

Abstracts

Contributed Papers (Poster and Oral)

ACB Orals

ACB Posters

Workshops

Colloquia

97th Annual International Conference of the American Society for Horticultural Science

Disney's Coronado Spring Resort

Lake Buena Vista, Florida, USA

23–26 July 2000

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

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

38 POSTER SESSION 1 (Abstr. 001–011) Crop Protection Monday, 24 July, 1:00–2:00 p.m.

001

Viruses Associated to Alstroemeria Varieties and Epidemiology of Tomato Spotted Wilt in cv. 'Rosario'

*Arcenio Gutierrez-Estrada¹, Emma Zavaleta-Mejía² and Gustavo Mora-Aguilera^{*2}*
¹Universidad Autónoma de Chiapas. Villa Flores, Chiapas 30470; ²Colegio de Postgraduados. Montecillo, México, 56230

Viruses associated to eight Alstroemeria varieties and the relationship of thrips density and environmental factors with Tomato Spotted Wilt (TSW) intensity as well as the TSW effect on yield were studied in 'Rosario' in Central México. Using hosts range the viruses detected were Tomato Spotted Wilt Tospovirus (TSWV), Impatiens Necrotic Spot Tospovirus (INSV), Alstroemeria Mosaic Potyvirus (AIMV), Alstroemeria Streak Potyvirus (ASV), Arabis Mosaic Nepovirus (ArMV), and Cucumber Mosaic Cucumovirus (CMV). With serology it was confirmed the presence of TSWV in 'Jubilee', 'Rosario', and 'Regina' varieties; INSV in 'Anabel', 'Jubilee', and 'Red Sunset'; and AIMV in 'Rosario', 'Red Sunset', 'Rosita', 'Yellow King', 'Jubilee', and 'Rojo Sangria'. TSWV and AIMV were found coinfecting 'Rosario' plants. Five percent of plants were serologically positive to TSWV in the first flower harvest (25 Jan.–5 Apr.), 10% in the second (12 Apr.–21 June), and third (5 July–13 Sept.), and 18% in the last harvest (23 Sept.–6 Dec.). The high-

est peak density of thrips (520 to 630 individuals per sticky trap) were registered when the maximum temperature was higher than 35 °C and the relative humidity was between 40% to 60%. However, such peak density was not correlated with a significant increase of TSW incidence. Number and quality of inflorescences and the stem growth rate were significantly higher ($P = 0.05$) in plots with asymptomatic plants than that with plants showing putative symptoms of TSW.

002

Epidemiology of Postbloom Fruit Drop in Sweet Orange cv. Valencia in Mexico

B. Reyes-Gonzalez¹, G. Mora-Aguilera*¹, S. Osada¹, D. Téliz¹, and U. Diaz²; ¹IFIT, Colegio de Postgraduados, Montecillo, México, C.P. 56230; ²CIRGOC-INIFAP, C.P. 93600 Mtz de la Torre, Veracruz, México

The temporal progress of postbloom fruit drop was characterized in North Veracruz, Mexico, in two commercial orchards with low and high management technology. A total of 200 flowers per orchard were assessed for disease incidence every 2 days during the flowering season. *Colletotrichum* isolates, putatively similar to *C. acutatum*, were obtained from diseased flowers and inoculated to *Citrus sinensis* and *Citrus latifolia* completing the Koch's postulates. The average Area Under Disease Progress Curve (AUDPC) (625 vs. 688 days, %) and final disease incidence (Yf) (68% vs. 67%) were statistically similar ($P = 0.05$) to both orchards. Epidemic rates were in the range of 0.05 to 0.16 units, with the highest variability in the high technology orchard. The total epidemic duration was 15 and 18 days for the high and low technology orchards, respectively. The highest absolute increase of disease occurred at 13 days after the beginning of flowering during the full bloom stage. The absolute increase of disease was not correlated ($P = 0.05$) with nonlagged values of relative humidity (%), maximum temperature (°C) and the number of *Colletotrichum* spores captured on a Burkard like trap. However, 5-day lagged values of spore numbers were apparently correlated with the highest absolute increase of disease. Similarly, 3- to 5-day lagged values of number of days with at least 85% relative humidity was needed to explain the main spore peaks.

