, and chloroform (chosen for their polarity) were used to extract the compounds from the ground material. The extracted residues were redissolved and spotted as thin streaks onto TLC plates. The TLC plates were then developed in different solvents and sprayed with different chemicals to bring out the different compounds found in the plant extract. Results on the TLC plates indicated that the amount of residue extracted with different solvents were significantly different. Therefore, TLC methods need to be considered when separating the different compounds. The growing media affected the amount of compounds produced from the corms during the 12-month period. The harvest season also played a role in the amount of active ingredients produced during the year. Therefore, cultivation practices influence the occurrence of active ingredients of *H. hemerocallidea*.

Response of Total Polyphenol Content to Nitrogen, Phosphorus, and Potassium Nutrition of Bush Tea (*Athrixia phylicoides*)

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Bush tea (*Athrixia phylicoides*) belongs to the Asteraceae family. It is a popular beverage, commonly used as an herbal tea and for medicinal purposes. In some parts of South Africa, people consume or drink it as an aphrodisiac. Bush tea was grown under varying nitrogen (N), phosphorus (P) and potassium (K) levels in the four seasons to determine the seasonal nutrient requirements for improved quality. Treatment consisted of 0, 100, 200, 300, 400, or 500 kg·ha^{-1} N, P, or K in a randomized complete-block design under 50% shade nets. Three N, P, and K parallel trials were conducted per season (autumn, winter, spring, and summer). Total polyphenols were extracted using Folin-Ciaocalteau reagents and analyzed in a spectrophotometer. Results for the N trial suggested that total polyphenols increased quadratically in response to N nutrition during summer, winter, and spring, but not in autumn. The optimum N level was 300 kg·ha^{-1}. The highest total polyphenol was 51.1 mg·g^{-1} in winter. For the P trial, total polyphenols also increased quadratically in response to P nutrition regardless of season. Again winter had the highest total polyphenols (46.8 mg·g^{-1}). The optimum P level was 300 kg·ha^{-1}. In the K trial, regardless of season, total polyphenols plateaued at 200 kg·ha^{-1} and the highest polyphenols were in winter (43.3 mg·g^{-1}). Therefore, for improved total polyphenol content, 300 kg·ha^{-1} N and P and 200 kg·ha^{-1} K are recommended regardless of season.

Carotenoid and Chlorophyll Pigments in Sweet Basil Grown in the Field and Greenhouse

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Therapeutic compounds in herbal crops are gaining recent attention. Sweet basil (*Ocimum basilicum* L.) is a popular culinary herbal crop grown for both fresh and dry leaf markets. Recently, basil (unidentified cultivar) was shown to rank highest among spices and herbal crops for xanthophylls carotenoids. This class of carotenoids is associated with decreased risks of certain cancer and age-related eye diseases. The research goal for the current study was to characterize the concentrations of nutritionally important carotenoid pigments among popular varieties of basil. Eight cultivars of sweet basil ('Genovese', 'Italian Large Leaf', 'Nufar', 'Red Rubin', 'Osmin Purple', 'Spicy Bush', 'Cinnamon', and 'Sweet Thai') were grown in both field and greenhouse environments and evaluated for plant pigments using HPLC methodology. Environmental and cultivar differences were significant for all of the pigments analyzed. 'Sweet Thai' accumulated the highest concentrations of lutein, zeaxanthin, and beta-carotene carotenoids, while 'Italian Large Leaf' had the lowest concentrations. Comparing the two environments, cultivar means for carotenoid and chlorophyll pigments were higher in the field environment when expressed on both a fresh and dry weight basis. Exceptions were found only for the purple leaf basils ('Osmin Purple' and 'Red Rubin'). Positive and highly significant correlations existed between carotenoid and chlorophyll pigments in both environments. This study demonstrates that sweet basil can accumulate high levels of nutritionally important carotenoids in both field and greenhouse environments.

Rooting Osha Crown Cuttings Using IBA and NAA

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Osha (*Ligusticum porteri*) is a Rocky Mountain native frequently used as a medicinal herb. It is currently harvested largely from the wild. Studies have been under way since 2001 to find ways to propagate and produce the plant. To potentially increase rooting success of crown cuttings of osha, two different rooting hormones were used, each at two concentrations. Treatments were controls, 2500 ppm, and 5000 ppm solutions each of indole-3-butyric acid (IBA) and α-naphthalene acetic acid (NAA). Cuttings were soaked in deionized water or treatment solutions for 2 min. After soaking cuttings were stuck in sterilized sand in 725-mL[2] containers, one cutting per container. Containers were placed on a mist propagation bench at 21 °C in a completely randomized design under natural light and day lengths. Data taken were days to visible root and shoot, and presence or absence of root formation after 50 days. Results indicated only one of 70 cuttings (<1%) produced a shoot. Roots formed on 14% of control cuttings, 64% in 2500 ppm IBA, 86% in 5000 ppm IBA, 36% in 2500 ppm NAA, and 14% in 5000 ppm NAA. Days to rooting ranged from 14.9 (2500 ppm IBA) to 29.0 (5000 ppm NAA). Due to considerable variation in days to rooting, and the number of cuttings that did not root, analysis of variance showed no differences among treatments. Frequency analysis indicated differences among treatments in root presence or absence. The 2500 and 5000 ppm IBA treatments showed more root formation than the controls or either NAA treatment. This indicates IBA may enhance rooting of osha crown cuttings.

Propagation by Stem Cuttings and Response of Seeds to Light and Temperature of Fever Tea (*Lippia javanica*)

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Fever tea (*Lippia javanica*) is one of the important medicinal plants belonging to the Verbenaceae family. The first objective of this investigation was to study the propagation of fever tea using stem cuttings. The main variables studied were cutting position, rooting media and rooting hormone. The germination requirement of fever tea seed is also not known. Therefore, the second objective was to investigate the ideal seed germination temperature and light combinations. Germination was tested at constant temperature regimes (15, 20, 25 and 30 °C) with a continuous light or dark period and at alternate temperatures of 20/30 °C and 16/8 hour (light/dark) combinations, respectively. For the stem cutting investigation, sampling was done every 5, 10, 15, and 20 days from plant establishment. Apical cuttings took less time to root than basal cuttings regardless of growing medium. Response of cuttings to rooting hormone was growing medium-related. With rooting hormone, it took 10 days to root most of the apical cuttings, whereas basal cuttings showed more roots in 15 to 20 days after plant establishment. Cuttings in sand took 5 days longer to root than in pine bark, regardless of rooting hormone. Therefore, for quicker establishment of fever tea stem cuttings, rooting hormone and pine bark should be used for propagation of both apical and basal cuttings. In the germination investigation, it was found that fever tea seeds are positively photoblastic. Regardless of temperature, seeds failed to germinate in continuous darkness. The germination percentage was improved at continuous or alternating temperatures above 20 °C with continuous light. However, the germination percentage decreased with alternating light and dark treatments.

Coriander (*Coriandrum sativum*) Seed Yield as Affected by Selected Growth Stimulators

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Experiments were conducted to quantify the effect of various rates of a triterpenic-rich extract from Siberian fir (*Abies sibirica*) (TTA), acetylthioproline (AP), a seaweed (*Ascophyllum nodosum*) extract (CSE), gibberellic acid 3 (GA), and a glycine-rich commercial mixture of amino acids and short-chain peptides (APC) on coriander (*Coriandrum sativum*) seed yield. Aqueous solutions of GA, TTA, CSE, APC, and AP were sprayed on the crop leaves at 21 and 35 days after crop emergence. GA did not increase coriander seed yield as compared to the control. At the rate of 300 mg·L^{-1}, TTA increased seed yield by about 9%. The highest seed yield increase was found in plants treated with CSE (60 mg·L^{-1}), AP (250 mg·L^{-1}), and APC (1200 mg·L^{-1}), in which seed yield increased by about 14%. These results indicate that APC, AP, TTA, and CSE, but not GA, may be useful in increasing coriander seed yield.

Severity of Leaf Removal Affects Regrowth of American Mayapple

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Podophyllotoxin is a pharmaceutical compound extracted from rhizomes of Indian mayapple (*Podophyllum emodi*). Leaves of American mayapple (*P. peltatum*) also contain podophyllotoxin, and the species is being investigated as a domestic, renewable, and alternative source of the compound. The objective of this study was to explore strategies of leaf removal that would not adversely affect regrowth of American mayapple shoots in subsequent years. Plots were established in two locations among naturally occurring populations in the wild, one in full sun and one in partial shade. Plots were 1.0 m^2 and leaves were removed from plants every spring, every other spring, or every third spring. In addition, leaves were removed in early spring, soon after shoots emerged and leaves had fully expanded, or in late spring, when leaves first showed evidence of yellowing and beginning to senesce. Sexual and asexual leaves were harvested separately. Leaf number, leaf area, and dry weight were recorded. Subsamples of leaf material were extracted to determine podophyllotoxin, α-peltatin, and β-peltatin contents. Results clearly showed that leaf removal every year, in combination with early harvest, was too severe and plants lost vigor over the 4-year period of this study. Plants subjected to this treatment combination produced significantly less leaf area and dry weight than any of the other treatment combinations. Results were similar for both sun and shade locations. Lignan content was not affected by treatment. Our results indicate that leaves can be removed from mayapple plants as often as every year provided harvests are not scheduled too soon after shoot emergence.

Inter- and Intra-specific Variation in Growth Parameters of *Ocimum* Species

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Basils (*Ocimum* species) of the mint family Lamiaceae are well known for their multiple uses as culinary, aromatic, and medicinal plants worldwide. Basils are integral components of Asian and Mediterranean cuisine and are also widely used for treating diabetes and cancers. Basil has a limited acceptance as a culinary herb in the United States. The potential exists for development of culinary, medicinal, aromatic, and ornamental basil cultivars for production in the southeastern United States. In a preliminary field trial, 84 accessions belonging to six species of the genus *Ocimum* were evaluated for agronomic parameters in single-row plots. Wide variations exist between and within species for all agronomic traits studied. The mean percent emergence between species ranged from 60.0% for *O. americanum* var. *americanum* to 100.0% for an unknown species from Italy and *O. campechianum*. The aboveground fresh biomass per plant ranged from 424.0 g for *O. sellol* to 1450.3 g for the unknown Italian accession. The unknown Italian accession produced more branches per plant and also had the highest root, leaf, stem, and inflorescence fresh and dry weights among species. *Ocimum sellol* plants emerged late, had a slower rate of emergence, and produced a lower total biomass than other species. *Ocimum gratissimum* partitioned a greater proportion of the total dry weight to leaves (37.9%) and roots (14.4%), whereas *O. basilicum.*

O americanum var. *americanum*, and *O. campechianum* partitioned a greater amount of dry matter to inflorescence and the least to roots than other species. In this presentation, the agronomic traits and basil cultivars with potential for ornamental and medicinal purposes will be discussed.

Oral Session 20—Genetics and Germplasm 2

Moderator: Donglin Zhang

July 19, 2005, 4:00–6:15 PM **Ballroom G**

Confirmation of 'Medjool' Date Palm (*Phoenix dactylifera* L.) as a Landrace Variety by a Study of 'Medjool' Accessions from Morocco Using AFLP Markers

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Six date varieties from Egypt, one 'Deglet Noor' and four 'Medjool' date accessions from California, and 66 accessions of 'Medjool' date from Morocco, the country of origin of 'Medjool' date, were examined using four sets of fluorescent labeled amplified fragment length polymorphism (AFLP) markers. A total of 402 AFLP bands were generated and 160 were polymorphic (39.8%). The 66 'Medjool' accessions from Morocco shared minimum 79% of genetic similarity. These results support the hypothesis that 'Medjool' date is a landrace variety and not a genetically uniform variety. 'Medjool' is the first confirmed landrace variety of date palm worldwide. This raises the possibility that other landrace varieties of date palm may exist in different date-growing areas and in centers of diversity. The confirmation of a landrace variety of date palm also has significant impact on future date palm germplasm collection and preservation. The mechanism(s) creating the genetic variation within 'Medjool' accessions remains unknown. One possible mechanism is that spontaneous genetic changes could occur frequently within vegetative tissues of date palm like offshoots under high temperature and drought stresses.

Application of Molecular Data on Ornamental Peach Systematics

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Ornamental peach [*Prunus persica* (L.) Batsch.] is a well-known ornamental plant for the garden. However, the genetic relationship among ornamental peach cultivars is not clear, which limits further studies of its molecular systematics and breeding. A group of 16 taxa of ornamental peach, originated from *Prunus persica* and *Prunus davidiana* (Carr.) Franch., had been studied using AFLPs and ISSRs. A total of 243 useful markers between 75 to 500 base pairs were generated from six EcoRI/MseI AFLP primer combinations (ACC/CAT, AGG/CAT, ACT/CAT, ACC/CTC, AGG/CTC, and ACT/CTC). The average readable bands were 41 per primer combination. Among them, 84% of the bands were polymorphic markers. A total of 132 useful markers between 300 to 1400 base pairs were generated from 10 ISSR primers (UBC818, UBC825, UBC834, UBC855, UBC817, UBC868, UBC845, UBC899, UBC860, and UBC836). The mean reliable bands were 14 per primer. Among them, 62% of the bands were polymorphic markers. Both methods generated very similar phenograms with consistent clades. From these results we concluded that AFLP and ISSR analysis had a great potential to identify ornamental peach cultivars and estimate their phylogeny. The application of these molecular techniques may elucidate the hierarchy of ornamental peach taxa.

Detection of Genetic Variation among Camellia Parents and Hybrids Using Random Amplified Polymorphic DNA (RAPD) Markers

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The reliability of the random amplified polymorphic DNA (RAPD) technique in amplifying polymorphisim among the hybrids and their parents' genomes of the genus *Camellia* was evaluated. Three hybrids ('Londontowne Blush', 'Ashton's Snow', and 'Ashton's Cameo') and one of the parents, *C. oleifrea* 'Plain Jane', provided by the America Camellia Society, Fort Valley, Ga., were investigated. Twenty 10-based random primers were tested in this study. Five out of 20 primers were selected for RAPD analysis based on the ability to produce unambiguously scoreable RAPD bands for evaluation and comparison of the genotypes under investigation. The five primers were selected because they produced distinct patterns of amplified bands for each tested genotype. A total of 162 RAPD bands were produced. Among the 162 bands, 86 bands showed polymorphisms. The amplified band sizes ranged from 236 to 1656 bp. These data indicate that in the three hybrids and one of the parents exist unique genomic regions. Our investigation results showed that the RAPD molecular approach can be used to discriminate genetic variation among hybrids and their parents.

QTL Associated with Day-neutrality in Strawberry

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While it is of great significance for strawberry breeders to know the genetics of day-neutrality (DN), evidence for inheritance of the trait is still contradictory. A linkage mapping approach is being used to determine how many QTL regulate DN and the proportion of the variability explained by each. A preliminary genetic linkage map was constructed for 125 individuals of the day neutral × short day (SD) cross 'Tribute' × 'Honeoye' using single dose restriction fragments (SDRFs) of amplified fragment length polymorphic (AFLP) markers. Over 500 SDRFs from 55 AFLP primer combinations were used to build the map using the software tool JoinMap 3.0 at a LOD score of 3.0. Single marker analysis using WinQTL cartographer software previously determined 27 SDRF markers to co-segregate with DN for 57 individuals of the mapping population phenotyped in the field for the years 2002 and 2003, indicating putative QTL for DN. These markers were included in the linkage analysis and seven of them mapped to five different linkage groups that may indicate the quantitative nature of the trait. For determining QTL and percentage of phenotype governed by each QTL, however, accurate phenotypic evaluation is critical. Therefore, controlled environment (growth chamber) studies were used to obtain flowering response data under SD and long day (LD) conditions with two day/night temperatures. This study was conducted for the entire mapping population (over 400 individuals) so that QTL detected can be confirmed by fine mapping the QTL regions. We will also test how robust the QTL detected are, by analyzing the same segregating population at six different field locations in the United States (California, Maryland, Michigan, Minnesota, New York, and Oregon) for their flowering response under SD and LD conditions.

The Use of DNA Sequences from the β-Amylase Gene to Determine the Genetic Relationship among Sweetpotato, *I. batatas* and Other *Ipomoea* Species in Series *Batatas* (Convolvulaceae)

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The sweetpotato *Ipomoea batatas* (L.) Lam. is classified in series *Batatas* (Choisy) in Convolvulaceae, with 12 other species and an interspecific

true hybrid. The phylogenetic relationships of a sweetpotato cultivar and 13 accessions of *Ipomoeas* in the series *Batatas* were investigated using the nucleotide sequence variation of the nuclear-encoded β-amylase gene. First, flowers were examined to identify the species, and DNA flow cytometry used to determine their ploidy. The sweetpotato accession was confirmed as a hexaploid, *I. tabascana* a tetraploid, and all other species were diploids. A 1.1–1.3 kb fragment of the β-amylase gene spanning two exons separated by a long intron was PCR-amplified, cloned, and sequenced. Exon sequences were highly conserved, while the intron yielded large sequence differences. Intron analysis grouped species currently recognized as A and B genome types into separate clades. This grouping supported the prior classification of all the species, with one exception. The species *I. tiliacea* was previously classified as a B genome species, but this DNA study classifies it as an A genome species. From the intron alignment, sequences specific to both A and B genome species were identified. Exon sequences indicated that *I. ramosissima* and *I. umbraticola* were quite different from other A genome species. Placement of *I. littoralis* was questionable: its introns were similar to other B genome species, but exons were quite different. Exon evolution indicated the B genome species evolved faster than A genome species. Both intron and exon results indicated the B genome species most closely related to sweetpotato (*I. batatas*) were *I. trifida* and *I. tabascana*.

Genetic Diversity Study of Green Bean [*Phaseolus vulgaris* (L.)] using Morphological, Allozyme, and RAPD Markers

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The purpose of this study was to analyze the genetic relationship by using morphological, biochemical, and molecular markers. Sixty accessions of green bean [*Phaseolus vulgaris* (L.)], including 43 from North China, 13 from the International Center for Tropic Agriculture, and four from Poland, were collected and divided into three groups: cultivated determinate (35), cultivated indeterminate (12), and semi-wild determinate (13). Dendrograms were constructed based on the genetic similarity and distance analysis of these 60 accessions by using biological characters, allozyme, and random amplified polymorphic DNA (RAPD) markers. The 60 accessions were classified into two groups based on the genetic relationship examined in their biological characters. The cultivated indeterminate formed one group, and cultivated determinate and semi-wild determinate belonged to another group. Ten allozymes with 25 polymorphic loci divided the 60 accessions into nine groups, i.e., five groups for cultivated determinate, two groups for cultivated indeterminate, and two groups for semi-wild determinate. Twenty-nine RAPD markers with 314 polymorphic loci divided the 60 accessions into 13 groups, i.e., nine groups for cultivated determinate, three groups for cultivated indeterminate, and one group for semi-wild determinate. The average genetic similarities and genetic distance of intra-group and inter-groups were 0.81 and 0.75, and 0.19 and 0.24, respectively. Ten bands were characterized as specifically associated with cultivated determinate, one band specific for cultivated indeterminate, and one band for semi-wild. These biochemical and molecular markers provided more information than morphological markers. Allozyme and RAPD markers can be used as an available tool to exploit green bean germplasm in the future.

Microsatellite Markers Developed from 'Bluecrop' Reveal Polymorphisms in the Genus *Vaccinium* and Are Suitable for Cultivar Fingerprinting

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Microsatellite markers for blueberry (*Vaccinium* L.) were created from a preexisting blueberry expressed sequence tag (EST) library of 1305 sequences and a microsatellite-enriched genomic library of 136 clones. Microsatellite primers for 65 EST-containing simple sequence repeats (SSRs) and 29 genomic SSR were initially tested for amplification and polymorphism on agarose gels. Potential usefulness of these SSRs for estimating species relationships in the genus was assessed through cross-species transference of 45 SSR loci and cluster analysis using genetic distance values from five highly polymorphic EST-SSR loci. Cross-species amplification for 45 SSR loci ranged from 17% to 100%, and was 83% on average in nine sections. Cluster analysis of 59 *Vaccinium* species based on genetic distance measures obtained from 5 EST-SSR loci supported the concept of *V. elliotii* Chapm. as a genetically distinct diploid highbush species and indicated that *V. ashei* Reade is of hybrid origin. Twenty EST-SSR and 10 genomic microsatellite loci were used to determine genetic diversity in 72 tetraploid *V. corymbosum* L. accessions consisting mostly of common cultivars. Unique fingerprints were obtained for all accessions analyzed. Genetic relationships, based on microsatellites, corresponded well with known pedigree information. Most modern cultivars clustered closely together, but southern highbush and northern highbush cultivars were sufficiently differentiated to form distinct clusters. Future use of microsatellites in *Vaccinium* will help resolve species relationships in the genus, estimate genetic diversity in the National Clonal Germplasm Repository (NCGR) collection, and confirm the identity of clonal germplasm accessions.

A New Dominant Trait of Natural Astringency Loss of Persimmon (*Diospyros kaki* Thunb.) Found in a Chinese PCNA 'Luo Tian Tian Shi'

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There is a non-astringent type of persimmon that loses its astringency naturally on trees, despite the absence of seeds. This type is called pollination-constant and non-astringent (PCNA)-type. PCNA-type was thought to have originated in Japan as a mutant that terminates tannin accumulation at an early stage of fruit development. This trait is confirmed to be recessive and the PCNA-type must be homozygous in all alleles. In fact, crossing among PCNA-type individuals yields only the PCNA-type in F_1, while crossing between PCNA-type and non-PCNA-type yields only the non-PCNA-type. However, a new PCNA cultivar, 'Luo Tian Tian Shi', was reported in 1982 to exist in Luo Tian County, China, and this PCNA-type seemed to have different mechanisms to be PCNA-type. Our previous report showed that a crossing between 'Luo Tian Tian Shi' and Japanese PCNA 'Taishu' yielded both PCNA-type and astringent-type in F_1, indicating that the trait of PCNA in 'Luo Tian Tian Shi' may be dominant. To confirm this hypothesis, we made crossings between 'Luo Tian Tian Shi' and Japanese astringent-type 'Yotsumizo' or 'Iwasedo', and top-grafted these seedlings for earlier fruiting. As we had some fruits in a total of 25 F_1 individuals last year, we investigated segregation of astringency among these individuals. We also confirmed the parental relationships of these progenies by analyzing several SSR markers. We confirmed the segregation of PCNA-type and astringent-type in F_1. No mistake of artificial pollination was shown in all individuals by SSR markers. Thus, we concluded that the trait of astringency-loss in 'Luo Tian Tian Shi' is dominant and the use of this cultivar as a parent will open a new window for breeding PCNA-type persimmon.

Identification of Unique Reproductive Characteristics in Six Pawpaw Populations for Germplasm Enhancement

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The North American pawpaw [*Asimina triloba* (L.) Dunal] is a tree fruit native to the eastern and midwestern areas of the United States. The fruit has a rich, unique flavor and pawpaw has great potential as a new fruit crop. Kentucky State University (KSU) in Frankfort is the

site for the USDA National Clonal Germplasm Repository (NCGR) for *Asimina* species, containing over 1700 accessions from 17 different states. The objective of this study was to evaluate the diversity in reproductive characteristics for pawpaw accessions in the KSU-USDA repository orchard from six geographic regions (Ind.-site 1, Ind.-site 2, Ky., Md., N.Y., and W.Va.). Data were collected in 2002, 2003, and 2004 for trunk cross-sectional area, total number of flowers, length of flowering, flowering peak, fruit set, total number of clusters, total number of fruit, number of fruit per cluster, average fruit weight, yield, yield efficiency, length of harvest, harvest peak, and growing degree days required for ripening. Significant differences in characteristics were found within and among populations for the various regions. Accessions from Kentucky and West Virginia had the latest flowering peaks. Trees from Maryland had the highest fruit weight in 2002, whereas the West Virginia population produced the largest fruit in 2004. The New York accessions consistently had the latest harvest peak and required the fewest growing degree days for ripening. Correlations were also found between several vegetative and reproductive characteristics. This study suggests that a significant level of reproductive diversity exists within KSU's repository collection that could be used in future breeding strategies for cultivar improvement.

Oral Session 21—Floriculture–Postharvest

Moderator: John M. Dole

19 July 2005, 4:00–5:30 p.m. Room 108

Pinching Impacts Cut Poinsettia Stem Quality and Profit Potential

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The development of the Renaissance series of cut poinsettias, *Euphorbia pulcherrima*, presents unique opportunities and challenges to cut flower producers. This series has curled bracts, long stem length, excellent vase life, and is highly marketable. Literature indicates that this crop is suited for pot or bed production, but does not compare how cultural methods impact stem quality. This study assessed the impact of pinching on final stem quality and crop profitability. Uniform rooted cuttings of 'Renaissance Red' obtained from a commercial supplier were transplanted into a 1.2 × 2.4 m bed containing a soilless media to obtain two plants per 0.09 m^2. A total of 56 cuttings were used and grown using standard production techniques. Transplanting occurred on 29 July 2004 with half of the plants being pinched on 19 Aug. 2004. To minimize border effects, plants in the outside rows were discarded. Upon harvest, stem length, stem diameter, bract diameter, floral development, and number of axillary shoots were determined for 30 interior plants. Both pinched and unpinched plants produced marketable stems; however, unpinched plants produced longer thicker stems with larger bracts. The number of stems obtained per square foot was greater with the pinched plants. While overall quality was reduced, this increase in stem number offset potential lost profit. The production of quality cut stems of 'Renaissance Red' poinsettias is possible with either pinched or unpinched plants.

Postharvest Handling of Cut *Linaria, Trachelium,* and *Zinnia*

John M. Dole*, Frankie L. Fanelli, William C. Fonteno, Beth Harden, Sylvia M. Blankenship

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Optimum postharvest handling procedures were determined for *Linaria maroccana* 'Lace Violet', *Trachelium* 'Jemmy Royal Purple', and *Zinnia elegans* 'Benary's Giant Scarlet' and 'Sungold.' A 24-hour 10% or 20% sucrose pulse increased the vase life of *Linaria* by 2–4 days, resulting in a vase life of 9 days as compared to 5 days for control flowers held in deionized (DI) water. Use of floral foam and cold storage at 1 °C for 1 week decreased vase life. Treatment with either 0.1 or 1.0 ppm ethylene had no effect. The use of a commercial holding solution (Floralife Professional or Chrysal Professional 2 Processing Solution) or 2% or 3% sucrose increased vase life 4–10 days. For cut *Trachelium*, ethylene caused florets to close entirely or stop opening; 1-MCP and STS prevented these ethylene effects. Stems tolerated 4 days of 1 °C storage, but 1 week or more of storage reduced the 14-day vase life of unstored flowers to 9 days. Stems in 2% or 4% sucrose had a longer vase life compared to DI water. While the use of floral foam was not detrimental when used with sucrose solutions, it reduced vase life when sucrose was not used. *Zinnia* stems could not be cold stored for 1 week at 1 °C due to loss of turgidity and cold damage. Stems stored dry at 5 °C regained turgidity and averaged a vase life of 14 days; however, petals remained slightly twisted and curled after being in the vase for several days. Treatment with ethylene had no effect. Floral foam reduced vase life to 9–10 days.

Postharvest Handling of Cut *Dahlia*, *Lupinus*, *Papaver*, and *Rudbeckia*

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Optimum postharvest handling procedures were determined for *Dahlia* 'Karma Thalia', *Lupinus mutabilis* ssp. *cruickshankii* 'Sunrise', *Papaver nudicaule* 'Temptress', and *Rudbeckia* 'Indian Summer.' *Dahlia* harvested fully open had a vase life of 7–10 days in deionized (DI) water that was increased by 1.5–2 days using commercial holding solutions (Chrysal Professional 2 Processing Solution or Floralife Professional). Neither floral foam nor 0.1–1.0 ppm ethylene had any effect on vase life. One week of cold storage at 1 °C reduced vase life up to 2 days. The longest vase life, 12–13 days, was obtained when floral buds, showing a minimum of 50% color, were harvested at the breaking stage (one petal open) and placed in 2% or 4% sucrose or a commercial holding solution. *Lupinus* flowers held in DI water lasted 8–12 days; 1 week cold storage at 1 °C reduced vase life by 3 days. Florets and buds abscised or failed to open when exposed to ethylene; STS pretreatment prevented the effects of ethylene. Commercial holding solutions increased *Papaver* vase life to 7–8 days from 5.5 days for stems held in DI water. While stems could be cold stored for 1 week at 1 °C with no decrease in vase life, 2 weeks of cold storage reduced vase life. Flowers were not affected by foam or ethylene. *Rudbeckia* had a vase life of 27–37 days and no treatments extended vase life. Stems could be stored at 2 °C for up to 2 weeks and were not ethylene sensitive. Floral foam reduced the vase life over 50%, but still resulted in a 13-day vase life.

Dormancy and Premature Emergence of *Hippeastrum*

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The majority of *Hippeastrum* bulbs sold in the U.S. market are shipped from other countries. The shipping time and temperature varies by the country that the bulbs are shipped from and the storage time and temperature also varies by the company that packages the bulbs for retail sale. These packaged bulbs then sit on a shelf until they are purchased and forced by the consumer. These various storage times and temperatures can affect the longevity after packaging (premature emergence) and quality of the finished plant. The objectives of this research were to determine the effects of various storage temperatures and durations on emergence and forcing of *Hippeastrum* hybrids. Bulbs were stored at temperatures of 5, 9, 13, 21, and 29 °C for 6, 9, 12, and 15 weeks after which time one set was stored at 21 °C (packaged display temperature) and the other set forced in the greenhouse. Emergence of leaves and buds when stored at the 21 °C display temperature and during greenhouse forcing varied by specific hybrid according to storage duration at 5, 9 and 13 °C. Storage at 21 and 29 °C resulted in only leaf emergence and no flower bud emergence during the 21 °C display temperature and greenhouse forcing. Storage at 5 and 9 °C generally resulted in slower leaf emergence and quicker bud emergence. Results

from this research can be used to help determine the best storage times and temperatures for preventing premature emergence of *Hippeastrum* based upon previous shipping times and temperatures.

The Effects of Postharvest Storage Temperature on Vegetative Cutting Respiration

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Poinsettia 'Prestige', New Guinea impatiens 'Sonic White', and petunia 'Improved Charlie' cuttings were harvested from stock plants, weighed, placed in glass jars, and placed at 10, 15, 20, or 25 °C. Carbon dioxide accumulation was measured and used to determine respiration rates at 2, 6, 10, 24, and 48 hours. Vegetative cuttings have very high initial respiration rates that quickly decline over time. At 2 hours, respiration rates at 25 °C were 5.4-, 2.4-, and 4.3-fold higher vs. 10 °C in poinsettia, New Guinea impatiens, and petunia, respectively. By 48 hours, there was little difference in respiration rates. In a second experiment, poinsettia 'Prestige' cuttings were pre-cooled at 10 °C for 0, 3, 6, 12, or 24 hours before being transferred to 20 °C. Respiration rates were measured at 0, 2, 6, 10, 24, 48, and 72 hours in the 20 °C environment. Regardless of pre-cooling duration, respiration rates increased when cuttings were transferred from 10 to 20 °C. Respiration rates of cuttings pre-cooled for 3, 6, or 12 hours were not significantly different from cuttings maintained at constant 20 °C. However, after transfer, cuttings pre-cooled for 24 hours had a respiration rate significantly lower than cuttings maintained at constant 20 °C, but by 72 hours, there were no significant differences.

Ethylene Exposure and 1-MCP Protection for Tulip Bulbs during Storage

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During transportation and storage of Dutch tulip bulbs, potential ethylene exposure could lead to flowering abnormalities, including accelerated flowering, shortened plant heights, and in the most extreme case, flower abortion. Sources of ethylene include *Fusarium*-infected bulbs, deteriorating tissues, and combustion engines. Treatment with 1-MCP (1-methylcyclopropene) may prevent ethylene action as 1-MCP occupies ethylene specific receptors on target tissue. Two aspects of this problem were quantified using four tulip cultivars: duration of ethylene exposure necessary to induce damage as well as the effective period of protection by 1-MCP against ethylene. Flower abortion appeared in susceptible cultivars after ≥9 days of ethylene exposure (10 ppm) and was only found in mature bulbs (late November). The effective protection period of 1-MCP against ethylene (2-week exposure of 10 ppm) was determined, using flowering percentages, to be as long as 4–7 days in young bulbs and 28 days for older bulbs. Effects of ethylene on other flower attributes and implications of these findings in industry practices will be discussed.

Oral Session 22—Floriculture–Nutrition/Media/ Pest Management

Moderator: Carinne Peters

20 July 2005, 8:00–9:30 a.m. Room 105

Variation in Media pH and Electrical Conductivity in Geraniums

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Pour-through extraction can provide data indicating geranium container nutrient status for growers to diagnose nutritional problems and prevent plant loss. The objective of this study was to examine changes in growing media pH and electrical conductivity during the production cycle of 10 cultivars from each of the three geranium classes (zonal, ivy, and regal). Thirty cultivars of geraniums were grown in pots using standard commercial greenhouse production guidelines for 12 weeks. Pour-through extractions were performed every 5 d and media pH and electrical conductivity were determined on the collected leachate. While there was a significant reduction in media pH for zonal and ivy geraniums 36 d after transplanting plugs, only one regal cultivar exhibited a decrease in pH during the production cycle. Statistically significant differences for mean media pH and electrical conductivity were also observed among cultivars within each class at several sampling dates. The results of this study indicate that zonal, ivy, and one regal cultivar's media pH decreases rapidly from day 21 to day 36, and then returns to initial levels by day 46. Because of the importance of media pH to nutrient uptake, this study allows for a better understanding of nutritional problems that are linked to pH that frequently occur at the stage of growth. It also suggests that fertigation rates should be adjusted by cultivar and growth stage to address this pH variation.

Cation Exchange Capacity and Base Saturation of 64 Peat Mosses

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Problems of inconsistent initial pH in peat moss-based substrates that are created using standard formulas for limestone additions, and pH drift from the target in those substrates may be due to variations in the CEC and BS of peat moss. This study was conducted to determine whether such variation exists. Sixty-four peat moss samples were obtained from several bogs across Alberta, Canada. Adsorbed cations on each peat moss sample were displaced with hydrochloric acid (HCl), and flushed out with three deionized water washes. The displacing/flushing solution was collected and later analyzed for concentration of bases (Ca, Mg, K, and Na) using atomic absorption spectrometry. After cations were removed, the peat moss exchange sites were saturated with barium acetate [$Ba(OAc)_2$] to displace the H^+, which were then collected by a second flushing with deionized water. This second displacing/flushing solution was titrated with measured amounts of NaOH to a phenolphthalein end point. Base saturation and CEC were calculated. There were significant variations in CEC (ranging from 108.12 to 162.25 $cmol \cdot kg^{-1}$) and BS (ranging from 13.52% to 63.97% of CEC) among the peat moss samples. Ca accounted for 78.08% of the BS. For a given peat moss, the higher the BS, the lower the neutralization requirement to achieve a target pH. Also, high CEC peat mosses may have greater buffering capacity than those with low CEC, which may result in less pH drift.

A Protocol to Quantify the Reactivity of Carbonate Lime for Horticultural Substrates

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Lime sources vary in their reactivity depending on particle size, surface area and crystalline structure, and chemical composition. Current horticultural practice for testing lime reactivity and the appropriate lime rate is through batch trials where lime is incorporated into growing media. Our objective was to test a laboratory approach that would provide a rapid analytical test on reactivity of lime sources, and could eventually be applied to measuring unreacted (residual) lime in container media. Four moles HCl was added to a lime sample, and the volume of CO_2 released over time was measured in a burette. Three lime types were tested, including reagent grade $CaCO_3$, and two pulverized dolomitic limestones used in horticultural media. 100% of $CaCO_3$ reacted in less than a minute after acid addition, whereas only 79.8% and 49.5% of the two commercial lime samples had reacted after 10 minutes. The time required for 50% of the two commercial lime samples to react was 5 and 10 minutes, respectively, whereas it took 20 and 60 minutes, respectively, for 95% neutralization. Reaction rates in the laboratory test correlated with the time required to achieve a stable pH level when limes were incorporated into a peat substrate. The reagent-grade $CaCO_3$ raised pH more rapidly (within 7 days) and to a higher level (maximum pH 7.5 at 9 g of lime per liter of peat) compared with the dolomitic lime sources. It may be possible to establish a lime reactivity index, for

example, based on CO_2 release after 10 minutes, and thereby provide a rapid screening of limes. Further gasometric analysis of lime types used in horticultural substrates is therefore needed.

The Effects of Root Zone Temperature and Limestone on pH and Electrical Conductivity on New Guinea Impatiens 'Celebration Orange'

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The purpose of this experiment was to examine the effects of various root-zone temperatures and pH on *Impatiens* ×*hybrida*, New Guinea impatiens 'Celebration Orange.' Greenhouse growers need to be cognizant of the root-zone medium pH, as New Guinea impatiens are sensitive to nutrient toxicities at low pH. It is thought that limestone at low root-zone medium temperatures is not quickly activated, leading to toxicities. The objectives of this project were to determine: the effect of root-zone medium pH on foliar symptoms of iron and manganese toxicity; and the effective rates and grind size of limestone on root-zone medium pH. Various rates of limestone and different grind sizes were incorporated into a sphagnum peat moss-based medium at a range of temperatures. This experiment used a two-way thermogradient plate to maintain varying, but stable root-zone medium temperatures, ranging from 12 to 42 °C. Plant growth as well as root-zone medium pH was monitored. Changes in root-zone medium pH were monitored over time. Results indicated that the addition of moderate or high rates of limestone, 6 or 3 $kg \cdot m^{-3}$, provided stable root-zone media pH over the course of time. Both limestone grind sizes at 325 and 100–200 mesh provided satisfactory starting and ending pH values for healthy New Guinea impatiens growth, especially between the root-zone temperatures of 30 and 18 °C. Higher and lower temperature extremes inhibited root growth, resulting in lower quality plants.

Phytotoxicity of TriStar Formulations on Fully Colored Poinsettia Cultivars

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Late season control of whitefly is problematic in many production ranges as systemic insecticides may not provide full season control. Most commercially available contact insecticides are not labeled for use on fully colored poinsettia, *Euphorbia pulcherrima*, plants due to potential phytotoxicity or residue on colored bracts. Recent formulation changes in TriStar make late season applications possible. This study assessed phytotoxicity and residue impacts of two formulations of TriStar on potted poinsettias. On 4 Aug. 2004, rooted cuttings of 47 poinsettia cultivars obtained from four commercial suppliers were transplanted into pots containing a soilless medium. A total of 235 cuttings were used to arrive at five pots per cultivar. Plants were grown using standard production techniques. On 11 Nov. 2004, all plants were fully colored and treated with TriStar 70 WSP or TriStar 30SG at maximum label rates. Phytotoxicity and residue levels were assessed 7 days later using a 1 to 9 visual scale. Overall the formulations had few negative impacts on poinsettias. Phytotociticy ratings were minimal for most cultivars; however, some cultivars, such as 'Silverstar Red' expressed an elevated level of phytotoxicity. Dark colored cultivars showed more residue than light colored cultivars. The TirStar 30SG formulation had the least amount of residue. TriStar 30SG may be an acceptable insecticide for late season control of whitefly on poinsettia crops. Producers are cautioned to test cultivars for phytotoxicity before applying to an entire crop as some cultivars are sensitive to TriStar 30SG.

Tank Mixtures Differentially Impact Survival of Predatory Mites used to Manage Western Flower Thrips

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Greenhouses contain a vast array of insect, mite, and disease pests primarily managed by applications of conventional and biorational pesticides including insecticides, miticides, and fungicides. However, biorational pesticides have a narrow range of pest activity. As a result, greenhouse producers tank mix to broaden application activity. Research has demonstrated that tank mixing can result in either synergistic or antagonistic interactions for targeted pests. However, the impact of tank mixing insecticides and fungicides on predatory mites, *Neoseiulus cucumeris*, used to manage western flower thrips, *Franklinella occidentalis*, is unknown. The objective of this research was to determine how mixtures of four different pesticides (Conserve, Avid, Cleary's, and Decree), alone and in all possible combinations affect predatory mite survival in a laboratory bioassay. Individual 2-day-old adult mites, isolated in a cell of a bioassay tray, were exposed to one of the 15 pesticide treatments, or a water control. Treatments were replicated 15 times. Trays were held in an environmental chamber and mite mortality was assessed after 24 hours. Mite mortality was differentially impacted by some pesticide treatments when compared with the water control. One pesticide mixture, Conserve + Cleary's, significantly reduced mite survival compared to other pesticide treatments or the water control. Up to 70% of the mites exposed to this treatment died. The combination of Conserve + Cleary's should be avoided as a tank mixture when the biological control agent, *Neoseiulus cucumeris*, is used to manage western flower thrips.

Oral Session 23—Nursery Crops 2

Moderator: Greg Litus

20 July 2005, 8:00 –9:15 a.m. Room 107

Operating a Process-based Simulation Model within a User-friendly Windows Environment to Predict the Transpiration and Photosynthesis of Red Maple Trees

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Application of process-based models beyond the research community has been limited, in part because they do not operate in a user-friendly Windows environment. We describe the procedure of adapting a spatially explicit biological-process model, MAESTRA, to run in a standard graphical user interface (GUI). The methods used to adapt the MAESTRA model are generally applicable to other process-based models and therefore simplify other coupling attempts. We discuss recommendations based on our experiences for model input structure and interface design, two components that will allow various models to work with a generic interface. MAESTRA uses modified versions of the Ball-Berry stomatal conductance (g_s) and Farquhar photosynthesis (A_{net}) models to estimate transpiration and photosynthesis on a leaf area basis and scale the sunlit and shaded fractions to the whole tree. We present MAESTRA estimates within a standardized graphical user interface for crop simulators (GUICS) windows environment and furthermore, we provide dialog boxes and graphical displays of the MAESTRA model input and whole tree output for red maple trees. In so doing, we present a technology transfer via the GUICS that prevents any watering down of the science behind the MAESTRA model, yet allows an accurate decision support tool to reach a wide audience.

Comparison of First- and Second-Year Growth between Container-grown 'Autumn Blaze' Maple Trees

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In May 2004, at the request of local nursery owners, young *Acer* ×*freemanii* 'Autumn Blaze' (Autumn Blaze maple) trees previously grown in a number 20 (#20) container pot-in-pot (PIP) system were planted at the Colorado State University Horticultural Farm alongside similarly sized trees field grown, balled and burlapped

(B&B). These trees were planted using methods recommended by the International Society of Arboriculture with half receiving 30% by volume soil amendment consisting of Organix compost mixed with the native soils. In addition, five trees grown for one year using the #20 PIP container system were maintained a second year in the same containers and compared to five trees transferred to #45 containers. After one season, the PIP-grown trees showed significantly more shoot growth and increased trunk caliper than the B&B trees. The application of amendments had no effect on the growth for either the B&B or PIP trees. Trees maintained in PIP containers for a second year had similar growth regardless of the container size.

Nitrogen Fertility Affects Growth and Water Use of *Cercis siliquastrum* Tree Species Native to Lebanon

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The Mediterranean region is a center of great plant diversity, harboring around 25,000 plant species, more than 20% of them endemic. Since the last Lebanese flora record in 1966, the country has experienced habitat fragmentation and destruction, due to overgrazing, overexploitation of natural resources, and urban expansion. A large number of Lebanese tree species have unexplored economic potential as either ornamental or medicinal plants. This study aimed at exploring the effects of two nitrogen fertility treatments on the growth and water use of 2-year-old *Cercis siliquastrum* seedlings. *C. siliquastrum* seeds were collected from different locations and mother trees in Lebanon in mid-Aug. 2001. Two-year old plants were then transplanted into 3-gal. containers and were randomly assigned to one of two N fertility programs, 25 ppm or 100 ppm. Plants from all redbud sources were significantly taller in the low N treatment and had significantly higher RGR than plants growing at 100 ppm N. On the other hand, plants growing at 100 ppm N level had significantly higher LAR and lower NAR than plants growing at 25 ppm N. There were significant differences in LAR and plant heights among the different sources. Water use was conducted monthly. It ranged from 3.6×10^{-4} to 1.3×10^{-3} g·cmHt^{-1} per hour at 25 ppm and from 2.6×10^{-4} to 1.3×10^{-3} g·cmHt^{-1} per hour at 100 ppm N through the experiment.