003

Viruses Associated to *Alstroemeria* Varieties and Epidemiology of Tomato Spotted Wilt in the Cultivar Rosario

Arcenio Gutiérrez-Estrada¹, Emma Zavaleta-Mejía, and Gustavo Mora-Aguilera*; ¹Universidad Autónoma de Chiapas, Villa Flores, Chiapas, 30470, Mexico; ²Colegio de Postgraduados, Montecillo, México 56230

Viruses associated to eight *Alstroemeria* varieties and the relationship of thrips density and environmental factors with Tomato Spotted Wilt (TSW) intensity as well as the TSW effect on yield were studied in 'Rosario' in Central Mexico. Using hosts range the viruses detected were Tomato Spotted Wilt Tospovirus (TSWV), Impatiens Necrotic Spot Tospovirus (INSV), *Alstroemeria* Mosaic Potyvirus (AIMV), *Alstroemeria* Streak Potyvirus (ASV), *Arabidopsis* Mosaic Nepovirus (ArMV) and Cucumber Mosaic Cucumovirus (CMV). With serology, the presence of TSWV was confirmed in 'Jubilee', 'Rosario', and 'Regina'; INSV in 'Anabel', 'Jubilee', and 'Red Sunset'; and AIMV in 'Rosario', 'Red Sunset', 'Rosita', 'Yellow King', 'Jubilee', and 'Rojo Sangría'. TSWV and AIMV were found coinfecting 'Rosario' plants. Five percent of plants were serologically positive to TSWV in the first flower harvest (25 Jan.–5 Apr.), 10% in the second (12 Apr.–21 June), and third (5 July–13 Sept.) and 18% in the last harvest (24 Sept.–6 Dec.). The highest peak density of thrips (520 to 630 individuals per sticky trap) were registered when the maximum temperature was higher than 35 °C and the relative humidity was between 40% to 60%. However, such peak density was not correlated with a significant increase of TSW incidence. Number and quality of inflorescences and the stem growth rate were significantly higher ($P = 0.05$) in plots with asymptomatic plants than that with plants showing putative symptoms of TSW.

004

Thrips (*Hercinothrips femoralis*) and Two-spotted Spider Mite (*Tetranychus urticae*) Resistance of Anthurium Cultivars under Interior Conditions

Jianjun Chen*, Richard J. Henny, Lance S. Osborne, Russell D. Caldwell, and Cynthia A. Robinson; University of Florida, Mid-Florida Research and Education Center, 2725 Binion Road, Apopka, FL 32703

Potted anthurium is becoming an important indoor flowering foliage plant because of its unique attractive appearance and continuous growth and flowering under interior conditions. However, an interior environment, with controlled op-

timal temperatures and relative humidity and living plants, is an ideal niche for pest development. Pests such as thrips and two-spotted spider mite on Anthurium have been great challenges to the interiorscape industry because many pesticides have been rigorously restricted for interior use. Thus, exploiting the genetic potential of cultivar resistance may be the best approach for the control of these pests. In this study, eight of the most popular Anthurium cultivars were evaluated for their resistance to a natural infestation of thrips (*Hercinothrips femoralis*) and two-spotted spider mite (*Tetranychus urticae*) under three light levels: 4, 8, and 16 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$, temperatures of 23.8 to 26.7 °C and a relative humidity of 60%. Results indicated that significant resistant differences exist among cultivars. The cultivars most resistant to thrips were not the most resistant to mite and vice versa. Cultivars that exhibited moderate resistance to thrips were also moderately resistant to mite. Low light intensity appeared to be a factor influencing thrips infestation since control plants that grew under a light intensity of 200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ had no observed thrips damage. On the other hand, two-spotted spider mite infestation was not influenced by light intensity.

005

Coir Inhibition of Soil-borne Fungal Pathogens was Not Due to Physical Properties or Biological Agents

Stephen B. Gaul and Michael R. Evans*; Department of Horticulture, Iowa State University, Ames, IA 50011