Effect of Fall Fertilization on Freeze Hardiness of Deciduous versus Evergreen Azaleas

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This experiment compared the effect of fall fertilization on freeze hardiness of evergreen vs. deciduous azaleas (*Rhododendron*). Beginning in Spring 2003, a 2 × 3 factorial experiment was conducted in Athens, Ga., on container plants grown outdoors under nursery conditions involving two taxa (*R. canescens* and *R.* ×*satsuki* 'Wakaebisu') and three fall fertigation regimes (Aug.–Sept., 75 mg·L^{-1} of N; Aug.–Nov., 75 mg·L^{-1} of N; and Aug.–Nov., 125 mg·L^{-1} of N). On 15 Nov. and 17 Dec. 2003 and 16 Jan., 18 Feb., and 19 Mar. 2004, plant stem tissue was harvested and exposed to 10 progressively lower temperature intervals between –3 °C and –30 °C under laboratory conditions in order to estimate azalea freeze hardiness. Freeze hardiness was affected by fertilizer and taxa treatments, but there were no significant interaction effects in this study. The timing of freeze hardening was not significantly different among the two species over time, and the fall fertilizer treatments did not affect the timing of hardening. Compared to the industry standard (75 mg·L^{-1} of N, Aug.–Sept.), *R. canescens* that received extended fertilization at the high rate (125 mg·L^{-1} of N, Aug.–Nov.) was less freeze hardy in November, December, and January, and *R.* ×*satsuki* was less freeze hardy in December. However, when compared to the industry standard, the low rate of extended fertilization (75 mg·L^{-1} of N, Aug.–Nov.) did not affect azalea freeze hardiness.

Comparison between Peat and Fresh Rice Hulls: Hydraulic and Chemical Characteristics

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One of the most widely used substrates in nursery production is peat, which is used as plain substrate or mixed with other media. Peat use is problematic, primarily because of the high price and the environmental implications connected with its extraction and disposal. For these reasons, the exploitation will be restricted in the future in both Europe and America. Thus, researchers are under pressure to find alternative substrates that can be used in an inexpensive and environmentally friendly way. Although aged, carbonized and composted rice hulls have been used to a limited extent, more studies are needed to characterize fresh rice hulls as a growing medium. This research was aimed at characterizing fresh hulls after being ground in different particle sizes, and comparing them with peat. Ground hulls were separated into four fractions (6-, 4-, 2-, and 1-mm diameter), which were characterized for pH, EC, CEC, organic matter, and total nitrogen content. The water retention curve was also estimated and the following hydraulic characteristics were measured and compared: TP, CC, AFP, EAW, and WBC. As expected, pH, N, and C content and CEC did not differ among rice hull fractions, while EC showed a slight but constant increase when particle dimensions decreased. Compared to peat, the TP of rice hulls was smaller independently from particle dimensions, but AFP was 19.5%, 44,1%, 114.2%, and 115.8% higher for 1-, 2-, 4-, and 6-mm particles, respectively, indicating a very good aeration capacity. EAW and WBC were higher only in 1- and 2-mm particles. A further experiment aimed at comparing the behavior of transplants in rice hulls (6 mm) and peat showed that tomato plantlets grew slower in the former, although transplants were of good, marketable quality.

Oral Session 24—Viticulture and Small Fruit–Culture and Management

Moderator: Kim E. Hummer

20 July 2005, 8:00–9:30 a.m. Room 108

Protected Culture Enhances Early Season Strawberry Fruit Yield and Quality in Southern California

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Total and marketable yield, fruit size and fruit rot were evaluated for 'Camarosa' and 'Ventana' strawberries grown with or without protected culture in southern California in 2003 and 2004. In both years, bareroot transplants were established on 5 Oct. using standard "open field" production methods. Fifty-five days after transplanting, metal posts and arcs were positioned over portions of the field and covered with 0.0324-mm-thick clear polyethylene (Tufflite Thermal, Tyco Plastics, Inc., Minneapolis, Minn.) to create "tunnel" structures 5 m wide, 25 m long, and 2.5 m high. Each tunnel covered three contiguous strawberry beds, and experiment design was a randomized complete block with four replications, with individual plots consisting of 20 plants. In 2003, early season (Jan.–1 Apr.) marketable yields in tunnels were 90% and 84% greater than outdoor culture for 'Ventana' and 'Camarosa', respectively. In 2004, use of tunnels resulted in a 140% marketable yield increase for 'Ventana' and 62% for 'Camarosa' (Jan.–31 Mar.); however, unusually high temperatures (38 °C) in April resulted in reduced yields in tunnels thereafter. In both years, increased early production coincided with highest fresh market fruit prices, resulting in $5700–7700 greater returns per-acre compared to open field production. For both cultivars, tunnel production resulted in 37% to 63% fewer non-marketable fruit due to less rain damage, better fruit shape, and decreased incidence of gray mold. For all treatments, fruit size decreased as the season progressed and was more pronounced in

tunnels after April. Overall, these studies indicate that tunnels have potential for enhancing early-season production and profitability of strawberries in southern California.

Iturup and Sakhalin Island Strawberries

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A plant-collecting expedition to Iturup and Sakhalin Islands, Russian Federation, occurred between 21 July and 12 Sept. 2003. *Actinidia, Rubus, Ribes,* and *Vaccinium*, as well as seven accessions of strawberries, *Fragaria* L., were collected. Among them, a wild strawberry, *Fragaria iturupensis* Staudt, was collected on the eastern slope of Atsonupuri Volcano, Iturup Island, at 630 and 650 m elevation. This species was similar in habit, leaf color and overall appearance to the American strawberry species *F. virginiana* Mill. Fruits were bright red, oblate spherical, about 1.4 cm in diameter, and had exerted achenes. The native distribution of this species was limited to the middle elevation of the slope of this volcano, and only on Iturup Island. Chromosome counts indicated that these plants were octoploid. Initial DNA fingerprinting aligned this sample with other octoploid species. In addition to this species, samples of *F. yezoensis* H. Hara (syn. *F. nipponica* Makino) were collected on Kuibyshewskii Bay of Cape Otlivnoy, Iturup, and near Ujno-Sakhalinsk City, Sakhalin Island. *F. iinumae* Makino was observed in Ogon'ki Village, Sakhalin Island. This report confirmed the existence of *F. iturupensis*, the only known native Asian octoploid strawberry, and documented its limited range. Seeds of these strawberry species are available for research by request from the U.S. Department of Agriculture, Agricultural Research Service, National Clonal Germplasm Repository in Corvallis.

Transport of Cross-pollen by Bumblebees in a Rabbiteye Blueberry Planting

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Blueberries are bee-pollinated species that benefit from cross-pollination. Cross-pollination is particularly critical for optimum fruit set of rabbiteye blueberries (*Vaccinium ashei* Reade) because of their limited degree of self-fertility. In order to determine if the failure to set adequate commercial fruit loads is due to a lack of cross-pollination, research was needed to establish how much out-crossing rabbiteye blueberry pollinators actually do. A novel method was developed to identify pollen grains on the bodies of bumblebees by cultivar. The technique discriminates between two cultivars, based on differences in pollen diameter. Bumblebees were collected in a plot composed of blueberry plants of the cultivars Brightwell and Climax since these cultivars produce pollen of different size. Pollen loads of bumblebees contained low proportions of cross-pollen regardless of the cultivar they were visiting. Data suggest that inadequate levels of cross-pollination play a major role in low fruit set problems of rabbiteye blueberry. The composition of bees' pollen load changed with the phenology of the crop. The greatest likelihood for cross-pollination occurred around the time of maximum bloom overlap. Bumblebees foraging on 'Brightwell' flowers carried more total blueberry pollen and a higher proportion of self-pollen than those visiting 'Climax'. This may be due to differences in pollen release between flowers of these two cultivars.

Plant Water Use Differs among Three Mature Highbush Blueberry Cultivars

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The water use of three mature highbush blueberry cultivars was determined during the growing season by using TDR technology. A combination of four buriable TDR waveguides at 6-, 12-, 18-, and 24-inch depth and two surface waveguides 6- and 18-inch length were installed in a 60-acre commercial 'Bluejay', 'Bluecrop', and 'Jersey' blueberry field with four replications for each cultivar. The reference evapotranspiration (ETo) was obtained for each cultivar from three weather stations located in the vicinity of replicated waveguides. Soil moisture data were collected every 3-5 days from April to the end of September. The average daily crop evapotranspiration (ETc) was significantly different at different plant developmental stages among three cultivars; the highest daily plant water use was during the fruit development stage for all three cultivars. The crop ETc for 'Bluejay' and 'Elliott' can be as high as 0.35 inches per day and average 1.5 to 2 inches per week during the summer. The estimated crop coefficients at bloom, fruit development, harvest, and postharvest are 0.90, 1.51, 1.05, and 1.05 for 'Bluejay'; 0.84, 1.11, 0.99, and 1.23 for 'Bluecrop'; and 0.94, 1.30, 1.39, and 1.17 for 'Jersey', respectively. The peak water use coincides well with the advancement of fruit maturity, suggesting irrigation scheduling should differ among early, mid, and later season highbush blueberry cultivars.

Flood Water Temperature and Duration Affect Nonstructural Carbohydrate Concentration of Cranberry Uprights and Roots

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Flooding is often used as a pest management tool in cranberry production. The "Late Water" flood is a 1-month flood held on some Massachusetts bogs from mid-April to mid-May, and has anecdotally been related to poor vine performance. The flood was simulated at 11 °C and 21 °C on potted cranberry uprights (cv. Stevens). Over the course of the 1-month flood, total nonstructural carbohydrate concentration (TNSC) of the upright tissue decreased by 23% and 50% in the 11 °C and 21 °C treatments, respectively. Decreases in upright TNSC in the 11 °C treatment were mostly due to a substantial decrease in sucrose, while in the 21 °C treatment, sucrose, glucose, fructose, and starch all decreased significantly over the course of the flood. The greatest decrease in upright TNSC in the 11 °C treatment occurred during the first week of the flood, while in the 21 °C treatment, the greatest decrease occurred during the fourth week. Root TNSC was not affected by flooding in the 11 °C treatment, but was reduced by 39% in the 21° C treatment. Two weeks following removal from the 1-month flood, uprights in the 11° C treatment contained 9% more TNSC than uprights in the 21 °C treatment, while root TNSC from the two treatments was similar. No temperature treatment differences were evident in the uprights or roots by harvest.

Correlation between Glassy-winged Sharp Shooter Feeding Preference and Pierce's Disease Development on Grapevines

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Although some of the American native *Vitis* species and their hybrids, particularly those originated from the southeastern United States, have been known for resistance to Pierce's disease (PD), their resistant status against the glassy-winged sharp shooter [GWSS, *Homalodisca coagulata* (Say)], the vector transmitting PD pathogen (*Xylella fastidiosa* Well), has not been reported. To determine GWSS feeding preferences on different grape species/cultivars and correlations of feeding to Pierce's disease development, a survey was conducted at Florida A&M University, Tallahassee. The feeding preference of GWSS on different species/cultivars was evaluated in two different ways: 1) count the number of GWSS on different grapevines in the field; and 2) determine the feeding preference by measuring the excretion of the GWSS feeding on difference grape species/cultivars, including highly susceptible *V. vinifera* cultivars, native American grape species and hybrids, and muscadine grapes. Results from this study indicated that the frequency of GWSS visits on different grapevines varied among the species/cultivars investigated. For example, PD-resistant grape *V. rotundifolia* (muscadine grape) had significantly fewer GWSS visits than did the PD-susceptible *V. vinifera* grape. The frequency of GWSS visits to *V. labrusca*, the native American grape susceptible to PD, was

intermediate between those found on *V. rotundifolia* and *V. vinifera*. Similarly, the GWSS sucked more xylem sap when they fed on PD-susceptible grapevines than on PD-resistant ones. Overall, there is a positive correlation between the GWSS visits/feeding and the status of grapevine resistance/susceptibility to Pierce's disease.

Oral Session 25—Fruit Crops–Management and Production

Moderator: Anita Nina Azarenko

20 July 2005, 10:00–11:45 a.m. Room 107

Economic Comparison of Five High-density Apple Planting Systems

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We performed an economic analysis of five orchard production systems [Slender Pyramid/M.26 (840 trees/ha), Vertical Axis/M.9 (1538 trees/ha), Slender Axis/M.9 (2244 trees/ha), Tall Spindle/M.9 (3312 trees/ha), and Super Spindle (5382 trees/ha)] using composite yield and labor usage data from several replicated research plots in New York state. Other costs and fruit returns were averages from a group of commercial fruit farms in New York state. The systems varied in costs of establishment from a low of $18,431/ha for the Slender Pyramid system to high of $47,524/ha for the Super Spindle system. The large differences in establishment costs were largely related to tree density. All of the systems had a positive internal rate of return (IRR) and net present value (NPV) after 20 years. They ranged from a low of 7.5% IRR for the Slender Pyramid system to a high of 11.1% IRR for the Slender Axis system. Profitability, as measured by NPV, was curvilinearly related to tree density with intermediate densities giving greater profitability than the highest densities. The optimum density was 2600 trees/ha when NPV was calculated per hectare, but only 2200 trees/ha when NPV was calculated per $10,000 invested. The earliest break-even year was 10 for the Slender Axis and Tall Spindle systems. The latest break-even year was 13 for the Slender Pyramid. An estimate of the number of hectares required to produce a $100,000 annual profit to the business was 222 for the slender pyramid system and 84–104 ha of the three best systems (Super Spindle, Tall Spindle, and Slender Axis). The analysis revealed that efforts to control establishment costs of land, trees and support system can substantially increase lifetime profits.

Rootstocks and Interstem/Rootstock Combinations for Lower Midwest Apple Orchards

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Use of precocious, high-yielding, dwarfing rootstocks for apple trees in southern Illinois has been limited by the prevalence of fire blight and crown rot diseases, as well as soil and climate stresses. Apple orchards in the region are generally situated on heavy clay soils and often receive excess rainfall in spring and fall, followed by drought in summer. New dwarfing rootstocks adapted to these biotic stresses were used as interstems on robust, vigorous rootstocks, to determine if earlier and greater cumulative yields could be obtained compared to the current industry standard MM. 111. The treatments consisted of 20 various interstem/rootstock combinations with 'Ruby Jon Jonathan' as the scion that were propagated and grown as feathered maidens in the nursery. The trees were planted at 4.5 × 6.0 m in a randomized complete-block design with eight replications in May 1996 at the Southern Illinois University Horticultural Research Center at Carbondale, Ill. The trees were trained in a vertical axis system with minimal initial pruning and complete deblossoming in the first 2 years. Trees were allowed to crop during the third- through ninth-leaf. Cumulative yields of the best performing interstem/rootstock combinations were two to three times greater compared with MM. 111. The trees on the most vigorous rootstocks consistently produced the largest fruit size, but four dwarfing clones, G. 30, V. 1, Bud. 9, and M. 7, used as interstems, generally produced higher yields with similar fruit size. These advantages were obtained without the negative side effects (excess root suckers, lack of scion uniformity, and increased mortality) traditionally associated with interstem performance in the lower Midwest.

Apple Rootstocks and Pre-plant Soil Treatments Alter Soil Microbial Community Composition in a New York Orchard

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Apple (*Malus* ×*domestica*) replant disease (ARD) is a soil-borne disease syndrome of complex etiology that occurs worldwide when establishing new orchards in old fruit-growing sites. Methyl bromide (MB) has been an effective soil fumigant to control ARD, but safer alternatives to MB are needed. We evaluated soil microbial communities, tree growth, and fruit yield for three pre-plant soil treatments (compost amendment, soil treatment with a broad-spectrum fumigant, and untreated controls), and five clonal rootstocks (M7, M26, CG6210, CG30, and G16), in an apple replant site at Ithaca, N.Y. Molecular fingerprinting (PCR-DGGE) techniques were used to study soil microbial community composition of root-zone soil of the different soil treatments and rootstocks. Tree caliper, shoot growth, and yield were measured annually from 2002–04. Among the five rootstocks we compared, trees on CG6210 had the most growth and yield, while trees on M26 had the least growth and yield. Soil treatments altered soil microbial communities during the year after pre-plant treatments, and each treatment was associated with distinct microbial groups in hierarchical cluster analyses. However, those differences among fungal and bacterial communities diminished during the second year after planting, and soil fungal communities equilibrated faster than bacterial communities. Pre-plant soil treatments altered bulk-soil microbial community composition, but those shifts in soil microbial communities had no obvious correlation with tree performance. Rootstock genotypes were the dominant factor in tree performance after 3 years of observations, and different rootstocks were associated with characteristic bacterial, pseudomonad, fungal, and oomycetes communities in root-zone soil.

Nitrogen Uptake in a Range of Alternative Orchard Floor Management Systems

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The percentage of N from fertilizer removed from the field by fruit trees is low. Overapplication of N in orchards has been a common practice and is a concern due to environmental and tree growth problems caused by excess N. Orchard floor management practices (OFMP) can improve the physical and chemical properties of the soil and may alter the soil biological community. Biological activity can affect mineralization rate and thus nutrient availability. The purpose of this study was to determine the effect of alternative OFMP on fertilizer N uptake. Research plots were located in Corvallis, Ore. (COR) (7-year-old 'Fuji'), and Hood River, Ore. (HR) (3-year-old 'Red Delicious'). Treatments were begun in 2001 in a split-plot completely randomized design with three replications. Main plot treatments were herbicide or cultivation. Subplot treatments were no amendment, bark mulch, compost, and barley/vetch mown and blown into the tree row. Depleted NH_3SO_4 was applied to single-tree replicates at budbreak. Trees were destructively harvested at harvest of 2003. At HR, the percentage of N derived from fertilizer (NDFF) was significantly lower in the whole tree, leaves, new wood, old wood, spurs, and roots of trees from compost than from unamended plots ($P < 0.05$). At COR, the NDFF in the leaves, fruit, new wood, spurs and roots was significantly lower in trees from compost plots than unamended plots ($P < 0.05$). The NDFF also tended to be lower in trees from bark mulch-treated plots than control plots, although

differences were not always significant. Vetch/barley amendment resulted in NDFF similar to no amendment. There were no significant differences between the total N of trees from unamended and compost plots. Trees from compost-treated plots appear to be acquiring N from sources other than fertilizer.

Polypropylene Row Covers Greatly Enhance Growth and Production of Fourth-leaf Sweet Cherry Trees

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Black, woven polypropylene row covers were compared to chemical sprays as methods to manage ground vegetation in a 'Regina'/Gisela 6 orchard planted in 2001. Row covers were installed within 1 month of planting. Exposed row cover width was 2.4 m, with edges (30 cm on each side) buried in the ground. Only a 30-cm band along the edge of row covers was sprayed with herbicide to facilitate mowing. Weed management of control trees consisted of chemical herbicide sprays. Trees were not fertilized since planting in 2001. Irrigation of all trees was applied with low volume (20 $L \cdot h^{-1}$) microsprinklers and scheduled according to soil water content. Row covers significantly increased trunk cross-sectional area (TCSA) by about 30% annually. By Summer 2004, trees with ground covers had filled their allotted space within rows, while control canopies were ≈50 cm apart. Trees in row covers produced a 130% higher average yield than controls (7.4 kg/tree vs. 3.2 kg/tree). Row covers produced larger and firmer fruit, which matured 2–3 days later than controls. Groundcovers slightly increased soil temperature from April to September by ≈2 °C at 5- and 10-cm depths. Roots under ground covers were denser and more spread out than in controls and water use efficiency was higher for trees growing in ground covers. Amount and labor for herbicide application was reduced to less than half with row covers. Although ground covers are expensive at ≈$2000 per acre, their cost could be offset by earlier and higher production and by long-term savings in labor, water use, and herbicides. Durability of row covers is expected to exceed 15 years.

The Effect of Surround WP on Apple Productivity and Fruit Quality in a Vermont Apple Orchard

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Surround WP, a kaolin clay-based biopesticide product, is a potential alternative to some organophosphates used in apple orchards for the management of pests, such as codling moth. In addition, Surround has been reported to have important nontarget horticultural impacts because of its effect on canopy temperature reduction. The label for use of Surround states: "When applied at recommended rates and frequencies, benefits such as increased plant vigor and improved yields may occur in certain apple cultivars." However, most of the research on nontarget effects has been conducted in warmer, semiarid environments. The objectives of this 3-year (2002–04) interdisciplinary research project were to determine potential nontarget effects of Surround WP application on apple tree vigor, productivity, and fruit quality in the relatively cool and moist climate of the Northeast. The research was conducted at the UVM Horticultural Research Center in South Burlington, Vt., on 'McIntosh'/M26 trees. The experiment used a completely randomized design with five treatments replicated six times. Each replicate consisted of single tree plots. Treatments included: 1) Surround beginning at green tip plus fungicides; 2) Surround beginning at green tip without fungicides; 3) Surround beginning at petal fall plus fungicides; 4) standard IPM; and 5) nontreated control. Results indicate no significant differences among treatments 1, 3, and 4 (treatments that included fungicide applications) in vegetative shoot length, spur characteristics, blossom number, fruit weight, firmness, soluble solids, and fruit calcium levels. Trees treated with Surround had significantly lower yield efficiencies in 2003 and 2004 than trees under IPM treatment.

Fine Root Dynamics in an Organic Apple Orchard under Two Ground Floor Management Systems

Dario Stefanelli*, Roberto J. Zoppolo, Ronald L. Perry

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Fine root dynamics, timing of the events, and their relationship with soil conditions are of major interest because the understanding of these phenomena will permit a better synchronicity between nutrients and plant uptake. The goal of this research is to study the effect of different soil conditions, generated from two ground floor management systems, on fine root dynamics of apple trees under organic protocol in Michigan. The research has been conducted at the Clarksville Horticultural Experimental Station (CHES) of Michigan State University (MSU), in the organically certified (by OCIA) orchard of "Pacific Gala" grafted on M9 NAKB 337, established in May 2000. The orchard floor management systems being studied are: 1) a mulch made of alfalfa hay on the tree rows, with a width of 1.8 m and 2) the "Swiss Sandwich System" (SSS) that consists in superficial tillage of two strips 80 cm wide at each side of the tree row, leaving a 40 cm strip in the middle (on the tree row, under the canopy) where volunteer vegetation is allowed to grow. Root dynamics are studied on four replicas of two trees per each of the two ground treatments (16 in total) in a block design. For each tree in the trial four clear butyrate minirhizotrons have been installed (64 in total) at a 45° angle facing the tree, in the summer of 2002. Root dynamics, measured through pictures taken with a Bartz Technology digital camera and analyzed with a new software under development at MSU. During the 2003 season differences between the two systems have been found depending on the parameter taken in consideration. Mulch had different root distribution compared to SSS. Mulch treatment showed shallower roots even if below 90 cm the two systems didn't show any difference.

Oral Session 26—Environmental Stress Physiology

Moderator: Carole L. Bassett

20 July 2005, 10:00–11:00 a.m. Room 108

Screening Pecan Cultivars for Drought Tolerance Using Physiological Parameters

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Pecan is a riparian species distributed over an area of geographic and climatic variation; such a wide distribution produces exposure to varied environmental conditions, providing a potential for genetic adaptation within the cultivars. Genotypes can be screened in order to obtain more drought tolerant cultivars using indirect screening parameters (chlorophyll fluorescence, osmotic adjustment, and abscisic acid assay) based on physiological responses of plants to abiotic stress conditions. A study was established at Texas A&M University, College Station, using a mixture of fritted clay (Quick dry) and pure sand in 1:1 (by weight) ratio to study the effects of drought on pecan rootstocks. The experiment was set up with the three water potential levels as treatments (–0.033 MPa, –0.1 MPa, –0.3 MPa) in a randomized complete-block design with three blocks. Measurements will include leaf water relations (relative water content, leaf water potential, osmotic adjustments, etc.), gas exchange parameters [net carbon dioxide assimilation rate (A), transpiration rate (E), stomatal conductance (gs)], chlorophyll fluorescence measurements [minimum (Fo), maximum (Fm), and variable fluorescence (Fv), quantum efficiency], water use efficiency, and abscisic acid assay on roots. Statistical analysis systems (SAS) package will be used for analysis. PROC GLM of the SAS will be used for statistical analysis of study involving plant response to water potential levels.

TREESTRESS: A Within Canopy Spatial Distribution Model for Simulating the Carbon and Water Exchange Response to Atmospheric Thermal and Rhizospheric Water Stress

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A model (TREESTRESS, a spatially explicit 3-D process-based model) for simulating the spatial distribution of intracanopy photosynthetic and transpirational responses to multiple stress factors is presented. The model includes intracrown validation on both deciduous and coniferous radiation transfer, incorporation of temperature response functions of Rubisco-, mesophyll-, and RuBP-limited photosynthesis to the widely used Farquhar et al. (1980) photosynthesis model, and a rhizospheric water stress submodel to constrain the Ball-Berry stomatal conductance submodel. The model also includes functions that account for acclimation and/or no acclimation to growth temperature. Taken together, the model aims at predicting spatially explicit intracrown response to multiple stresses (primarily temperature, water, and radiation stress). The model was parameterized for red maple trees under nursery conditions and validated by sap flow, photosynthesis, and radiation measurements. The integration of multiple stress response functions in a spatially explicit process-based model could provide a proficient method to simulate stress interactions and predict carbon uptake and water use in crowns, canopies, ecosystems, and landscapes.

Characterization of Sequences Up-regulated in Peach Bark in Response to Low Temperature

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Genes whose expression is regulated by exposure to low temperature (LT) in peach (*Prunus persica* L. Batsch.) bark were identified by PCR suppression subtractive hybridization. Among the genes identified by this technique were several that had previously been associated with LT responsiveness, as well as a few that have not been reported to be regulated by cold. Genes represented by the first group included *Ppdhn1*, previously characterized as a seasonally expressed gene predominantly seen in bark tissue collected in winter months. A novel dehydrin found in this study, *Ppdhn3*, was also observed to be up-regulated at LT and seasonally expressed. Two genes not previously associated with LT response were found to be up-regulated at 5 °C. These genes encode a polypeptide related to some unknown mitochondrial process (*Pptar1p*) or a transducin-like protein (*Pptlp1*) that may be associated with signal transduction. Expression of these genes with respect to seasonal variation and drought stress is compared to genes from peach bark (*Ppdhn1* and *Ppdhn2*), whose patterns of expression in different seasons and under water deficit are well documented.

Cold Hardiness and Budbreak of Two Buckthorn Species

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Can Carolina buckthorn (*Rhamnus caroliniana*) persist north of its native habitat without becoming invasive? Its distribution (USDA zones 5b to 9b) suggests that genotypes vary in cold hardiness, and invasiveness of other *Rhamnus* sp. has been linked to unusually early budbreak each spring. Therefore, we investigated depth of cold hardiness and vernal budbreak of Carolina buckthorns from multiple provenances and made comparisons to the invasive common buckthorn (*Rhamnus cathartica*). Budbreak was recorded in Ames, Iowa, from 9 Apr. to 10 May 2002. Buds of common buckthorn broke earlier than those of Carolina buckthorn, and mulching plants of Carolina buckthorn hastened budbreak. Stem samples were collected in October, January, and April from a plot in Ames, Iowa (USDA zone 5a), of Carolina buckthorns from three provenances (Missouri, Ohio, and Texas) and of naturalized common buckthorns. A similar schedule was followed during the next winter, when two plot locations [Ames, Iowa, and New Franklin, Mo. (USDA zone 5b)], were compared, but Carolina buckthorns from only Missouri and Texas were sampled. Carolina buckthorn and common buckthorn survived midwinter temperatures as low as –21 °C and –24 °C, respectively. Provenance differences were minimal; Carolina buckthorns from Missouri were more hardy than those from Ohio and Texas only in April of the first winter. We conclude that its cold hardiness will permit use of Carolina buckthorn beyond where it is distributed in the southeastern United States. Delayed budbreak of Carolina buckthorn relative to that of common buckthorn may underscore the potential for Carolina buckthorn in regions with harsh winters and may lessen its potential to be as invasive as common buckthorn.

Oral Session 27—Postharvest-Cross-Commodity

Moderator: Robert K. Prange

20 July 2005, 3:30–5:15 p.m. Room 107

Sensory Evaluation of Six Varieties of Organically Grown Edamame-type Soybean

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Consumer testing and descriptive analysis were conducted on six commercial varieties of organically grown edamame-type soybean. In the affective tests, 54 panelists rated pods and beans for appearance, and beans for aroma, taste, texture, aftertaste, and overall acceptability on a 9-point hedonic scale and willingness to buy on a 9-point category scale. 'Sayamusume' was liked significantly better than all varieties except 'Kenko' and 'Sapporo Midori' for taste. 'Kenko' was also rated higher than 'Sapporo Midori', 'Misono Green', and 'Early Hakucho' for pod appearance. 'Misono Green' texture was liked less than that of all other varieties except 'White Lion'. In the descriptive analysis, 10 trained panelists rated the beaniness, sweetness, nuttiness, and chewiness of the same six varieties. 'Kenko' rated significantly sweeter than all other varieties except 'Sapporo Midori'. 'White Lion' rated as significantly lower in chewiness than all other varieties. Beaniness and nuttiness could not be consistently differentiated among varieties. The data suggest that consumer liking of bean taste varies, though subtly, among the six edamame varieties tested here and that preferences may differ with gender. Results from descriptive analysis also suggest that panelists relied on texture (i.e., chewiness) and sweetness to differentiate between varieties. These results are particularly important in overall product quality management strategies as chewiness and sweetness may be influenced by production practices and harvest timing.

Hydroperoxide Lyase Activity Necessary for Normal Aroma Volatile Biosynthesis of Tomato Fruit, Impacting Sensory Perception and Preference

Mauricio Canoles, Marisol Soto, Randolph Beaudry*

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The aldehydes cis-3-hexenal, hexanal, and trans-2-hexenal; the alcohols 1-hexanol, and cis-3-hexenol; and the ketone 1-penten-3-one are produced as a consequence of lipid degradation following tissue disruption and are among the most important volatile compounds in tomato (*Lycopersicon esculentum* Mill.) aroma. The biosynthesis of cis-3-hexenal and other volatiles noted involves the action of a sequence of enzymes including lipase, lipoxygenase (LOX), hydroperoxide lyase (HPL), isomerase, and alcohol dehydrogenase (ADH) on glycerolipids containing the fatty acids, linoleic acid (18:2) and linolenic acid (18:3), via the LOX pathway. In the current work, the formation and sensory perception of volatile compounds was studied in tomato plant lines where HPL activity

was genetically altered. LeHPL co-suppression dramatically reduced the production of lipid-derived C6-volatiles in leaves, but in fruits, only unsaturated C6-volatile production was affected, suggesting LeHPL-independent formation of hexanal occurs in fruits, but not in leaves. Increased production of 5-carbon volatiles is proposed as an alternative way to metabolize 13-hydroperoxy linolenic acid in plants with reduced LeHPL activity. Changes in the volatile profile of leaves and fruits of tomato lines in which LeHPL activity is reduced markedly are readily detected by nontrained sensory panels. The studies demonstrate that a marked reduction in the activity of one of the most critical steps in the LOX pathway can markedly impact sensory perception. Efforts to improve total volatile formation may require the modification of LOX pathway at several steps simultaneously, including precursor formation, and LOX and HPL activities.

Activity of Cell Wall-associated Enzymes in Cold-stored Tomato Fruit

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Tomato fruit (*Solanum lycopersicon* L.) can develop mealiness and enhanced softening when exposed to chilling temperatures during storage, but the involvement of cell wall-associated enzymes in chilling injury development is not well understood. To study this aspect of injury development, we have exposed breaker stage tomato cv. Trust fruit to a chilling temperature of 3 °C for 0, 7, 14, and 21 days followed by storage at 20 °C for 12 days. Ethylene production was not affected by storage except after 21 days, where production was greater at 20 °C. Exposure of fruit to chilling temperatures delayed the ripening-related color change (chroma and hue) and initially increased compression values, but percentage of extractable juice was not affected consistently. Increased polygalacturonase activity during ripening was reduced by about 50% after 7 days at 3 °C, and further inhibited with increasing storage periods. In contrast, the activities of pectin methylesterase and α-galactosidase were not significantly affected by the cold treatments. β-Galactosidase activity was greater in all chilled fruit compared with fruit ripened at harvest, whereas endo-β-1,4-glucanase activity was lower after 21 days at 3 °C. These results will be compared with equivalent changes in the activities of cell wall enzymes that are associated with wooliness development in chilling-injured peach fruit.

Wound-induced Phenolic Accumulation and Browning in Lettuce (*Lactuca sativa* L.) Leaf Tissue is Reduced by Exposure to n-alcohols

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A wound signal originates at the site of injury in lettuce [*Lactuca sativa* (L.)] leaf tissue and propagates into adjacent tissue where it induces a number of physiological responses that include increased phenolic metabolism with the de novo synthesis of phenylalanine ammonia lyase (PAL, EC 4.3.1.5), the synthesis and accumulation of soluble phenolic compounds (e.g., chlorogenic acid), and subsequent tissue browning. Exposing excised mid-rib leaf tissue to vapors (20 μmol·g^{-1} FW) or aqueous solutions (100 mM) of n-alcohols inhibited this wound-induced tissue browning by 40% and 60%, respectively. Effectiveness of the alcohol increased linearly from ethanol to the seven-carbon heptanol, and then was lost for the longer n-alcohols 1-octanol and 1-nonanol. The 2- and 3-isomers of the effective alcohols did not significantly reduce wound-induced phenolic accumulation at optimal 1-alcohol concentrations, but significant reductions did occur at much higher concentrations (100 μmol·g^{-1} FW) of the 2-, and 3-isomers. The active n-alcohols were maximally effective when applied during the first 2 h after excision, and were ineffective if applied 12 h after excision. Phospholipase D (PLD) and its product phosphatidic acid (PA) are thought to initiate the oxylipin pathway that culminates in the production of jasmonic acid, and PLD is specifically inhibited by 1-butanol, but not by 2- or 3-butanol. These results suggest that PLD, PA, and the oxylipin pathway may be involved in producing the wound signal responsible for increased wound-induced PAL activity, phenolic accumulation, and browning in fresh-cut lettuce leaf tissue.

Carbon Dioxide Is a Promoter of Ethylene Action in Potato Tubers

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In three consecutive years of storage trials, the effects of reduced O_2 levels, elevated CO_2 levels, and ethylene on the fry color and sugar content [sucrose and reducing sugars (glucose and fructose)] of 'Russet Burbank' potato (*Solanum tuberosum* L.) tubers were evaluated. The potatoes were stored in modified atmosphere chambers and the atmosphere mixtures were supplied from compressed gas cylinders. Fry color and sugar content were assessed at the start of each trial and after several weeks of exposure to the treatment atmospheres. Four 4-week trials were conducted in 2002 and two 9-week trials were conducted in each of 2003 and 2004. No differences in fry color or sugar content attributable to either increased CO_2 or decreased O_2 were observed, compared with untreated controls, in any year. In the second and third years, only selected treatments were repeated, with or without 0.5 μL·L^{-1} ethylene. Ethylene alone caused a moderate darkening of fry color and an increase in reducing sugars. However, the fry color and reducing sugar content of tubers exposed to a combination of elevated CO_2 and ethylene were considerably darker and higher, respectively, than observed with ethylene alone. No similar interaction between ethylene and O_2 level was observed. These results suggest that CO_2 promoted ethylene-induced fry color darkening, which may explain the contradictory effects of CO_2 on fry color frequently observed by the potato industry. This is contrary to published research on other fruits and vegetables, which has generally shown that CO_2 inhibits ethylene action.

Absorption of 1-MCP by Nontarget Materials during Storage

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We tested the sorptive capacity of a number of nontarget materials found in apple storage rooms on their capacity to remove 1-MCP from the storage atmosphere and thereby compete with the fruit for the active compound. Furthermore, we evaluated the impact of temperature and moisture. Nontarget materials included bin construction materials [high density polyethylene (HDPE), polypropylene (PP), weathered oak, nonweathered oak, plywood, and cardboard] and wall construction materials (polyurethane foam and cellulose-based fire retardant). Each piece had an external surface area of 76.9 cm^2. We placed our "nontarget" materials in 1-L mason jars and added 1-MCP gas to the headspace at an initial concentration of ≈30 μL·L^{-1}. Gas concentrations were measured after 2, 4, 6, 8, 10, and 24 hours. The concentration of 1-MCP in empty jars was stable for the 24-hour holding period. Little to no sorption was detected in jars containing dry samples of HDPE, PP, cardboard, polyurethane foam, or fire retardant. Inclusion of plywood, nonweathered oak, and weathered oak lead to a loss of 10%, 55%, and 75% of the 1-MCP after 24 hours, respectively. Using dampened materials, no sorption resulted from the inclusion of HDPE, PP, polyurethane foam, or the fire retardant. However, the rate of sorption of 1-MCP by dampened cardboard, plywood, weathered oak, and nonweathered oak increased markedly, resulting in a depletion of ≈98%, 70%, 98%, and 98%, respectively. The data suggest that there are situations where 1-MCP levels can be compromised by wooden and cardboard bin and bin liner materials, but not by plastic bin materials or typical wall construction materials.

Effect of Storage Conditions and Genotype on Shelf-life of Fresh Southernpea

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Fresh-shelled southernpeas [*Vigna unguiculata* (L.) Walp.] is a popular

vegetable. Postharvest storage of fresh-shelled peas is a crucial step in the production process. Farmers strive to produce a product that is high in quality and freshness with appropriate texture and appealing color. Improper storage and handling of southernpeas will result in deterioration. In an effort to prevent potential losses of southernpeas, this study was conducted to determine the best method to ship and store shelled peas. Five southernpea varieties: 'Early Acre', 'Early Scarlet', 'Excel Select', 'Coronet', and 'Arkansas Blackeye #1' were planted in a randomized block design at the University of Arkansas. Twelve mature green pods of each variety were subjected to a sweated and unsweated treatment and then shelled. After shelling, seed were subjected to four different environmental conditions, and each treatment was evaluated for changes in physical appearance. Objectives of the study were to determine the best variety and environmental condition to maintain a quality marketable product. The study showed that a refrigerated environment at or near 3 to 5 °C allowed the crop to be stored for up to 2 weeks. It also appeared that sweating assisted with the shelling process and maintained appearance of each variety longer.

Oral Session 28—Cross Commodity Nutrition II

Moderator: Barbara E. Liedl

20 July 2005, 3:30–4:45 p.m. Room 108

Environmental Losses of Soil-applied Nitrogen Sources in Lowbush Blueberry Production

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Environmental losses of soil-applied nitrogen fertilizers were examined during 2004 in commercial wild blueberry fields in the vegetative phase of production in Nova Scotia (NS) and Prince Edward Island (PE). A randomized complete-block experimental design with five treatments, five replications, a plot size of 8 × 6 m, and 2-m buffers between plots was used. Treatments consisted of a control (no fertilizer application) and nitrogen applications (N at 35 kg·ha^{-1}) of ammonium sulphate (AS), urea (U), diammonium phosphate (DAP), and sulfur-coated urea (SCU). Nitrogen applications occurred on 19 May and 9 June at the Kemptown (NS) and Mount Vernon (PE) sites, respectively. Cumulative ammonia volatilization was determined through the use of open top chambers with volatilization samples collected on 1, 2, 5, 8, and 12 days after treatment application. In addition, leaf tissue and yield component data were collected. A significant volatilization treatment effect was present at the Kemptown site with the U and SCU treatments having volatilization rates that were 321% and 207% greater than the control, respectively. Therefore, results from this study indicate that volatilization losses are significant and site specific and can negatively influence blueberry growth.

Mobilization of Iron from Ferric Citrate In Vitro

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Plants grown on calcareous soils often exhibit symptoms of Fe-deficiency induced chlorosis despite a high content of total Fe in the leaf tissue. Iron is transported in the xylem primarily as the ferric citrate (Fe-Citr) chelate, and changes in pH, HCO_3^-, and Citr can lead to the formation of different Fe-Citr species. Understanding how Fe dissociates from these chelates may help explain why Fe is immobilized in the leaves. The goal was to quantify Fe mobilization (Fe-Mob) from Fe-Citr in an assay system buffered at pH 5, 6, or 7 when: 1) the molar ratio of HCO_3^- to Fe increased in a 1 Fe : 1 Citr system; 2) the molar ratio of Citr increased in a 1 Fe : 3 HCO_3^- system; and 3) solutions were photoreduced (PR) or left in the dark. For non-PR solutions, Fe-Mob from Fe-Citr using 500 µmol NADH was the greatest at the 1 Fe : 0 HCO_3^-- level, and decreased as HCO_3^- increased. Fe-Mob also decreased as buffer pH increased from 5 to 7. Increasing the Citr ratio was effective in increasing Fe-Mob, but the effect decreased as buffer pH increased from 5 to 7. PR solutions behaved quite differently. In the 1 Fe : 1 Citr system, little to no Fe-Mob was detected at any buffer pH. However, there were already large pools of Fe^{2+} in solution, which decreased as HCO_3^- increased, irrespective of buffer pH. Increasing the Citr ratio greatly increased Fe-Mob in the 1 Fe : 3 HCO_3^- system, and mobilization decreased as buffer pH increased. Increasing Citr did not increase the amount of Fe^{2+} in solution. This work illustrates that increasing the HCO_3^- : Fe ratio can lead to an immobilization of Fe, and that increasing the Citr ratio can aid in Fe-Mob from Fe-Citr when the HCO_3^- : Fe ratio is high. Increasing the Citr ratio, however, does not increase the amount of PR Fe^{2+}.

Do Circadian Rhythms Accentuate K Deficiency in Geranium?

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Geranium (*Pelargonium ×hortorum*) typically follows the C3 metabolic pathway. However, it switches to CAM metabolism under certain abiotic stress environments. This switch may affect the nutritional requirement and appearance of visible deficiency symptoms of these plants. Because potassium (K) plays a key role in stomatal function, K-deficiency was studied in geranium. Plants were grown hydroponically in a glass greenhouse. The treatments consisted of a complete, modified Hoagland's solution with millimolar concentrations of macronutrients, 15 NO_3-N, 1.0 PO_4-P, 6.0 K, 5.0 Ca, 2.0 Mg, and 2.0 SO_4-S and micromolar concentrations of micronutrients, 72 Fe, 9.0 Mn, 1.5 Cu, 1.5 Zn, 45.0 B, and 0.1 Mo, and an additional solution devoid of K. It took longer to develop the classic K deficiency symptoms than other bedding plant species commonly require. The K-stress plants' dry weight was 10% and 37% of control at incipient and advanced stage, respectively. When portions of geranium leaves were covered, symptomology on leaves with K stress developed rapidly (within 2 days) compared to the uncovered portion of the leaf blade. Control plants contained an abundance of marble-shaped K crystals in the adaxial surface of leaf mesophyll, but were lacking in the K-deficient plants. Geranium is more prone to K stress during short days than long days and an additional supply of K would be needed for normal growth in short days.

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

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Increasing production of agricultural waste impacts health, economic, and environmental welfare. Thermophilic anaerobic digestion is a technology developed to treat these waste streams whereby the organic material is converted to biogas and effluent. The effluent, available in solid and liquid form, holds promise as a fertilizer. Digested (broiler litter) liquid effluent was compared to chemical and certified organic fertilizers with application rates based on soil analyses and crop recommendations. An unfertilized control and an effluent treatment at twice the recommended amount were also included. Beds treated with liquid effluent maintained higher levels of available phosphorus established from treatment in prior years with solid effluent. Beds treated with liquid effluent showed a significant increase in K, Mg, Cu, and Mn. Potato fresh weight and tuber number for 2× effluent beds were significantly better than the other treatments. Average tuber weight was also statistically significant, but organic, 2×, and 1× effluent were best. For tomato, the 2× effluent treatment was statistically better for fruit number, average weight, and total weight. In fact, the total weight per plant for the 2× effluent treatment was more than three times higher than the other fertilizer treatments. The chemical and effluent treatments were statistically better for broccoli than the organic or unfertilized control. Blueberry yields were not significantly different between treatments. As this is a perennial crop, it may be several years before a significant difference is observed. While not a total solution, our

research shows the effectiveness of digested poultry litter as part of a nutrient management program, thereby making a safer, less-polluting alternative to raw livestock residuals.