Seedlings of *Catharanthus roseus* (L.) G. Don 'Pacifica Red' were transplanted into substrates composed of either 80% sphagnum peat or coir with the remaining volume being perlite, sand, or vermiculite. The six substrates were inoculated with *Pythium irregulare* Buisman at 0 or 50,000 oospores per 10-cm container. The containers were irrigated daily to maintain moisture levels near container capacity. No visually apparent symptoms of infection or significant differences in shoot and root fresh and dry weights were observed among the uninoculated substrates and the inoculated coir substrates. Inoculated peat substrates had an 80% infection rate and significantly reduced shoot and root fresh and dry weights as compared to uninoculated substrates. Seedlings of *C. roseus* were transplanted into pasteurized and unpasteurized substrates composed of 80% (v/v) coir or sphagnum peat with the remaining 20% being perlite. Substrates were inoculated with 0, 5000, or 20,000 oospores of *P. irregulare* per 10-cm container. No visually apparent symptoms of infection or significant differences in shoot and root fresh and dry weights were observed among the uninoculated substrates and the inoculated pasteurized coir. The inoculated pasteurized peat substrate, inoculated unpasteurized peat substrate, and the inoculated unpasteurized coir substrate grown plants had an 88% infection and a significant reduction in the shoot and root fresh and dry weights.

006

Susceptibility of Forty-six Cultivars of Lisianthus to Fusarium Crown and Stem Rot

Brent K. Harbaugh* and Robert J. McGovern; Univ. of Florida, Gulf Coast Research and Education Center, 5007 60th St. East, Bradenton, FL 34203

Fusarium crown and stem rot, caused by *Fusarium avenaceum*, is a serious disease of lisianthus, *Eustoma grandiflorum* Raf. (Shinn.). While more than 80 new cultivars of lisianthus have been released for sale in the United States in the past decade, there is a lack of information on their susceptibility to this pathogen. Forty-six cultivars of lisianthus were evaluated for resistance to *F. avenaceum*. Cultivars were grouped according to blue/purple, pink, or white colors and evaluated within their color class. Although all cultivars evaluated were susceptible to *F. avenaceum*, partial resistance was observed as indicated by differences in the length of time to symptom expression and in the frequency of diseased plants. 'Ventura Deep Blue' and 'Hallelujah Purple' (25%) in the blue group, 'Bridal Pink' (23%) in the pink group, and 'Heidi Pure White' (53%) in the white group had the lowest frequency of diseased plants at 55 days after inoculation. In 21 of the 46 cultivars, 80% to 100% of the plants expressed symptoms at 55 days after inoculation. Screening cultivars for resistance to *F. avenaceum* is the first step to breeding and developing resistant cultivars. These results also can be useful to growers who could select cultivars that express some level of resistance as an aid in management of this disease until more resistant cultivars are released.

007

Evaluation of the Spring Frost Susceptibility of Strawberry Genotypes Using Chlorophyll Fluorescence Measurements

S. Khanizadeh, J.R. DeEli*, and N. Hakam: Agriculture and Agri-Food Canada, Horticultural Research and Development Centre, 430 Gouin Blvd., St-Jean-sur-Richelieu, Québec, Canada J3B 3E6

Frost tolerance of flower buds is one of the most important characteristics of strawberry cultivars that produce fruit early or very early in the season. The objective of this study was to evaluate chlorophyll fluorescence (CF) as a suitable rapid method to assess spring frost injury of strawberry flowers. More specifically, to determine if there was a relationship between a decrease in CF and the appearance of visual symptoms (visual expression of necrosis (VEN) based on the amount of dark, damaged, and/or water soaked tissue of the pistil) due to frost. Sixty-six strawberry genotypes with varying levels of chilling susceptibility were used. The plants were grown in a greenhouse under a 16-h light period at 20–22 °C during the daytime and 16–18 °C at night. For the CF and VEN measurements, the plants were stored at –3 °C for 24 h followed by 24 h in the greenhouse. The CF measurements were made on dark-adapted tissue, using the F_v/F_m test of an OS-500 modulated fluorometer. For the VEN method, the flowers which had dark, damaged, and/or water soaked pistils were counted. The results showed that variable fluorescence (F_v) decreased as the temperature was lowered. The spring frost resistant cultivars maintained F_v at a stable level and had a smaller regression slope (β_v), whereas the susceptible cultivars showed a very dramatic decrease in F_v . The CF method gave results that correlated with the VEN results. The strong relationship between chilling tolerance determined via visual and fluorescence techniques supports the use of CF in selecting resistant spring frost selections in a breeding program. The use of CF will allow the breeder not only to select for spring frost-resistant selections independently of environmental changes, but also to select frost resistant seedlings prior to planting in the field.