Wool and Hair Waste as Nutrient Source for High-value Crops

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One small-plot field and five container experiments were conducted to evaluate sheep wool-wastes and human hair-wastes as soil amendments and nutrient sources for high-value crops. Overall, the wool-waste or hair-waste addition to soil: 1) increased yields from basil, garden sage, peppermint, valerian, thorn apple, marigold, foxglove, and swiss chard; 2) increased the amount of secondary metabolites (such as essential oils and alkaloids); 3) increased NH_4-N and NO_3-N in soil; 4) increased total N (and protein) content in plant tissue; 5) did not affect soil microbial biomass; and 6) decreased mycorrhizae 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, retained a significant amount of S and some N, and was not fully decomposed. Our results indicate that single addition of wool or hair-waste of 0.33% by weight to soil would support two to five harvests or crops, without addition of other fertilizers, and may improve soil biological and chemical characteristics.

Oral Session 29—Teaching Methods

Moderator: Marihelen Kamp-Glass

21 July 2005, 8:00–9:45 a.m. Room 107

Interdisciplinary Teaching: Taking the Fear out of the Unknown

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If we want our students to engage in complex intellectual tasks to interrogate the insights of different disciplines, then let's join them in the task, modeling it and sharing the difficulties and richness of its possibilities. Interdisciplinary study is not rejection of the disciplines. It is firmly rooted in them, but offers a corrective to the dominance of disciplinary ways of knowing and speculation. We need the depth and focus of disciplinary ways of knowing, but we also need interdisciplinarity to broaden the context and establish links to other ways of constructing knowledge. It is this dialogue between analysis and synthesis that provides the creative tension from which we will all benefit in a world in which crossing intellectual boundaries is increasingly the norm.

Experiential Education Employed to Demystify Food Irradiation as a Viable Technology for Food Industry Professionals

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Research shows that food irradiation is a safe food technology effective in reducing pathogenic microorganisms, prolonging shelf-life, and controlling pests, such as fruit flies, to avoid quarantine. However, this technology may not be understood widely by food industry professionals. The purpose of this research was to study the effectiveness of professional development designed with a variety of experiential education strategies targeting food industry regulators, Extension agents, and others in the food industry. The workshop, *Improving Safety of Complex Food Items Using Electron Beam Technology,* included presentations by experts in food irradiation technology, tours of food irradiation facilities, group activities, and a taste-test of irradiated meats and produce. Data were collected from 19 males and 3 females in the paired workshop pre- and post-tests which assessed participants' knowledge, perceptions, and concerns about food safety and food irradiation, using Likert-type scales. The workshop produced significant knowledge gains. Respondents' perceptions of food safety and food irradiation issues were improved significantly as a result of participation in the workshop. Also, respondents' perceived knowledge and understanding of food safety, food irradiation, and the technology behind food irradiation improved significantly upon completion of the workshop and post-test.

America's Funniest Home Videos and the Lottery Come to Plant Propagation: Using Technology to Promote Learning

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Large lectures continue to challenge teaching and learning. Our plant propagation course attracts a large number of non-majors seeking to fulfill their science requirement. Although the laboratory is quite successful in maintaining interest, the lecture is plagued by poor attendance and lack of commitment. To deal with these issues, I have incorporated an audience response system (as used in *America's Funniest Home Videos*) and a multiple-choice exam that uses a scratch-off answer system similar to the instant-win lottery tickets. The audience response system facilitates attendance, and both systems provide immediate feedback to questions. Student and faculty assessment will be presented. Technological and pedagogical challenges will be discussed.

Interactive Web-based Plant Identification and Use

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University of Florida's Department of Environmental Horticulture offers undergraduate and graduate courses at seven locations throughout the state. To ensure students have access to a sufficient variety of classes, many courses are delivered by distance education. Distance education has significantly expanded student enrollment while unifying lecture content and minimizing duplication of faculty resources. However, delivering hands-on laboratory portions of courses continues to be a challenge, thus necessitating the need for web-based supplemental learning tools. An interactive, web-based tour of the 1-acre Indian River Research and Education Center (IRREC) Teaching Garden was created, allowing students at all distance education sites to learn similar plant material and landscape design principles. The virtual tour was developed by converting digital panoramic images of the landscape to movie files. The movies are navigated using a computer mouse, and plants within the tour are hyperlinked to information sheets highlighting plant characteristics. Although the website was initially developed for a Florida native landscaping course, it can be utilized in other plant identification and landscape courses, as well as by those who wish to virtually explore the garden.

Learning by Building: How a Landscape Construction Studio Enriches Horticultural Education

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The Department of Horticultural Sciences at North Carolina State University began offering landscape horticulture students a construction studio in 2002. This unique studio engages students in experiential learning (hands-on) and service learning (client-based) projects while simultaneously applying knowledge they have gained during their

university education. Three years later, the Landscape Construction Studio is a model course that pushes students to design creatively, while providing a practical foundation in how ideas transition from paper to reality. Projects embody several learning objectives, including fostering exploration and discovery while raising students' awareness of strengths and limitations of traditional and nontraditional construction materials. In addition, the studio enables the elimination of students' tendency to compartmentalize course work, and encourages students to broaden their understanding and appreciation of the world around them. A typical semester incorporates several smaller projects that introduce students to a variety of materials and lessons in construction methodologies. Projects increase in size and complexity over the course of the semester, leading to a comprehensive landscape design and installation project in which students experience the entire design process. Through this final project, students see how information gained from other horticultural and general classes are applied in landscape design. This presentation will discuss the importance of incorporating experiential learning components to horticultural courses, and the pros and cons of service learning projects. Presentation of best management practices will stimulate discussion among the audience.

Experiential Partnerships Enhance Student Learning during Construction of Campus Gardens

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Students in a Penn State landscape contracting class were involved in the construction of the Hintz Alumni Gardens from Nov. 2002 through Apr. 2005. While campus construction projects have long been a part of the curriculum, the scope and complexity of the Alumni Gardens created unique challenges and opportunities for learning. The project was broken into phases that were installed over a 3-year time period. Professional staff from the University's Office of Physical Plant, including landscape supervisors, masons, electricians, plumbers, and carpenters, were integrated into course activities. They worked with students during planning phases and throughout field operations. Students learned first-hand from experts who had years of experience in their discipline. In addition, three contractors were hired to lead activities in specific areas of bridge construction, pond construction, and irrigation installation. This unique collaboration exposed students to a wide variety of construction techniques, and gave them experience in project management, scheduling, and procurement. The end result of their efforts was a successfully completed garden installation.

Use of the Horticultural Trade Show as a Guided Learning Experience in Undergraduate Horticulture Courses

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One of the largest horticultural trade shows in the United States, the Tropical Plant Industry Exhibition, takes place each January in Fort Lauderdale, Fla. The timing of this show coincides with the offering, during the spring semester, of an undergraduate horticulture course, Palm Production and Culture (ORH 4321C, 3 credits). We have developed a guided activity in which we assign the students to visit several preselected exhibits in this show, so that each exhibit in the show is visited by at least one student. The students complete a questionnaire for each exhibit in which they note the identity of the palm species present, the number of species present, the number of individuals of each species, and the total number of palms in each exhibit. Data in the questionnaires are compiled and used to augment and reinforce class discussions on morphology, cultural requirements, interiorscape management, species richness, species diversity, and field laboratory work in morphology and taxonomy. Procedures used have the potential for adaptation to other types of horticultural trade shows and other types of horticultural crops, as well as for other courses in horticulture.

Oral Session 30—Produce Quality, Safety, and Health Properties

Moderator: Dennis J. Osborne

21 July 2005, 8:00–9:45 a.m. Room 108

Yield and Microbial Quality of Iceberg Lettuce as Affected by Moisture at Harvest

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The effect of moisture conditions on yield and microbial quality of iceberg lettuce was investigated. Iceberg lettuce cvs. Honcho II and Sahara grown at the Yuma Agricultural Center were evaluated for weight, diameter, microbial population, and postharvest quality, either following different irrigation termination schedules or before/after a rainfall event. Two trials were conducted with early (24 or 18 days before harvest), middle (16 or 8 days before harvest) and late (6 or 4 days before harvest) irrigation termination. Lettuce receiving the last irrigation 6–4 days before harvest showed increased weight and diameter, higher total aerobic bacteria and shorter shelf life than plants having the early irrigation termination. The plants receiving middle termination irrigation showed similar weight at harvest, lower total aerobic count and longer shelf life than plants receiving late irrigation termination. The effect of the field's moisture prior to harvest on quality was further evaluated with lettuce harvested before and 1, 2 and 7 days after a rainfall event. After rain, mesophilic bacteria population increased 1 $\log_{10}$ CFU/g in outer leaves and more than 2 $\log_{10}$ CFU/g in head leaves. The microbial population in outer leaves declined more rapidly, possibly due to more rapid drying and higher impact of sun UV light. The results from this study suggest that managing moisture conditions at harvest is important to enhance quality of lettuce. Although the potential decrease in weight produced with an early irrigation termination is a great concern of growers, it was shown in this study that excessively late preharvest irrigation of lettuce is not necessary to obtain maximum weight at harvest.

Antagonistic Effect of Lactic Acid Bacteria on Microflora of Shredded Cabbage in High CO_2 Modified Atmosphere Packaging

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Shredded cabbage was packaged in four types of non-perforated and perforated OPP films with initial 10% CO_2. In the perforated OPP film with a O_2 permeability of 25,000 mL/m^2 per day/atm, CO_2 remained at about 10%, O_2 decreased to 13%, and the shreds showed the best organoleptic quality after 4 days of storage at 10 °C. The bacteria isolated from the shredded cabbage in the perforated MA package were predominantly Gram-negative rod-forms including Enterobacteriaceae and phytopathogenic bacteria, while only lactic acid bacteria (*Leuconostoc citreum*) was isolated as Gram-positive bacteria. For biological control of the pathogens, two lactic acid bacteria strains (*Leuconostoc mesenteroides* subsp. *mesenteroides* and *Pediococcus acidilactici*) were selected from bacteriocinogenic 6 strains, based on the growth in culture broth under 5% to 20% CO_2 atmospheres. Shredded cabbage was inoculated with these two bacteriocin-producing strains, packaged in 10% CO_2 perforated MA packaging, and stored at 10 °C. The growth of coliforms and psychotrophic aerobic bacteria was reduced due to antagonistic effect of lactic acid bacteria and the quality of shreds was not affected detrimentally by the strains. These results indicate that the combination of added bacteriocin-producing lactic acid bacteria and 10% CO_2 perforated MAP was useful in biopreservation of shredded cabbage.

Antioxidant Profile and Contribution to Quality and Nutritional Attributes of Different Pecan Cultivars

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The objective of this study was to evaluate kernels of different pecan (*Carya illinoinensis*) cultivars for their antioxidant profile and their contribution to nutritional and quality attributes. Kernels were analyzed for their antioxidant capacity (AC), phenolic, tannin, and vitamin C content. Fatty acid (FA) composition and phenolic profile were determined using, respectively, gas and liquid chromatographic techniques. AC was measured using one spectrophotometrical [2,2-diphenyl-1-picrylhydrazyl (DPPH)] and one fluorescence method [oxygen radical absorbance capacity (ORAC)]. Phenolic and tannin content were determined using spectrophotometrical assays. Ascorbic and dehydroascorbic acid were determined using a HPLC. Both AC methodologies gave similar results with marked differences between cultivars. 'Desirable' had an antioxidant capacity of 47,747 $\mu g \cdot g^{-1}$ TEq/DW with DPPH method followed closely by 'Cheyenne' (36,192 $\mu g \cdot g^{-1}$ TEq/DW) and, with smaller amounts, by 'Cape Fear' and 'Pawnee' (16,540 and 13,705 $\mu g \cdot g^{-1}$ TEq/DW, respectively). Total phenolic content showed a similar trend, but 'Pawnee' showed a higher phenolic content than 'Cape Fear'. The FA composition varied between cultivars. This phenolic profile jointly with FA composition and other compositional characteristics will provide the quality and nutritional attributes of each specific cultivar. Furthermore, the high antioxidant profile of pecans suggests that bioactive and anticancer properties should also be evaluated. Results from the present research can be used as an additional tool to evaluate pecan cultivars and help create new guidelines for breeding programs to select "healthier" pecans.

Antioxidant Activity of 'Rio Red', 'Marsh White', and Commercial Juice In Vitro Model Systems

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Antioxidant activity is widely used as a parameter to characterize different plant materials for potential health benefits. This activity is related with compounds capable of protecting a biological system against the harmful effect of reactions that can cause excessive oxidation, involving reactive oxygen and nitrogen species (RONS). There has been growing interest in the beneficial health effects of consuming fruits and vegetables. Mainly, the presence of lycopene, ascorbic acid, and phenolic antioxidants is believed to have the protective mechanism. The free radical-scavenging activities of grapefruit extract of 'Rio Red', 'Marsh White', and commercial juice were extracted with different solvents, such as hexane, ethyl acetate, and chloroform. The dried extracts were screened for their radical scavenging activity using the α,α -diphenyl-β-picrylhydrazyl (DPPH) method. The ethyl acetate extracts of commercial juice and 'Marsh White' were found to possess more radical scavenging activity compared with the other two extracts. However, chloroform extracts of 'Rio Red' grapefruit were the most active, which may be ascribed to the presence of more lycopene. Furthermore, the antioxidant capacity of 'Rio Red' and 'Marsh White' extracts was assayed through the phosphomolybdenum method and expressed as equivalent to ascorbic acid ($\mu mol \cdot g^{-1}$ of the extract). The order of antioxidant capacity for 'Rio Red' extracts was found to be hexane > chloroform > ethyl acetate, while the order for 'Marsh White' was chloroform > hexane > ethyl acetate. The results indicate that the extent of antioxidant activity of the extract is in accordance with the amount of lycopene/phenolics present in that extract; commercial juice and 'Rio Red' may provide a good source of antioxidants.

Project Management in a Regional USDA-funded Food Safety Program

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This paper summarizes the management framework of a multi-state, multi-institutional partnership delivering a targeted "train-the-trainer" program. Procedures associated with assuring on-schedule deliverables and budget compliance will be reviewed. The program provided Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs)-based training to southeastern U.S. fresh fruit and vegetable (produce) growers and packers. Twelve southern U.S. states cooperated in this project: Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. The 2000–04 work was funded by U.S. Department of Agriculture–Cooperative State Research, Education, and Extension Service (USDA–CSREES) National Food Safety Initiative grants. This project developed materials, pilot-tested them, refined them for use by a regional group of specialized agents, assisted the agents in delivering the new programming, and evaluated the results.

Integrating the Local School System in Food Safety Training

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Food safety, including fresh produce food safety programming and GAPs (Good Agricultural Practices) third-party audit considerations are impacting the ability of producers marketing their crops. These relatively new federal programs are voluntary, but major buyers and chain stores are beginning to require that growers and sellers demonstrate participation in the programs. Recently, there were no training programs or materials readily available to meet educational needs of Cooperative Extension clients. Local producers began to request information on participation, compliance, and the end results. In Rowan County, N.C., two different programs addressed information and training material limitations for local producers. In one training session, local farmer's market participants were introduced to risk management concepts that helped them meet the GAPs training requirements. In another program, local school personnel were introduced to new food safety concepts in a local training for Hispanic workers. Since translation capability is limited, we have partnered with Spanish speakers from a local bank and from a migrant worker education group. This networking was valuable to our cooperators, since they reached new clients, and to us in getting workers trained in food safety.

Citrus Limonoids Induce Apoptosis in Human SH-SY5Y Neuroblastoma Cancer Cells

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Limonoids are triterpinoids unique to citrus and neem trees with potential cancer-preventing properties in animals and human cell lines. Antioxidant activity and apoptotic induction are thought to be the principal effects of citrus limonoids in the antiproliferative properties, but this postulate lacks firm experimental evidence. In this study four highly purified 17 β-D glucopyranosides of citrus, limonin glucoside (LG), obacunone glucoside (OG), nomilinic acid glucoside (NAG), and deacetylnomilinic acid glucoside (DNAG), were tested for their effects against human SH-SY5Y neuroblastoma cells. Neuroblastomas account for 10% of childhood cancers, and in our study the cultured cells were treated with different concentrations and different time intervals. Micromolar levels of LG and OG significantly ($P \leq 0.001$) stopped cell growth and induced cell death in 24 hours, but had no adverse effect over Chinese hamster ovary (CHO) cells at the highest toxic level tested. The viability studies were based on trypanblue exclusion and dimethylthiazol diphenyltetrazolium (MTT) reduction assays. The limonoids significantly increased the downstream caspases 3/7 activity ($P \leq 0.005$) within 12 hours of treatment, suggesting an explicit role of apoptotic induction, which was confirmed by flow cytometry and DNA fragmentation assays. Highest S phase cell number was reduced

by LG, followed by OG, NAG, and DNAG as compared to the known inhibitor camptothecin. Structural variations of limonoids could be ascribed to antioxidant activity. This study strongly supports apoptosis induction as an anticancer mechanism of citrus limonoids. Funded by USDA 2001-52102-11257 and 2004-34402-14768.

Oral Session 31—Human Issues/Public Horticulture

Moderator: Emily Hoover

21 July 2005, 10:00 a.m.–12:00 noon Room 102

Invasive Plant Species: Consumer Awareness, Knowledge, and Expectations

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Consumers were surveyed at the 2004 Philadelphia Flower Show in Philadelphia, Pa. from 8–10 Mar., to quantify their attitudes and behaviors towards invasive plant species and the potential problems associated with purchasing and planting invasives in the landscape. A majority of the 341 participants (81.5%) was aware that non-native exotic plants were used in the landscape and that these plants may be invasive in natural areas. Less than half (40.1%) acknowledged owning plants that were considered invasive, while one-third (33.5%) did not know. Less than half (41.3%) believed that laws should be passed to prevent sale of non-native exotic plants, while 27.8% believed that laws should be passed to allow sale of only native plants in their area. Three distinct consumer segments were identified using cluster analysis: "Invasive savvy," participants knowledgeable about invasives and interested in alternative species; "Invasive neutral," participants neutral in their decision to purchasing alternatives to invasive plants and price sensitive in regard to paying more for plants tested for invasiveness; and "Invasive inactive," participants opposed to purchasing genetically modified plants or those bred to be seedless. Survey results indicated that media sources (e.g., television and newspapers/magazines/books) would be effective for educating consumers about potential problems associated with invasive species in the landscape.

Urban Residents Rate the Benefits of Trees in Cities Highly and Are Unconcerned with Problems Associated with Trees

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In a survey, residents of the largest metropolitan areas in the continental United States rated the social, environmental, and practical benefits from trees in urban areas highly. They ranked the ability of trees to shade and cool surroundings highest. The potential of trees to help people feel calmer was ranked second highest. Survey respondents were not very concerned about potential problems with trees in cities, and felt that trees should be planted in cities regardless of any annoyance. Practical problems with trees, such as causing allergies, were bigger concerns than were financial issues. Responses varied slightly, based on childhood background and current demographic factors. For example, people who grew up with a garden near their home or actively worked with plants during childhood were more likely to appreciate the potential benefits of trees than were those who did not have such early experiences. People who strongly agreed that trees were important to their quality of life and those who did not strongly agree ranked the tree benefits and problems similarly, however. Those who strongly agreed that trees were important to their quality of life rated the benefits of trees more highly than people who did not strongly agree.

The Effect of Community Gardens on Property Crime Rates in Inner City Houston

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Today, in many of America's major cities, communal gardening projects have not only yielded produce to their participants, but also a plethora of neighborhood success stories, including feelings of well-being, safety, and the beautification of acres of vacant land. According to anecdotal evidence, the presence of a community garden can connect people to the earth, nature, and each other, as well as reduce crime. The purpose of this study was to determine if a relationship existed between reported property crimes and the presence of inner city community gardens in Houston, Texas. According to the Houston Police Department, property crimes include vandalism, breaking and entering, and burglary. Crime data for reported property crimes from 1995 through 2004 were obtained from the Houston Police Department. The Houston Police Department divides the city into "beats" and property crime rates were determined for each beat. At least one active community garden was targeted for each police beat. Results for the study compared crime rates within a 1/8-mile radius surrounding the community garden and the property crime rate for the entire police beat. In addition to the evaluation of crime data, community garden members were surveyed for thoughts and opinions pertinent to the presence of their particular community garden.

The Effects of an After-school Garden Club for Fourth Graders Regarding Fruit and Vegetable Nutrition

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An eight-lesson gardening and nutrition curriculum with a hands-on gardening emphasis was taught as an after-school program to determine the effect it had on increasing children's nutrition knowledge, fruit and vegetable (F&V) preference, and improving children's self-efficacy (SE) and outcome expectations (OE) for gardening and for consuming fruit and vegetables. Seventeen fourth-grade students participated in the experimental group as part of an after-school gardening club, and 21 fourth-grade students served as the control group. Nutrition knowledge; F&V preference; SE; OE; as well as demographic measures were obtained at baseline and end-program. There were no differences in nutrition knowledge scores between or within groups at baseline or at end-program. However, baseline scores were high (>7 out of 10 possible) for both groups. Both groups indicated a high preference for fruit at baseline and end-program. Vegetable preference did not increase over the course of the program for either group. At baseline, measurements of gardening SE and OE were significantly different between the groups, and during the length of the study the control group significantly increased in their gardening SE and OE while the experimental group maintained their high SE and OE for gardening. Some possible explanations for these unexpected findings could be recruitment effect and seasonal change. Further research to clarify which aspects of gardening (i.e., season, harvesting, crops grown) have the greatest impact on influencing preference, SE and OE of fourth-grade children is needed.

Service-learning Horticulture Students Benefit through Hands-on Science Activities with Elementary School Students

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A garden-based science curriculum (Junior Master Gardener) was introduced into public elementary schools as an informal education program conducted by Master Gardener volunteers and service-learning university students. The program was held once a week for 2 hours during regular school hours with fifth grade classes. The service-learning students were enrolled in a senior level horticultural science education class. Students were surveyed pre- and post-program with the Science Teacher Efficacy Belief Instrument (STEBI-B, preservice), a background survey instrument, and weekly journals. There were significant differences in the students' perceived teaching efficacy pre- and post-program. Most of the student's STEBI scores either remained the same or increased over the semester. Overall, the service-learning college students had very positive responses to their experiences as

teachers and mentors in public elementary schools. In addition, the students were able to use their horticultural skills and knowledge and they also gained an appreciation for the teaching profession.

Children's Garden in Residence Program at the Minnesota Landscape Arboretum

Tim Kenny, Emily Hoover*

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The Minnesota Landscape Arboretum has been educating urban youth in a garden setting through the Children's Garden in Residence program located in Minneapolis, Minn., for 20 years. The program partners with community groups to teach pre-K to 4th grade students about the wonders of science and nature. The program presently educates between 100 and 120 children each summer. In addition to serving more children, the program curriculum and activities have evolved through the years, developing, trying, redesigning, and trying again curricula to meet the needs of urban children. The result of this process is a program that emphasizes hands-on, garden-based lessons in science, nutrition, and art. We are in the process of documenting the curricula used in the program. This paper will discuss the history of the program, highlight a few units used at the different grade levels, and discuss the documentation process.

The Project Green Reach Summer Program at Brooklyn Botanic Garden: A Case Study

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Project Green Reach (PGR) is a part of the Children's Gardening Program at Brooklyn Botanic Garden (BBG), a public garden regarded as a model program for garden-based youth education. PGR utilizes the indoor classroom and outdoor laboratory to engage K-8 students and teachers at Brooklyn's Title I schools in informal science learning. Every year, PGR instructors accept a group of students into the summer program where they work in teams on garden projects at BBG. Students who participate in this program often come from challenging home and school environments. Anecdotal evidence reveals that after participating in the summer program, these students quickly develop improved confidence and academic skills, evolving into scientists and gardeners. The purpose of this study is to investigate the effects of a gardening program on inner city youth and to document the PGR summer program as a potential model for informal science youth education in the public garden forum. Field observations of PGR summer program participants and program document collection were conducted during the 2004 Summer Program. This was followed by interviews of adult PGR Summer Program alumni and former staff who discussed their experiences while participating in the program and described the meaning of PGR in their lives. Preliminary results have revealed the positive impact PGR has had on participants' lives, indicating that PGR affected their childhood development, relationships with family members and friends, and their views on BBG, gardening, and science. Findings from the in-depth analysis of the interviews, observations and document review will be presented.

Brooklyn Botanic Garden Children's Gardening Program: A Survey of Alumni

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Children's gardening programs are growing in popularity. Among public gardens, Brooklyn Botanic Garden (BBG) hosts the oldest children's gardening program in the United States. Founded in 1914, the Brooklyn Botanic Garden Children's Gardening Program (BBG CGP) has succeeded in involving a steady flow of children year after year, creating an environment where children have the opportunity to interact with nature. Over 35,000 children have participated in the BBG CGP since its inception in 1914. A mail survey was conducted of alumni of the BBG CGP to identify how the program has affected their adult lives. A random sample of 700 participants was selected from the BBG CGP alumni records. The survey consisted of five major sections: 1) current gardening interest; 2) involvement with public gardens; 3) current involvement with children's gardening programs; 4) childhood experiences in the BBG CGP; and 5) demographic variables. Preliminary results suggest that the participants' childhood development and learning skills gained from this program have played an important role in their adult lives and that they regard the BBG CGP as having great value in their lives. Additional results and impacts of the program will be presented.

Oral Session 32—Horticulture Curriculum and Instruction, Instruction Methods

Moderator: Michael A. Arnold

21 July 2005, 10:00–11:45 a.m. Room 107

A Survey of Horticulture Graduate Programs and Faculty Salaries at North American Universities

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Surveys were sent to 53 North American universities offering horticulture curricula to characterize the types of degrees offered, student demographics, participation in distance education, remuneration and assistance available for graduate students, and faculty rank and salary distributions. Twenty-five institutions responded. This represented 10 PhD, 14 MS, and 12 M. Agr. or MS non-thesis professional degree programs in horticulture and 13 PhD, 13 MS, 12 M.Agr. or M. non-thesis degree programs in plant sciences or a closely related area. On average, graduate students were predominantly Caucasian (70.7%), followed by Asian (16.1%), Black (3.2%), Hispanic (2.6%), and Native American (0.2%). Most were supported by research assistantships (56.3%), with the second largest group being self-supported (13.8%). Teaching assistantships were a small source of support (4.6%). Stipends (12-month equivalent) where variable among fellowships ($2000 to $30,000), teaching ($6600 to $25,000), research ($2000 to $25,239), extension ($12,000 to $17,000), or combination assistantships ($900 to $26,000). Most assistantships included a stipend plus in-state and out-of-state tuition waivers: about half included medical insurance. Mean full-time in-state tuition and fees was $6,535, while out-of-state was $13,876. Participation in distance courses was greatest for non-degree students (18.3%), and low for all others (9.2% to 6.4%). The average academic unit had 15.1 professors, 8.9 associate professors, 6.8 assistant professors, 0.3 senior lecturers, and 1.6 lecturers with mean reported average salaries of $85,142; $70,132; $58,918; $55,608; and $37,887, respectively.

The Pros and Cons of Migrating Classes to the Web: Are We Getting What We Truly Want from This Effort?

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Proponents of distance education encourage the migration of courses and entire degree programs onto the web. To this end, vast amounts of time, energy, and funds are directed to the development of new courses as well as the enhancement of traditionally taught courses. The question now begs to be asked, "Are we getting what we truly want from distance education?" Using a web platform provides a framework with excellent options to develop audio and visually rich courses. Distance programs also provide access to students not able to participate in traditional on-campus degree plans, providing the potential for a boost in enrollment. However, there are serious considerations that need to be balanced, including student satisfaction/dissatisfaction, enrollment management, faculty time commitment, and technical support. In this presentation, some of the benefits and liabilities of web courses will be discussed and program management suggestions will be explored.

Enhancing Horticulture Students' Reasoning and Thinking Skills: Applying the Perry Theory to Horticulture

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This study explored students' cognitive complexity as defined by William Perry (1970) as influenced by teaching methods promoting active involvement at a higher level of interchange than traditional lecture. Two components of this research are: 1) an understanding of Perry's theory to serve as a guide for curricula development incorporating activities to influence intellectual growth by considering the student's current Perry positions in order to encourage upward movement according to Perry's Scheme; and 2) to investigate the reliability of using the student's Learning Environment Preference Inventory (LEP) (Moore, 1987) as a tool to understand the student's cognitive growth. The qualitative portion of this research examined cognitive complexity using the LEP instrument. LEP would give instructors an approximate idea of how to construct their courses to deliver information encouraging higher-order thinking. It is a mistake to assume students in upper division courses are all operating in upper Perry positions. It is difficult to make significant gains in intellectual development during one semester, but it is particularly challenging if instructors are unaware of where students are initially in respect to cognitive complexity. The utilization of a reliable instrument may also help explain some perplexing incidents that occur in classrooms. Instructors can be comforted knowing that what frequently transpires in a class might be motivated more by where students are in their cognitive development than by what is said or done by the instructor.

Plant Science Graduate Students: Demographics, Research Areas, and Recruitment Issues

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Graduate student enrollment in the plant sciences has decreased over the past several years, and there is increasing interest in recruitment/retention strategies. Before successful strategies can be implemented, however, the status of current plant science graduate programs needs to be determined. Survey data on graduate student demographics, research area, support levels, current recruitment strategies, and career opportunities were collected from 23 plant science graduate programs. Overall, 55% of graduate students in plant sciences were male and 45% were female; about 60% were domestic and 40% were international. Cellular/molecular biology and breeding/genetics were the two disciplines that had the greatest number of graduate students and the greatest number of job opportunities. Most programs cited financial support as the biggest obstacle to recruitment. However, stipend number, the guarantee of multiple years of support, the funding of tuition waivers, and health insurance costs also impact student numbers. As more of these costs are shifted to faculty, there appears to be an increasing inability and/or reluctance to invest grant funds (which support 60% of the plant science graduate students) in graduate student education. These data suggest that the decline in plant science graduate student enrollment may be due to shifting of more of the total cost of graduate training to faculty, who may be unable/unwilling to bear the cost. There is also a clear shift in the research focus of plant science graduate students, as postdoctoral and career opportunities are weighted toward molecular biology/genetics, leaving the more applied plant science areas particularly vulnerable to low graduate enrollment.

A New Horticultural Science Distance Education Graduate Certificate Program

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Many potential students, because of distance from the university campus and/or job requirements, cannot take traditional courses on-campus. This group of learners is "place-bound"—a group of learners who may be employed full-time, most likely married with job responsibilities and/or other situations demanding most of their attention. The Horticultural Science Department and Graduate School at N.C. State University are addressing place-bound limitations in several ways, including the creation and offering of a Graduate Certificate Program in Horticultural Science via distance education (DE). By using DE, high demand, low-seat-available classes can offer additional enrollment for credit. Second, courses can be offered asynchronously or with alternative delivery methods. Also, courses offered collaboratively among institutions can generate a level of interest and enthusiasm that may not exist for "home-grown" courses. Such efforts as these promise to help meet continuing education demands of "non-traditional" students. These include Cooperative Extension's more than 120 Horticultural Crops Extension Agents ("field faculty") and over 300 other field faculty whose interests include horticultural topics.

Undergraduate Involvement in Master Planning the Anishinabe Culture and Wellness Center

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A cooperative project between Turtle Mountain Tribal Community College and Southern Illinois University (SIU) completed a master plan for the Anishinabe Culture and Wellness Center in Belcourt, N.D. The project involved four SIUC undergraduate landscape horticulture students and the researcher visiting the 100-acre site, students and faculty of the Community College, as well as residents of the reservation. The purpose of the project was to: 1) explore developing a distance learning landscape horticulture program as a model project; 2) offer hands-on learning experience for the undergraduates; and 3) develop a master plan for a cultural, wellness, and environmental educational center. Developing the master plan involved four stages conducted by SIUC and Turtle Mountain participants. This included an inventory of the site and surrounding area, visiting classes at Turtle Mountain Tribal College, and interviewing numerous people from the reservation. An analysis was completed to review desired activities, such as a native plant garden, medicine wheel garden, pow wow site, and an outdoor kitchen, in relation to physical and observed features of the site. Environmental concerns, including water quality of the lake, were also addressed in the analysis. A master plan was completed after design concepts were explored. Future goals to complete the Anishinabe project include educational workshops and seeking funds to implement the master plan. Participants felt that the learning exercise for this model project was rewarding and successful. Therefore, SIUC and Turtle Mountain will continue to develop distance learning opportunities for students and potentially invite other tribal colleges with an interest in landscape horticulture to be involved.

CSI Manhattan: Using the Theme of a Popular Television Series to Enhance Student Learning Beyond the Lecture Hall

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According to brain-based learning theory, learning is enhanced by challenge and inhibited by threat. Effective learning occurs when students are immersed in the educational experience, challenged yet not threatened, and encouraged to actively process information. All of these components are part of simulation or role-play games. With these basic concepts in mind, we approached the challenge of enhancing student learning in a plant identification course taught in a large class setting. Considering that plant identification requires some basic detective skills, and the popularity of criminal investigation television programming, we designed a role-play exercise involving case files, investigation zones, and detective teams. As a spin-off from the television shows "CSI: Crime Scene Investigation" and "CSI: Miami," the exercise was coined "CSI: Manhattan, Conifer Site Investigation in Manhattan, Kansas." It was designed to fit into a 50-minute class period. Throughout the exercise, detective teams (students) needed to collectively locate and identify plants based on previous knowledge and clues within the case files and

at the sites. Upon completion, plant specimens were checked in and identification logs discussed in order to provide immediate feedback and reinforcement of learning. Students enjoyed the exercise, offering positive feedback and conversations about the exercise throughout the balance of the semester. Six months later, while walking past one of the investigation sites, students remembered the site, exercises performed, and the plant name. The exercise includes both interactive and experiential learning components. This session will discuss the "CSI" exercise and its value in linking action to information.

Oral Session 33—Marketing and Economics

Moderator: Elio Jovicich

21 July 2005, 10:00–11:30 a.m. Room 108

Market of Colored Bell Peppers and an Estimated Profitability for the Production in Greenhouses in Florida

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The uninterrupted supply of high quality colored peppers to the U.S. is mainly from imports of greenhouse-grown fruits. Average year-round wholesale market price of these imports was $4.80/kg when U.S. field-grown fruit price was $1.60/kg for colored and $0.91/kg for green. High market prices and a suitable environment for growing colored peppers in inexpensive protected structures led to construction of 25 ha of greenhouses currently growing peppers in Florida. Greater demand for specialty vegetable crops, loss of methyl bromide, and an increase in urban sprawl and price of arable land may result in growers considering greenhouses to produce high value peppers. We estimated the profitability of a greenhouse enterprise with a budget analysis and calculated the returns to capital and management. We assumed use of current technology applied in commercial greenhouse crops in Florida, and in experimental crops at the Univ. of Florida. Revenues per square meter were estimated from current yields and historical fruit price data. Plants were grown in perlite in a high-roof polyethylene-covered greenhouse (0.78 ha) located in north central Florida. Transplanting occurred in August and fruits were harvested from November to May for a yield of 13 $kg \cdot m^{-2}$ with a total cost of production of $41.09 and an estimated return of $17.89. The return on investment was 17%. Only yields greater than 7.8 $kg \cdot m^{-2}$ generated positive returns using the average wholesale fruit price during the season ($5.29/kg). For this price, a range of possible yields (5–17 $kg \cdot m^{-2}$) led to returns ranging from $–9.52 to $30.84, respectively. The estimates indicated that production of greenhouse-grown peppers could represent a viable production alternative for Florida vegetable growers.

Consumer Preference among Three Cold-climate Strawberry Production Systems

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Three cold-climate strawberry production systems, conventional matted row, advanced matted row, and cold-climate annual hill plasticulture, were compared for consumer preference in a pick-your-own (PYO) setting. Replicated 6 × 15 m plots were established in 2002 in Maryland and cropped in 2003 and 2004. To simulate PYO marketing, volunteers were recruited to harvest 3.6-m plots in each of the three production systems and to complete a five-part questionnaire. The questionnaire collected demographic information and allowed volunteers to compare the three systems both prior to and after their harvesting experience. Harvests were carried out twice weekly, with 75 participants in 2003 and 45 participants in 2004. The 2003 season was cool and wet, with frequent rainfall and a high incidence of fruit rot. Spring 2004 was unseasonably hot, resulting in an unusually short harvest season. Consumer preference differed between years and among harvests within a season. The annual hill system was favored early in the 2003 season, with preference shifting to the other systems as the season progressed. The advanced matted row was favored early in the 2004 season. Many of the participants' comments, both positive and negative, were directed at the plastic mulch and raised beds. In several cases, participants indicated that their preferences after picking from each system did not match their initial impressions. Implications of this research to the social components of sustainability will be discussed.

The Changing Face of the American Gardener

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As the diversity of the American population increases, so should efforts to understand gardening behavior of different subcultures. Businesses need this information to effectively target these consumer groups, and improve their level of product satisfaction. An Internet study of gardening activities was conduced in Sept. 2004, with a sample of 1591 individuals, but over sampled for African-, Hispanic-, and Asian-Americans. Results showed many differences in the purchases, enjoyment, expenditures, and product satisfaction for these groups compared to the Caucasian sample. More Caucasians had mowed their own lawn in the year prior to the study (60.2%) than African-Americans (47.1%), Hispanics (50.4%), or Asians (50.5%). More Caucasians (58.2%) had participated in flower gardening than African-Americans (33.5%) or Hispanics (44.1%), but similar to the percentage of Asian-Americans (50.9%). However, a similarly high percentage of Asians had participated in fruit, vegetable, or herb gardening (33.8%), compared to Caucasians (33.5%). Both groups participated in fruit, vegetable, or herb gardening more than African-Americans (16.3%) or Hispanics (26.7%). Hispanic gardeners spent 7.3 hours in the garden on average each week, compared to 6.7 hours for Caucasians, 6.5 for Asians, and 4.7 for African-Americans. Yet, Hispanic (3.8) and Asian (3.8) gardeners rated their level of outdoor gardening enjoyment (7-point Likert scale) higher than African-Americans (3.1) but lower than for Caucasians (4.0). This first glimpse of non-Caucasian gardeners shows businesses should target these groups for specific gardening products and may have some extra work to do to improve their level of satisfaction and enjoyment.

Assessing Consumer Acceptance of Edamame-based Patties

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A sensory evaluation was conducted on 9–10 Feb. 2005 at The Pennsylvania State University, University Park campus, to determine consumer acceptance of two edamame [*Glycine max* (L.) Merrill] -based patties. This value-added product was chosen because of the increasing popularity of vegetable-based burgers. Patties were mainly composed of edamame, mushrooms, and onion; however, they differed, based on the type of mushroom and seasonings used and the addition of walnuts to one of the recipes. One type of patty was evaluated each day with participants rating it on overall appeal, flavor, appearance, and texture. A total of 209 consumers participated in the 2-day sensory evaluation, 106 on the first day and 103 on the second; and 23.6% and 25.2%, respectively, were familiar with or had heard of edamame before. Overall mean liking for the patties was 6.38 and 6.58 (1 being dislike extremely and 9 being like extremely) and mean liking for flavor was 6.44 and 6.83, respectively. Based on the sample, 43.4% and 35.9% of participants each day indicated that they "probably would buy" or "definitely would buy" this item from a supermarket. Consumers also ranked select product characteristics that influence their decision to purchase new food items in terms of importance. Results were similar for both days with flavor, nutritional value, and price ranked as the three most important factors that influence their purchasing deci-

sions. Verbal comments from participants indicated a strong interest in purchasing this product. Results suggested that consumers found the two edamame-based patties acceptable. Small-acreage growers could consider marketing edamame for use in value-added products such as these.

Pecan Cultivation in China

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Pecan [*Carya illinoinensis* (Wangenh.) C. Koch], a world-famous nut tree native to North America, was introduced to China in the early 1900s. However, little success had been recorded in terms of its nut production. Based on comparative studies of the geoclimate, soil conditions, and growth and performance of the pecan crop between southeastern U.S. and China, as well as in 12 other countries with successful pecan cultivation, it is feasible to grow pecan in China within the latitudes 25–35°N. In these areas, the summer temperatures range from 25–35°C with lower DIF. The annual precipitation is 500–1500 mm. Further studies using the Dendroclimate Predicative Analysis of water and heat conditions in the U.S. Pecan Belt, which is composed of seven factors, including the annual mean and extreme low temperatures, annual frost-free days, and annual precipitation, concluded that four pecan cultivation regions should be designated in China. These regions were the Favorable Region (I), the Northern and Southern Suitable Regions (IIa, IIb), the Northern and Southern Marginal Regions (IIIa, IIIb), and the Northern and Southern Undesirable Regions (IVa, IVb). The Favorable Region is along both sides of the Yangtze River in-between latitudes 25–35 °N and longitudes 100–122 °E. Some areas with microclimates, such as western Yunnan, nourish several pecan cultivars and have demonstrated a promise of pecan production. The demand for pecan is high in China, and this regionalization of pecan cultivation will ultimately enhance further collaboration on pecan production between horticulturists in China, United States, and other countries. Future research will result in the introduction of much better pecan cultivars to the different cultivated regions in China.

Improving the On-farm Productivity and Supply of Capers to Processors in Morocco

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Morocco is the world's leading caper producer. Its export position has declined as worldwide production increases. Farm gate prices have declined as market prices have diminished. A joint program among the Moroccan Federation of Food Processors (FICOPAM), the Institut Agronomique et Veterinaire Hassan II (IAV Hassan II), and DAI was supported by USAID to examine how to improve industry competitiveness. Field surveys and workshops with farmers, buyers, and processors in Morocco's three main caper growing regions were used to inform a national conference to arrive at a consensus action plan. The plan focuses on a shift from weight-based to grade-based buying practices. Supporting changes were identified to modify on-farm practice; equip and regulate buying floors at major markets; institute minimum traceability requirements; and establish HACCP programs for caper processors in collaboration with Moroccan export authorities. Training programs to support these changes were completed with farmers and extension personnel in 2004.

Oral Session 34—Seed and Stand Establishment

Moderator: Gene M. Miyao

21 July 2005, 2:00–3:00 p.m. Room 105

Comparison of Direct Seed versus Transplant Yield and Fruit Quality of Processing Tomatoes in the Southern Sacramento Valley

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Canning tomato transplants were compared to direct seed in field trials to evaluate fruit yield and quality. Trials were conducted either at the University of California at Davis Long Term Research on Sustainable Agriculture field facility or in a commercial direct-seeded tomato field near Woodland. To closely match harvest dates of both propagation methods, transplants were mechanically planted after direct-seeded plants approached the 2 to 3 true-leaf stage. Trial design was replicated, factorial with propagation method and with plant population comparisons. Populations were 8712, 6534, 5227, and 4356 planting units per acre. Direct-seeded plots were thinned to clumps of three plants centered on 12, 16, 20, or 24 inches between clumps within the seed line. Transplants were 6-week-old, commercial, greenhouse-grown plants that were mechanically planted to match the direct-seed spacing. Plant rows were single lines per bed centered on 5 feet. The entire 100-foot plot length was mechanically harvested into specially designed portable weigh trailers to measure yield. Fruit yield between direct-seed and transplants were similar in two of the 3 years. In one of the 3 years, production problems were encountered resulting in low overall yield, but significantly lower with the transplants. 'Halley', a cultivar common in the region, was used in all of the test years. Transplant yields were slightly reduced linearly as spacing between plants increased while yield from direct seed was less affected. Fruit quality tended to be similar among the treatments.