008

Virulence of Entomopathogenic Fungi (Hyphomycetes) against *Anthonomus fulvipes* (Coleoptera:Curculionidae) in Organically Grown Barbados Cherry Trees: Laboratory and Field Trials

R. Lezama-Gutierrez*, J. Molina-Ochoa, O. Rebolledo-Dominguez, M. Gonzalez Ramirez, and M. Lopez-Edwards: Facultad de Ciencias Biológicas y Agropecuarias de la Universidad de Colima. A.P. 36, C.P. 28100, Tecoman, Colima, México

Virulence of several isolates of the entomopathogenic fungi *Beauveria bassiana* (Bals.) Vuill., *Metarhizium anisopliae* (Metsch.) Sor. and *Paecilomyces fumosoroseus* (Wize) Brown & Smith were evaluated on adult weevils of *Anthonomus fulvipes* Boheman at dose of 10^8 spores/mL under laboratory conditions. The study was complemented by testing one isolate each of *M. anisopliae* and *P. fumosoroseus* against adult weevils on organically grown Barbados cherry trees at dose of 2×10^{15} spores/ha. All fungi species showed high virulence against *A. fulvipes* adults, with mortality ranging from 92% to 100%. LT_{50} values varied 2.7 to 4.8 d. The *M. anisopliae* isolate 10, and the *P. fumosoroseus* isolate 1 were selected for field evaluation because laboratory insect cadavers presented the best sporulation. After applying the fungi to the trees, total weevil captures were 38, 56, and 100 for the *P. fumosoroseus*, *M. anisopliae*, and the check (untreated) plots, respectively. Statistical differences in fruit damage were detected among treatments: *M. anisopliae* and *P. fumosoroseus* treatments showed an average of 50% of undamaged fruits, whereas in the control plots presented 36% of undamaged fruits. Laboratory and field experiments suggest that entomopathogenic fungi have a potential as microbial control agents against the weevil *A. fulvipes* in organically grown Barbados cherry trees.

009

Susceptibility of Mexican Fruit Fly Larvae to Entomopathogenic Nematodes (Steinernematidae and Heterorhabditidae)

Roberto Lezama-Gutierrez*, Jaime Molina-Ochoa, Oscar L. Contreras-Ochoa, Martin Gonzalez-Ramirez, Oscar Rebolledo-Dominguez, and M. Lopez-Edwards: Facultad de Ciencias Biológicas y Agropecuarias, Universidad de Colima, Apartado Postal 36, Tecoman, Colima, 28100, Mexico

The susceptibility of third-instar larvae of *Anastrepha ludens* (Loew) to the entomopathogenic nematodes *Steinernema carpocapsae* (Weiser) (All and Tecoman strains), *S. feltiae* (Fillipjev), *S. glaseri* (Steiner) (NC strain), *S. riobrave* (Cabanillas, Poinar & Raulston), and *Heterorhabditis bacteriophora* Poinar (NC, Patronato, and Tecoman strains), was evaluated under laboratory conditions. Ster-

ile distilled water (1.0 mL) with 4000 infective juvenile nematodes were applied on 300 g of moistened sterile soil into 1000-mL pots, and 20 third-instar larvae were placed on the soil surface, 1 mL of distilled water without nematodes was applied as control. Each nematode treatment was replicated four times. After nematode application, pots were incubated at 25 °C. Mortality of larvae and pupae was evaluated 6 and 12 d after inoculation. Cadavers of larvae and pupae were dissected and examined for the presence of nematodes. Our results showed that Mexican fruit larvae were susceptible to entomopathogenic nematodes. *S. riobrave* and *S. carpocapsae* All strain caused 90% of larval and pupae cumulative mortality, *H. bacteriophora* NC strain and *S. feltiae* killed more than 80%, whereas *H. bacteriophora* Tecoman and *S. glaseri* caused a 52.5% mortality. These results suggest that the nematodes *S. riobrave* and *S. carpocapsae* All strain have a potential as biological control agents against *A. ludens*.