Seed Dormancy in Three Wild Rye (*Elymus*) Species

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Wild rye (*Elymus*) contains several species of cool season grasses that are important components of forest and woodland ecosystems. Little specific information is known about seed dormancy in wild rye species, but cool season grasses generally display endogenous, non-deep physiological dormancy that would normally be satisfied by moist chilling during winter to permit early spring germination. However, few studies have documented the effect of extended chilling stratification on dormancy release in cool season grasses. Therefore, the objective of this study was to document the dormancy condition of representative wild rye species and to observe the impact of chilling stratification on dormancy release. Three species of wild rye (*E. virginicus*, *E. macgregorii*, and *E. villosus*) were selected based on their taxonomic and ecological relationships. All species showed conditional dormancy with respect to germination temperature. At 15 °C, *E. virginicus*, *E. macgregorii*, and *E. villosus* germinated at 75%, 81%, and 40%, respectively, compared to 5%, 3%, and 12% for each species at 20 and 25 °C. Chilling stratification at 10 °C improved germination compared to non-stratified seeds to 95% and 94% for *E. macgregorii* and *E. villosus*, but had no effect or reduced germination in *E. virginicus*. Stratification at 5 °C was not as effective as 10 °C for dormancy release and appeared to cause chilling injury in *E. virginicus* and *E. macgregorii*. The data suggest that these wild rye species express a form of conditional endogenous, non-deep physiological dormancy that is most pronounced when seeds are germinated at non-optimal temperatures.

Onion Seed Quality

Alan G. Taylor*
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High seed quality is required to obtain optimal plant stands and to achieve maximum yield potential. Onion seeds are commonly coated and treated with an insecticide and fungicide to control early season insects and diseases. The seed treatments may cause phytotoxicity in standard germination tests, and thus reduce the percent germination of a seed lot. The objective of this study was to examine the effect of seed quality on seed storage, stand establishment and yield. Two seed lots of two long-day onion varieties were pelleted and treated with the seed treatments Trigard and Pro-Gro. Standard germination and saturated salt aging tests were performed on each seed lot, indicating a high and lower quality seed lot for each variety. Aging was conducted by equilibrating pelleted seeds at 35% relative humidity and aging at 25 °C for up to 12 months. Aging decreased germination with time, especially for the lower quality lots. Field studies were conducted in two locations in upstate New York. The plant stand was greater in the high compared to the lower quality lots in both varieties at both locations. Yield was reduced in the lower quality than high quality lot; however, the response differed by variety and location. Overall, the initial seed quality had an impact on seed storagability, stand establishment and yield.

Effect of Multiple Plants per Plug on Processing Tomato Yield in California

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In recent years, an estimated 65% of processing tomato acreage has converted from direct seeding to transplanting the crop. Growers have been switching to transplants for a number of reasons, including land use efficiency, water conservation, and weed management. Field studies investigating plant spacing and multiple plants per transplant plug (cell) were initiated when observations by growers indicated that there were seemingly decreased fruit yields from transplanted crops. A transplant density experiment was established in 2004 in a commercial field of processing tomatoes grown on the west side of Fresno County in the San Joaquin Valley, the major tomato production area in California. The field trial investigated in-row spacing (37.5 cm and 75 cm), the number of plants per transplant plug (1, 2, or 3), on a medium vine size variety (Halley 3155) and a large vine size variety (AB2). Individual plots were large enough for mechanical harvest. Yield results indicate that these two varieties responded similarly to increasing plant density. In general, a spacing of 37.5 cm with 2 or 3 plants per plug yielded significantly more than 1 plant per plug, regardless of variety. There was no yield advantage in seeding 3 plants per plug when compared to yields with 2 plants per plug, regardless of variety or in-row plant spacing. A plant spacing of 75 cm with only 1 plant per plug yielded the least.

Oral Session 35—Fruit/Nut Crops Production

Moderator: Kathleen M. Kelley Anderson

21 July 2005, 2:00–3:15 p.m. Room 102

Effect of Plant Architecture on the Performance of Two High-chill Pear Cultivars

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Pear growing in subtropics began with the advent of low-chill pears, but their fruit quality is inferior to high-chill European/Oriental pears. Thus, the best way to produce high-chill pears in subtropics is by topworking them on the low-chill pears. To attain this, pruned wood with spurs of 'Doyenne du Comice' (DCP) and 'Victoria pear' (VP) cultivars were collected in January from Hort Expt Center Chaubatia, India (6825'ASL), and tongue grafted on low-chill 'Pant Pear-18' (PP18). The grafting was at different heights on trees using 25-cm and 1-m long stocks on Tatura trellis-trained PP18 trees at the Hort. Research Center, Pantnagar (760' ASL). More than 90% grafts succeeded and both DCP and VP produced high quality fruits, but DCP grafts had an edge over VP scions. Both high-chill cultivars topworked on 25-cm stocks had better grafting success (95%) than the scions topworked on 1-m stocks (92%). The increase in topworking heights on stock trees reduced the floral spur numbers in both scions grafted on 25-cm stocks, but not on the scions grafted on 1-m stocks. With the incremental height of topworking irrespective of the length of stocks, the percentage of fruit set was curtailed by 28% and 12% for the DCP and VP scions, respectively. Irrespective of the topworking heights and stock lengths, the fruit yield for DCP (12.5 lbs/tree) was markedly higher than for VP (7.9 lbs/tree). Fruit quality attributes judged by organoleptic testing, TSS, total sugars, acidity, and ascorbic acid, were better for both DCP and VP than for PP18 and other local pear cultivars. The reuse of previous year's scions topworked even after artificial chilling and/or GA_3 application to supplement chilling exhibited no fruiting advantage over the grafting using fresh scions.

Evaluation of Chill Models in 'Bing' Sweet Cherry Rest-breaking Trials in California from 1994 to the Present: Validation of the Dynamic Model

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Moderate California winters often result in delayed, erratic or extended bloom, inadequate overlap with pollenizers, poor leafing-out, low fruit set, and irregular fruit maturity. In recent years, use of rest-breaking agents has become commonplace in California sweet cherry (*Prunus avium* L.) culture, mainly to promote earlier bloom and fruit maturity, but also to promote uniform flowering and overcome lack of marginal chilling. Variable responses by different cultivars and in different seasons may be due to different chilling requirements, despite little variation in genetic background for chill requirement in California's commercial cultivars. Other sources of variation include the activity of the rest-breaking agent used, concentration and carrier volume. A minimum amount of effective chill appears to be required for a given cultivar before rest-breaking agents can be effectively applied. This threshold, as exhibited by degree of response to treatment, can be an important indicator of when to spray. Method of measuring chill accumulation, and thus, timing of applications, varies by region and historic acceptance. California's tree fruit industry typically uses the 45 °F "chill hour" model. The Utah Chill Unit Model and the Modified 45 °F Chill Hours Model had not been thoroughly tested under California conditions nor with the rest-breaking chemicals that are in use today in California. We tested our research results against these models and the Dynamic Model developed in Israel and concluded that the Dynamic Model provided the best explanation of responses in our experimental trials. We have been developing recommendations for application of rest-breaking chemicals based on Dynamic Model chill portion accumulation.

Integration of Precision Agriculture and Systems Modeling in Pistachio

Todd Rosenstock*[1], Patrick Brown[2]

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Alternate bearing exerts economic and environmental consequences through unfulfilled yield potential and fertilizer runoff, respectively. We will discuss a systematic biological–statistical modeling management integration approach to address the concert of mechanisms catalyzing alternate bearing. New engineering technologies (precision harvesting, spatially variable fertigation, and mathematical crop modeling) are enabling optimization of alternate bearing systems. Four years of harvest data have been collected, documenting yield per tree of an 80-acre orchard. These results have shown variability within orchard

to range from 20–180 lbs per tree per year. Results indicate irregular patterns not directly correlated to previous yield, soil, or tissue nutrient levels, or pollen abundance. Nor does significant autocorrelation of high or low yields occur throughout the orchard, suggesting that genetically dissimilar rootstocks may have significant impact. The general division of high- and low-yielding halves of the orchard may infer a biotic incongruency in microclimates. This orchard does not display a traditional 1 year-on, 1 year-off cyclic pattern. Delineation of causal mechanisms and the ability to manage effectively for current demands will empower growers to evaluate their fertilization, irrigation, male : female ratio, site selection, and economic planning. In comparison to annual crops, the application of precision agriculture to tree crops is more complex and profitable. When applied in conjunction, the aforementioned methods will have the ability to forecast yields, isolate mechanisms of alternate bearing, selectively manage resources, locate superior individuals, and establish new paradigms for experimental designs in perennial tree crops.

Shoot Preformation and Neoformation in Pistachio: Influences on Bearing Habit and Yield Components

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Rootstock significantly alters the pattern of shoot growth of pistachio (*Pistacia vera*) cv. Kerman. Trees grown on *P. atlantica* typically produce a single flush of spring growth, whereas trees on *P. integerrima* selection PGI and *P. atlantica* × *P. integerrima* selection UCB-1 can produce multiple flushes during the season. We have shown that the spring flush is entirely preformed in the dormant bud for all three rootstocks, but later flushes are neoformed, that is, nodes are initiated and extended during the same season. Shoots producing both preformed and neoformed growth have lower yield efficiency than those producing only preformed growth. Additionally, yield components of the crop from shoots with both preformed and neoformed growth was different than for shoots producing only preformed growth. However, these differences do not appear to be significant at the whole tree level. These data suggest that neoformed growth can both compete with fruit growth for available resources (lower yield efficiency) and act as an additional source (altered yield components), depending on the factor being measured. Controlling neoformed growth may potentially increase pistachio yield through a shift to the more efficient preformed shoots while at the same time lowering orchard maintenance costs by reducing required pruning. We have data to indicate that regulated deficit irrigation and new pruning techniques may be viable methods for controlling neoformed growth in pistachio without affecting yield.

The Effect of Kaolin on Walnut (*Juglans regia*) Quality in California

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The effect of kaolin (Surround™) on walnut quality parameters, including edible yield, reflected light index, insect damage, off grade, price per pound, and the incidence and severity of sunburn, were evaluated over a 4-year period in 'Vina' and 'Chandler' walnut orchards. Results indicate that applications of kaolin significantly improved edible yield, reflected light index, price per pound, and the incidence and severity of sunburn in most orchards in most years. Improvements in these parameters were more consistent with the 'Vina' cultivar. Off-grade was not significantly reduced by the use of kaolin. Codling moth damage levels were too low to detect in all orchards in all years.

Oral Session 36—Vegetable Crops Management/ Protected Culture

Moderator: William J. Lamont, Jr.

21 July 2005, 2:00–3:00 p.m. Ballroom G

Tomato Production in the Hot-wet Season using Grafting and Rainshelter Technology

Manuel Palada*, Deng Lin Wu

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Production of tomato (*Lycopersicon esculentum*) during the hot-wet season in the lowland humid tropics can be increased using grafted plants and rainshelter. This technology can reduce soil-borne diseases, improve the ability of tomato plants to tolerate high temperatures and flooding due to high rainfall, and protect the crop from the impact of heavy rains. AVRDC has developed tomato lines that are resistant to virus diseases and high temperatures. This experiment was conducted to evaluate the performance of these lines in the hot-wet season, with and without rainshelter protection. Tomato lines (CHT501, TLCV15, and FMTT847) were grafted onto eggplant (*Solanum melongena* cv. EG203) rootstock and grown under rainshelter and open field. Nongrafted plants of three lines were also grown under two rainshelter treatments. The experimental design was a split-plot with four replications. Plants were managed using AVRDC standard practices for summer tomato production. TLCV15 and FMTT847 were highly resistant to tomato leaf curl virus (ToLCV), whereas CHT501 was greatly infected by the virus disease. All nongrafted plants died from bacterial wilt, whereas grafted plants survived the disease and outyielded nongrafted plants by 233% in the open field and 143% under rainshelters. Plants under rainshelters had a slightly lower yield than in the open field, but the difference was nonsignificant. Due to lack of frequent high rainfall during the season, the benefit of rainshelter was not detected and realized. It was concluded that TLCV15 and FMTT847 are well suited for grafted tomato production during the hot-wet season.

Regionalizing Agent Training with the Greenhouse Tomato Short Course

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The protocol for agent training has always been for extension specialists to train agents within the same state in each aspect of agriculture. However, with ubiquitous cutbacks among universities, and extension in particular, it is no longer feasible for every state to provide expertise in each field. Consequently, agents cannot receive training in some specialized fields. With a partnership agreement from the USDA Risk Management Agency, the Greenhouse Tomato Short Course in Jackson, Miss., provided training for five to seven agents from each state in the region: Louisiana, Tennessee, Kentucky, and Mississippi. Funding was made available to cover travel expenses, registration, and a resource notebook for 25 agents. As a result, these agents took part in 3 days of intensive training seminars, as well as a 1-day tour of greenhouses. Invited speakers from around the United States spoke to these agents, as well as current and prospective commercial growers from all over the United States. Topics included basics of producing a commercial crop of hydroponic greenhouse tomatoes, budget for establishing and operating a greenhouse business, marketing and promotion, principles of risk management, pest and disease identification and management,

grower's point of view, heating, cooling, and ventilation of greenhouses, new technologies, diagnostics, recent research in greenhouse production, and alternative crops (lettuce, peppers, mini-cucumbers, galia melons, baby squash) for the greenhouse. With this training, agents from throughout the south-central region returned to their offices with the skills to assist growers in their counties to succeed in the hydroponic greenhouse tomato business. Complete information on the short course can be found at www.greenhousetomatosc.com.

Influence of Rainshelter and Irrigation Method on Yield, Water, and Fertilizer Use Efficiency of Chili Pepper

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Chili pepper (*Capsicum annuum* cv. Delicacy) was grown in single- and double-bed rainshelters and irrigated using furrow and drip irrigation to determine effect on yield and efficiency of water and nutrient application in the lowland tropics of southern Taiwan during the hot wet season. The experiment was laid out using a split-plot design with four replications. The main plots were rainshelters (single, double, open field) and the two irrigation methods (furrow and drip) were the subplots. Grafted chili seedlings were transplanted in double rows on raised beds at row spacing of 80 cm and plant spacing of 50 cm. The furrow-irrigated crop was applied with basal $N\text{-}P_2O_5\text{-}K_2O$ at the rate of 180–180–180 $kg{\cdot}ha^{-1}$ and 240–150–180 $kg{\cdot}ha^{-1}$ of $N\text{-}P_2O_5\text{-}K_2O$ as sidedressing. The drip-irrigated crop received half of the total rate applied for the furrow-irrigated crop. Significant differences (P <0.05) in marketable yield were observed between rainshelter treatments. Highest yield (42.2 $t{\cdot}ha^{-1}$) was produced from the single-bed rainshelter, and crops grown under double-bed rainshelters produced the lowest marketable yield. Irrigation method did not significantly influence marketable yield, but crops grown under drip irrigation produced a higher yield than furrow-irrigated crops. Nutrient uptake by plants grown under drip irrigation was also higher (P <0.05) than for furrow-irrigated crops. Water use efficiency was 60.7% higher in drip-irrigated plots. Results indicate that in high rainfall vegetable production areas, drip irrigation minimizes nutrient loss through leaching and maximizes efficiency of fertilizer use.

High Tunnels or a Poor Man's Greenhouse?

William Lamont*, Michael Orzolek

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After being interviewed by a newspaper reporter on high tunnels and explaining in great detail what a high tunnel is and how it is different from a greenhouse, you can guess my shock to read the headline "High Tunnels—A Poor Man's Greenhouse." High tunnels do not offer the precision of conventional greenhouses for environmental control, but they do sufficiently modify the environment to enhance crop growth, yield, and quality and provide some frost protection, but their primary function is to elevate temperatures a few degrees each day over a period of several weeks. In addition to temperature control, there are benefits of wind and rain protection, soil warming, aid in control of insects, diseases, varmints, and birds. They are relatively inexpensive, about $1.30/sq. ft., excluding labor. This system is particularly appealing to new-entry growers with limited capital who utilize retail-marketing channels. High tunnels like plastic-covered greenhouses are generally quonset-shaped with a peak, constructed of metal bows that are attached to metal posts, which have been driven into the ground about 2 feet deep. They are covered with one layer of 6-mil greenhouse-grade polyethylene, and are ventilated by manually rolling up the sides each morning and rolling them down in early evening. There is no permanent heating system, although it is advisable to have a standby portable propane unit to protect against unexpected below-freezing temperatures. There are no electrical connections. The only external connection is a water supply for trickle irrigation.

Oral Session 37—Postharvest Fruit Crops

Moderator: Carlos H. Crisosto

21 July 2005, 2:00–4:00 p.m. Room 107

Influence of Preharvest AVG Application on the Activity of Sorbitol Dehydrogenase in Apple Fruit

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Sorbitol dehydrogenase (SDH) is a key enzyme in apple fruit converting sorbitol into fructose. SDH activity in 'Fuji' apple was reported to increase close to harvest, perhaps as part of the ripening process. Aminoethoxyvinylglycine (AVG) is used to delay fruit ripening and prevent fruit drop, though its effect on sorbitol metabolism is not known. To determine if the late season increase in SDH activity is common among apple cultivars and if AVG use affects SDH expression and activity, AVG was applied to 'Lodi', 'Redchief Delicious', and 'Red Fuji' trees 4 weeks before harvest. Control and AVG-treated fruit were collected 1 week prior to, at, and 1 week after the normal harvest date for assessment of ethylene production over time after harvest and SDH presence and activity at harvest. Ethylene production in control fruit increased after harvest and AVG reduced it in all cultivars. 'Redchief Delicious' fruit had the highest ethylene production of the treated samples. The levels of SDH activity in controls were similar across dates for 'Redchief Delicious' and showed no consistent pattern in the other cultivars. 'Redchief Delicious' and 'Red Fuji' showed the highest and lowest levels of SDH activity, respectively. AVG did not affect SDH activity in 'Redchief Delicious', and substantially increased SDH activity in 'Red Fuji' on each of the three harvest dates, and, in 'Lodi', only 1 week after normal harvest. SDH presence was confirmed through immunoblotting for all cultivars and harvest dates. Overall, fruit with the greatest reduction in ethylene production in response to AVG also showed changes in SDH activity.

Synergistic Effects of the Combined Application of MCP and Low O_2 on Apple Fruit Ripening

Mehar Asif[1], Prabodh Trivedi[2], Theophanes Solomos*[3], Autar Mattoo[4]

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We have studied the effects of MCP and low O_2, applied singly and in combination, on apple fruit ripening at 1, 7, and 18 °C. The single application of 2 ppm MCP is more effective in delaying the onset of the C_2H_4 climacteric than is 1% O_2. However, the combined application has a much larger effect than the single applications of either MCP or 1% O_2. For instance, at 7 °C, the onset of the C_2H_4 climacteric occurs at 15, 50, and 90–95 days for the controls, 1% O_2 and 2 ppm MCP, respectively, whereas the combined application of 2 ppm MCP and 1% O_2 suppressed the initiation of the C_2H_4 climacteric for 200 days, the duration of the experiment. The retardation of the climacteric onset by the treatments is associated with the suppression of ACC-synthase (ACS1) and the putative receptor ERS1. The accumulation of their transcripts is critically dependent on the rate of C_2H_4 evolution. As expected, the combined application of MCP and 1% O_2 completely suppressed the expression of both genes. Yet when the fruits were transferred to 18 °C in air, they ripened normally. A similar pattern of inhibition in response to the above treatments was also observed with a C_2H_4-dependent MAPK. The expression of ETR1, ETR2 and ACC-oxidase was not affected by the treatments. The nature of this strong effect of the combined application of MCP and low O_2 is not

clear. It should be pointed out that MCP does not inhibit the induction of hypoxic proteins such as ADH.

Apple Scald Development and Regulation

Theo Solomos*[1], Prabodh Trivedi[2], Mehar Asif[3]

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We have studied scald development by comparing changes in gene expression, C_2H_4 evolution, and α-farnesene and conjugated trienol contents in scald-resistant cultivars, i.e., 'Gala' and 'Braeburn', and scald-sensitive cultivars, i.e., 'Red Delicious' and 'Granny Smith'. We also carried out similar comparisons between controls and treatments that diminished scald symptoms in sensitive cultivars. The data show that scald development is critically dependent on the initiation of the climacteric rise in C_2H_4 evolution, since treatments that suppress the latter inhibit scald development at low temperatures coincident with a suppression of α-farnesene and conjugated trienols. However, in scald-resistant cultivars, there is an increase in α-farnesene and conjugated trienols, although to a lower degree than in the sensitive cultivars. This indicates that factors other than the auto-oxidation of α-farnesene are also involved in scald development. Analytical data show that malonyl dialdehyde (MDA) increases only in scalded areas, which, in turn, suggests that oxidative reactions are involved in scald development. Storage of 'Granny Smith' at temperatures above 7 °C prevents the development of scald without affecting the accumulation of α-farnesene and conjugated trienols. This in turn suggests that chilling temperatures induce as yet unknown enzymes that contribute to scald development. In short, the data show that in addition to cultivars, low temperature stress and the induction of the C_2H_4 climacteric play a crucial role in scald development. Preliminary data show that treatment of 'Granny Smith' apples with olive oil emulsions suppress scald development symptoms.

Diphenylamine and Diphenylamine Derivative Content of 'Granny Smith' Peel: Influence of Ethylene Action and Regular or Controlled Atmosphere Storage Duration

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Diphenylamine (DPA) is used for superficial scald control in apple fruit. A number of DPA derivatives resulting from *C*-nitration, *C*-hydroxylation, *O*-methylation, and *N*-nitrosation can be present in DPA-treated apple fruit after storage. The presence of the compounds may be indicative of metabolic processes that lead to scald development. Therefore, apple peel DPA and DPA derivative content in fruit treated at harvest with DPA or DPA plus 1-methylcyclopropene (1-MCP) was assayed upon removal of fruit from controlled atmosphere (CA) and regular atmosphere (RA) storage and during a 14-d post-storage ripening period. Apples were also treated at harvest with different concentrations of DPA and assayed after 6 months CA storage to confirm recovery of DPA and DPA derivatives is linear over a wide concentration range. Harvest maturity notably affected peel DPA and 4-hydroxydiphenylamine (4OHDPA) content. Post-storage ripening, 1-MCP treatment, and CA storage had varied affects on DPA derivative content, suggesting reactive oxygen or nitrogen species, such as $^{\cdot}OH$, $^{\cdot}NO$, and $^{\cdot}NO_2$, or enzyme catalyzed reactions may be generated during ripening and senescence related physiological processes. Consistent correlations between scald incidence and content of specific derivatives were not observed.

Postharvest Peel Pitting in Citrus Fruit at Nonchilling Temperatures Is Affected by Climatic Factors and Advanced by Changes in Peel Water Status

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Several citrus varieties, including 'Navel' oranges, 'Marsh' grapefruit and 'Fallglo' tangerines are prone to develop postharvest peel pitting at nonchilling temperatures. The disorder is characterized by depressions in flavedo that ultimately affect oil glands. Increasing evidence indicates that changes in peel water status during postharvest handling of fruit plays a major role in the appearance of the disorder. Peel pitting was triggered when fruit were transferred from low to high relative humidity (RH) consistently in several citrus growing areas. A transient increase in fruit ethylene production and ABA content was observed within the first 24 hours after transfer from low to high RH. Water potential decreased with storage at low RH in flavedo and albedo, and recovered faster in flavedo than in albedo cells upon transfer to high RH. The differential recovery in water potential between flavedo and albedo is postulated to cause collapse of external albedo layers and pitting. The effect of climatic conditions in the field at harvest was also examined. Harvesting fruit at low RH induced more severe pitting after storage than harvesting at high RH. In addition, increasing hours of low RH storage prior to storage at high RH resulted in increased pitting. The results demonstrate that change in peel water status is a major factor leading to the development of postharvest peel pitting in citrus.

Biofumigation with *Muscodor albus* Pads for Controlling Decay in Commercial Table Grape Cartons

Julien Mercier*, Paul Walgenbach, Jorge I. Jiménez

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The volatile-producing fungus *Muscodor albus* is being developed as a biological fumigant for postharvest use, as it can kill storage pathogens and control fungal decay in various commodities. A wettable pad or sachet system made of teabag paper containing desiccated rye grain culture of *M. albus* was designed for the biofumigation of individual fruit containers. The fungus is reactivated before use by a brief immersion of the pad in water. This research was conducted to determine the potential of the pad system for controlling decay of table grapes in commercial cartons. Individual pads containing 24 or 86 g of grain culture (to achieve a 1:10 ratio of fumigant to box volume or a 1:100 ratio of fumigant to fruit weight, respectively) were added to Styrofoam cartons containing 8.6 kg of freshly harvested 'Thompson Seedless' (TS) or 'Ruby Seedless' (RS) grapes, which were then placed in cold storage at –1 to 0 °C. Control cartons exposed to SO_2 were placed in a separate storage room and SO_2 fumigation was performed once for TS and weekly for RS. After 8 to 9 weeks, the grapes were taken out of storage and rated for decay. In the experiment with TS, the 24-g and 86-g pads provided significant control of gray mold rot when compared to untreated cartons and were not statistically different from cartons exposed to a single SO_2 fumigation. In the experiment with RS, only the 86-g pads provided significant decay control. Measurements of the three most abundant volatile compounds in empty cartons containing 10 g of the biofumigant revealed that partial coverage of holes mimicking obstruction by packed fruit achieved levels of isobutyl alcohol, 2-methyl-1-butanol, and isobutyric acid of 0.7, 1.6, and 11.2 ppb, respectively.

SmartFresh™ in Combination with Film Coatings Reduces Sugar Spots and Extends "Yellow Life" of Bananas

Jorge Siller-Cepeda*, Manuel Baez-Sañudo,
Rosalba Contreras-Martinez, Laura Contreras-Angulo,
Rosabel Velez, Dolores Muy-Rangel

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Banana fruits 'Cavendish' type were obtained from a warehouse at color green stage. At arrival, fruits were taken out of boxes, dipped into a thiabendazole solution for 5 minutes, dried at room temperature and separated into three lots. One lot was sprayed with FreshSeal™ (FS) at 3 °Brix, a second lot was treated with SemperFresh™ (SF) at 1.2%, and the third was left as a control. After that, all fruits were packed again inside the plastic bags within the original carton boxes. Film-coated and control fruits were ethylene treated for 24 hours at 150 ppm, and vented for 24 hours until they reached color 3 (more green than yellow). After that, film-coated and control fruit boxes were collected inside 238-L airtight containers to apply Smartfresh™ (SMF)

treatments at 0 and 300 ppb for 12 hours at 22 °C, complementing six different treatments. Later, fruits were stored at 22 °C and 80% to 90% relative humidity for 5 days to follow up changes. Quality evaluations were registered every day, including weight loss, firmness, color, CO_2, ethylene, pH, titratable acidity, °Brix, and sugar spots. SF alone and the combinations SF + SMF and FS + SMF reduced weight loss as compared with the other treatments. SMF alone or in combination with FS or SF maintained higher firmness and delayed yellow color development as compared with the other treatments. Combinations of SF or FS with SMF delayed and reduced the incidence of sugar spots as compared with control fruits. Chemical characteristics were not significantly affected by the treatments, but SF + SMF had higher acidity and a lower pH. All treatments reached between 20 and 21 °Brix after 5 days. The data show that combined treatments of SMF and film coatings reduce sugar spot incidence, improving appearance and extending yellow life of fruits.

Developing a Tree Fruit Code [*Prunus persica* (Batch.)] for Cultivars According to Their Organoleptic Characteristics

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Cultivar segregation according to their organoleptic perception was attempted by using trained panel data evaluated by principal component analysis in four sources of 24 peach and 27 nectarine cultivars as a part of our program to develop minimum quality indexes. Source significantly affected cultivar ripe soluble solids concentration (RSSC) and ripe titratable acidity (RTA), but it did not significantly affect sensory perception of flavor, sourness and aroma by the trained panel. On two out of 51 cultivars tested, source played a role on sweetness perception. In all of these cases, when source fell out of the proposed cultivar organoleptic group it could be explained by fruit being harvested outside the commercial physiological maturity (immature or overmature). The perception of the four sensory attributes was reduced to three principal components that explain 92% for peach and 94% for nectarine of the variation in the sensory characteristics of the cultivars tested. Season did not affect significantly the classification of three cultivars that were evaluated during these two seasons. By plotting organoleptic characteristics in PC1 and PC2 (~76%), cultivars were segregated into groups (balanced, robust, sweet, peach or nectarine aroma, and/or peach or nectarine flavor) with similar sensory attributes; nectarines were classified into five groups and peaches into four groups. Based on this information, we recommend that cultivars should be clustered in organoleptic groups and a development of a minimum quality index should be attempted within each organoleptic group rather than proposing a generic minimum quality index based on RSSC. This organoleptic cultivar classification will help to match ethnic preferences and enhance the current promotion and marketing programs.

Oral Session 38—Environmental Physiology Growth & Development/Cross Commodity

Moderator: L. Gene Albrigo

21 July 2005, 2:00–3:30 p.m. Room 108

Citrus Shoot Age and Flowering Potential

L. Gene Albrigo*

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Three hurricanes in Florida starting in late Summer 2004 caused severe leaf loss, which stimulated many fall shoots. Flush occurred after each hurricane and by December, shoots were 6- to 12-weeks-old when cool temperatures capable of causing flower bud induction started. To evaluate the potential for these flushes to mature buds that could be induced to flower, flushes that were stimulated on potted trees in a greenhouse were allowed to mature 4, 6, 8, or 10 weeks before moving trees to flower-inducing conditions for 6 weeks (15 °C day/10 °C night). Plants were then returned to the greenhouse, which was kept at 20 °C or higher (ambient), until buds sprouted. Only 1% of sprouting buds on shoots that matured for 4 weeks had flowers. In shoots that matured for 6 weeks, 18% of sprouting buds had flowers. After 8 weeks of growth, 57% of the buds that sprouted were flower buds, while after allowing 10 weeks for shoots to mature, induction resulted in 76% of the sprouting buds producing flowers. Consequently, 8 weeks of development were necessary for citrus shoots to develop mostly mature buds that responded to flower inductive conditions. This is about the same amount of time required for new citrus leaves to fully mature.

The Implications of Temperature and Mesophyll Response Functions in a Biochemically-based Model of Photosynthesis: Effects on Whole Crown Carbon Exchange Estimates

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The estimate of the photosynthetic response to temperature is important for accurate growth predictions in process-based models designed to respond to broad variation in environmental conditions. Several studies have attempted to decipher the temperature and mesophyll response functions for use in the widely used Farquhar et al. (1980) biochemically based photosynthesis model. Unfortunately, published values of Rubisco kinetic properties (K_c and K_o) differ among species. To compound the problem, the methodology used to estimate K_c and K_o has not been consistent. We compared the variation in carbon gain estimates of a whole tree by incorporating the different temperature parameter estimates of Bernacchi et al. (2001, 2003) and Medlyn et al. (2002) into a three-dimensional biological process-based model. In addition, we also investigated the contribution of mesophyll conductance by incorporating Rubisco enzyme kinetics parameters reported by Bernacchi et al. (2002). Temperature parameters substantially influenced our whole tree carbon gain estimates. The variation among model estimates of aboveground net carbon gain was ≈11% for 3-year-old red maple saplings. Variation was even greater when mesophyll conductance was incorporated. The different parameter estimates, if not validated at the whole plant scale, can introduce inaccuracies and exacerbate carbon gain estimates of single plants, stands of plants, and entire ecosystems.

Photosynthetic Response of Carrots to Varying Irradiances, CO_2 Concentrations, Moisture, and Nutrition

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Genotypes and environmental parameters interactively act on plants and modify their yield responses through modifying photosynthetic processes. In order to optimize yield, it is critical to understand the photosynthetic behavior of the crop as altered by genotypes and environment. Leaf gas exchange parameters of carrot (*Daucus carota* L.) cultivars Cascade, Carson, Oranza, and Red Core Chantenay (RCC) were examined in response to various irradiances, fertility levels, moisture regimes, and to elevated CO_2 concentrations. Leaf net photosynthetic rate (P_N), stomatal conductance (g_s), and transpiration rate (E) were measured. Cultivars responded similarly to increasing *PAR* and CO_2 concentrations and did not differ in photosynthetic parameters. Increasing *PAR* from 100 to 1000 $\mu mol \cdot m^{-2} \cdot s^{-1}$ increased P_N, which did not reach saturation. The g_s and E increased to a peak between 600 and 800 μ$mol \cdot m^{-2} \cdot s^{-1}$, then rapidly declined, resulting in a sharp increase in water use efficiency (WUE). Increasing CO_2 concentrations from 50 to 1050 $\mu mol \cdot mol^{-1}$ increased P_N until saturation at 650 $\mu mol \cdot mol^{-1}$. The g_s and E increased to a peak at 350 $\mu mol \cdot mol^{-1}$ and then declined. WUE increased linearly with increasing CO_2. Carrots

exposed to drought over a period of 5 days decreased P_N and E. The P_N decrease was cultivar specific. Nutrient concentrations of 0 to 400 ppm gave a similar pattern of decrease for P_N, E, and g_s. Treatment of 50 ppm had the highest P_N, E, and g_s. The WUE generally increased with increasing nutrient concentration.

Patterns of Root Growth in Grape and Apple in Relation to Shoot Phenology

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Growers plan most of their horticultural activities around certain shoot phenological stages, such as bloom, veraison, and harvest. Timing of root growth in relation to these stages of the shoot is of interest in fertilization scheduling and in understanding carbon allocation demands of the root system. With the recent use of minirhizotron root observation tubes, a much greater understanding of patterns of root growth has been made possible. In Fredonia, N.Y., 5 years of root investigation in 'Concord' grape indicate considerable variability in timing of root flushes. Root flushes could occur any time between bloom and veraison, but were generally not observed after harvest. Wine grapes in the Napa Valley exhibited similar patterns. In apple, root flushes may occur at bloom, but often not after harvest. Consequently, we rarely observed the bimodal distribution of root flushes commonly depicted in textbooks for apple and grape. Our data suggest that general perceptions of the timing of root growth may be in error.

Effect of Annual Defoliation on Yield, Juice Quality, Leaf Net Gas Exchange, Leaf Size, and Number in 'Hamlin' and 'Valencia' Orange Trees

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The effect of annual defoliation over two consecutive years on fruit yield, juice quality, leaf size, and number was examined in 11-year-old 'Hamlin' and 13-year-old 'Valencia' orange [*Citrus sinensis* (L.) Osb.] trees. Removal of up to 50% of the leaves in late November had no effect on fruit number, fruit weight, fruit yield, soluble solids yield, juice °Brix, and °Brix : acid ratio of juice in 'Hamlin' oranges. In 'Valencia' oranges, removal of up to 50% of the leaves in late March also did not affect °Brix or the °Brix : acid ratio of the juice, but decreased fruit yield and soluble solids yield. Leaf size was reduced by removal of 50% of the leaves in both cultivars. Removal of up to 50% leaves in late November had no significant influence on net CO_2 assimilation (aCO_2) of the subsequent spring flush leaves in early May in 'Hamlin' oranges, whereas aCO_2 of 'Valencia' spring flush leaves in early May increased linearly with increasing levels of defoliation in late March. The results indicate that fruit yield, fruit quality, leaf size, and number were not negatively impacted when annual defoliations did not exceed 25% of the total canopy leaf area for 'Valencia' and 'Hamlin' oranges for two consecutive years. Overall, in whole 'Hamlin' or 'Valencia' orange trees, fruit weight increased linearly with increasing ratio of leaf area to fruit, suggesting that fruit enlargement depends on available photosynthate and can be limited by leaf area.

Injuries from Mechanical Harvesting Have Little Effect on Tree Vigor and Productivity in Citrus

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The shedding of leaves, branches, flowers, and young fruit; scuffing of bark; and exposed roots that are caused by trunk or canopy shakers during harvest appears to be unavoidable, but generally does not reduce long-term yields. Nonetheless, such visible injuries have limited the widespread adoption of mechanical harvesting in Florida's citrus industry. We determined if such physical injuries caused by a properly operated trunk shaker resulted in any physiological injures or any consequent decline in vigor and productivity of well-managed, healthy citrus trees. We continuously monitored various physiological indexes in mature 'Hamlin' and 'Valencia' orange trees annually harvested by hand or by a linear-type trunk shaker with various shaking durations. Trunk shaking did not reduce return bloom, fruit set, young fruit growth, or canopy and root growth. There was a correlation between the seasonal timing of a simulated bark injury and recovery from the injury. Although some root exposure was frequently observed during trunk shaking, leaf water relations and fine root growth were unaffected. There was no difference in leaf dry weight per area and leaf nitrogen among treatments. Mechanical and hand harvesting in late season 'Valencia' during full bloom removed similar amounts of flowers. However, immature fruit were removed by trunk shaking when 'Valencia' were harvested after mid-May, and the number of young fruit removal increased with shaking duration and fruit size. The loss of young fruit for the next crop remains a major problem of mechanical harvesting in late harvest 'Valencia'.

Oral Session 39—Fruit Breeding

Moderator: Thomas M. Davis

21 July 2005, 3:00–4:15 p.m. Room 105

Cloning and Characterization of Five MADS Box Genes in Peach (*Prunus persica*)

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MADS box genes regulate most of the development processes in plants. Studying peach MADS box genes will provide insights into its flower and fruit development. Five MADS box cDNAs with complete coding regions were cloned in this study. PpMADS2 cDNA is 1116-bp long. RT-PCR analysis indicated that PpMADS2 is expressed in leaf, flower, fruit, and nutlet. PpMAD4 cDNA is 824-bp long, which is the homologue of Agamous. RT-PCR analysis indicated that PpMADS4 is expressed in the two inner parts of flower, fruit, and nutlet; and was absent in leaf and the two outer parts of the flower. This expression pattern is similar to that of Agamous gene in *A. thaliana*. PpMADS4 could promote the flowering process in *A. thaliana* tested by genetic transformation. PpMADS5 cDNA is 873-bp long, which is the homologue of SEP3. RT-PCR analysis indicated that PpMADS5 is expressed in the three inner parts of flower, fruit, and nutlet; and was absent in leaf and sepal, similar to the expression pattern of SEP3 gene in *Arabidopsis*. PpMAD6 cDNA is 1037-bp long, which is the homologue of FUL. RT-PCR analysis indicated that PpMADS6 is expressed in leaf, sepal, petal, carpel, and fruit; and was absent in stamen and nutlet. PpMAD7 cDNA is 1147-bp long, which is the homologue of SEP1. RT-PCR analysis indicated that PpMADS7 is expressed in the four parts of flower and fruit, and was absent in leaf, stamen, and nutlet. Furthermore, two SSRs were identified in the 5' UTR in the two MADS box genes, PpMADS2 and PpMADS7, respectively. The SSR in PpMAD2 was more polymorphic than that in PpMADS7 in the 39 *Prunus* accessions collected.

New Genomics Resources for Strawberry

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The past year has brought substantial progress in the development of functional and structural genomic tools for strawberry. Sequencing of cDNA library clones from the cultivated strawberry *Fragaria ×ananassa* and the diploid model species *Fragaria vesca* has provided more than 3000 new EST sequences. We have also constructed a large (~40 kb) insert genomic (fosmid) library from *F. vesca*. About 33,000 fosmid clones have been picked and spotted onto hybridization filters. Filters have been successfully probed with three single copy gene probes, one gene family probe, and chloroplast DNA (cpDNA) and mitochondrial DNA (mtDNA) probe sets. The combined cpDNA and mtDNA clone content of the library is about 11%. After correction for organelle insert content, the nuclear genome coverage of the library is about 6×. Complete sequencing of two fosmid clones identified 12 putative protein-encoding genes, four of which were organized in colinearity with the corresponding chromosomal region of *Arabidopsis thaliana*. We will sequence an additional 50 fosmid clones, and use the resulting sequence data as the basis for developing a novel marker technology, to be described. These genomic tools will provide a basis for connecting specific genes to specific traits in the octoploid, cultivated strawberry, paving the way for implementation of gene-based, marker assisted selection as a tool for strawberry breeders. Opportunity for cross-species comparisons of gene sequence and composition, as well as genome organization and linkage group structure, between *Fragaria* and other members of the economically important Rosaceae family has been significantly enhanced, thus expanding the relevance of the project results to peach, cherry, apple, rose, brambles, and many other Rosaceous species.

Candidate Gene Analysis of Internal Breakdown in Peach

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Candidate gene (CG) analysis can be an efficient approach for identifying genes controlling important traits in fruit production. Three chronological steps have been described for determining candidate genes for a trait—proposing, screening, and validating—and we have applied these to the problem of internal breakdown of peach and nectarine. Internal breakdown (IB), also known as chilling injury, is the collective term for various disorders that occur during prolonged cold storage and/or after subsequent ripening of stone fruit. Symptoms include mealiness, browning, and bleeding. Candidate genes for IB symptoms were proposed based on knowledge of the biochemical or physiological pathways leading to phenotypic expression of the traits. Gene sequences for proposed CGs were obtained primarily from the Genome Database for Rosaceae. Screening the CGs involved identifying polymorphism within a progeny population, relying mainly on simple PCR tests. Several polymorphic CGs were located on a peach linkage map and compared with phenotypic variation for IB susceptibility. A major QTL for mealiness coincided with the *Freestone-Melting flesh* locus, which itself is likely to be controlled by a CG encoding endo-polygalacturonase, an enzyme involved in pectin degradation. Further gene sequences positioned on the consensus linkage map of *Prunus* by other researchers were co-located with QTLs for IB traits. Validation of the role of identified CGs will require detailed physiological or transgenic studies.

Linkage of RAPD and SSR Markers to Thorniness and Floricane Fruiting in Blackberry

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Molecular markers have been used previously to identify linkages to important traits of interest. In this study two marker types, randomly amplified polymorphic DNA (RAPD) and simple sequence repeats (SSR), were used to find molecular markers linked to two morphological traits in blackberry (*Rubus* L. subgenus *Rubus*). Thorniness and floricane fruiting are both qualitative, recessive traits that are inherited tetrasomically. A cross of 'Prime-Jim'® × 'Arapaho' was made to create a population that segregated for the two traits. A random sample of 98 plants from a population of 200 were assayed to find molecular markers that co-segregate with the two traits. Three putative markers were identified for the floricane fruiting trait (two SSRs and one RAPD; $\chi^2 = 4.09$ to 9.99, $P < 0.001$ to 0.043). Five potential RAPD markers were found for the thorny trait ($\chi^2 = 3.88$ to 10.23, $P < 0.001$ to 0.048). Identification of markers linked to these traits could potentially be useful in marker-assisted selection.

A Modified Method for Inducing Precocious Flowering in Grape Seedlings

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Breeders of woody perennials seek to shorten the time from propagation to flowering and the turnover time between generations. Grapevines usually flower and fruit no earlier than their third season. Onset of flowering occurs when anlagen, undifferentiated primordia arising from axillary and terminal bud meristems, begin to develop into inflorescences as well as tendrils. This occurs in response to hormonal stimuli; high levels of gibberellins in juvenile tissue favor vegetative growth, whereas increased cytokinin levels in physiologically mature tissue favor reproductive growth. We modified a method developed for *Vitis vinifera* for use on grape rootstock seedlings. Exogenous applications of chlormequat and N-benzyl-9-(2-tetrahydropyranyl) adenine (PBA, a cytokinin) were used induce precocious flowering by increasing the cytokinin:gibberellin ratio, triggering anlagen to develop into inflorescences on physiologically juvenile vines. The optimum treatment was a single application of 3000 micromolar chlormequat and 250 micromolar PBA, followed by 10 subsequent daily applications of PBA alone. Lower concentrations of treatments resulted in a loss of efficacy, and higher treatment concentrations and/or longer durations resulted in phytotoxicity. Abnormalities in flower and leaf morphology were observed with all treatments. Grape rootstock seedlings are dioecious and staminate vines were more responsive to the treatments than pistillate vines. We did not observe production of hermaphroditic flowers on staminate vines. Pollen collected from flowering staminate seedlings was successfully used in crosses that produced fruit and viable seeds. The ability to induce precocious flowering in juvenile grape seedlings has many applications in grape breeding and genetic research.