010

Exotherm Characteristics and Cold Hardiness Mechanisms within the Buds of Some Deciduous Fruit Trees

Pinghai Ding*¹ and Sanliang Gu²; ¹Department of Horticulture, Ag. & Life Science Bldg. 4017, Oregon State University, OR 97331-7304; ²Viticulture and Enology Research Center, 2360 East Barstow Avenue M/S VR 89, Fresno, CA 93740-8003

Exotherm characteristics of dormant apple, pear, peach, plum, grape, persimmon, and black walnut buds were investigated from late autumn to early spring. Differential thermal analysis indicated differences in the high-temperature exotherm (HTE) and low-temperature exotherm (LTE) among the fruit species and sampling dates. According to exotherm characteristics and cold hardiness, the species tested could be divided into two groups, those without LTE (apples and pear) and those with LTE (grape, persimmon, black walnut, peach, and plum). The later group with LTE could be further categorized into two sub-groups those possessing three stages of hardiness development (peach and plum group) and those with five stages of hardiness development (grape, persimmon, and black walnut). In peach and plum group HTE and no LTE could be detected in the first and last stages when bud water content was higher than 55%. The second stage both HTE and LTE could be detected when bud water content was between 40% and 50%. In the grape, persimmon, and black walnut group the first stage with only HTE was from bud formation to deep supercooling initiation when bud water content was higher than 52%. The second stage with both HTE and LTE was when bud water content was between 40% and 48%. The third stage when only LTE could be detected and bud water content was usually lower than 40%. The fourth stage was from HTE reappearance to LTE disappearance before bud swell. The fifth stage was from LTE disappearance to when only HTE could be detected. No detection of LTE in the buds of apple and pear and no detection of HTE in the buds of grape, persimmon and black walnut were both closely associated with water status in the buds.

011

Emulsions of Edible Plant Oils Reduce Fruit Decay in 'Delicious' Apples and 'Ya Li' Pears

Yousheng Duan*, Zhiqiang Ju, Liye Ju, and Aixin Guo: Fruit Research Lab, Dept. R&D, Eureka Biotechnology Co. Shandong, P.R. China

Effects of 10% plant oils (corn, soybean, peanut, canola, sunflower, safflower, rape seed, linseed, and cottonseed), 100 mg·L⁻¹ chlorine, or 100 mg·L⁻¹ chlorine plus 10% oil combinations on pathogen (*B. cinerea*, *P. expansum*, or *G. cingulata*) infection and fruit decay in 'Delicious' apples and 'Ya Li' pears were studied. None of the oils showed inhibition on spore germination of the three pathogens by in vitro test. In inoculated fruit, oil treatments did not affect incidence but reduced severity of decay after 6 months storage at 0 °C plus 7 days at 20 °C, but no difference was found among the oils at the same concentration. In non-inoculated fruit, oils reduced fruit decay to low levels (4%) even in the most severe season. Oils also maintained fruit quality attributes, reduced water losses, and controlled scald in apples and internal browning in pears. Chlorine reduced incidence but did not reduce severity in decayed fruit. Fruit first drenched with chlorine then dipped in oil emulsions without pathogen inoculation remained decay free, while control fruit developed 10% to 15% or 13% to 23% decay after 6 months at 0 °C plus 7 days at 20 °C in both apples and pears, respectively.

90 POSTER SESSION 8 (Abstr. 012–021)
Crop Protection
Tuesday, 25 July, 1:00–2:00 p.m.

012

Management of Powdery Mildew on Flowering Dogwood with Soybean Oil

Dennis E. Deyton¹, Carl E. Sams¹, and Mark T. Windham²; ¹Depts. of Plant and Soil Sciences and ²Entomology and Plant Pathology, Univ. of Tennessee, Knoxville, TN 37901

Field-grown dogwood trees in a commercial nursery were sprayed with 0%, 1%, or 2% soybean oil emulsified with Latron B-1956 at 2-week intervals from 10 June until 19 Aug. 1998. In 1999, dogwood trees were sprayed with 0%, 1%, 1.5%, 2%, or 2.5% emulsified soybean oil at 2-week intervals from 22 June until 26 Aug. The trials had treatments arranged in randomized complete-block designs with eight trees per block and six and four replications in 1998 and 1999, respectively. Disease severity of powdery mildew was estimated using the following scale: 0 = healthy, 1 < 2%, 2 < 10%, 3 < 25%, 4 < 50%, 5 > 50%, and 6 = 100% of foliage with symptoms or signs of powdery mildew. In 1998, trees sprayed with soybean oil had higher net photosynthesis rates and more caliper and height growth than control trees. Untreated trees and ≈25% of foliage infected with powdery mildew on 8 July, while trees sprayed with 1% or 2% soybean oil had about 2% of leaves infected. In 1999, the powdery mildew was already present on foliage (wet spring) when the first application of oil was made. Repeated sprays of soybean oil did not reduce the incidence of powdery mildew. Thus, soybean oil appeared to provide protective control of powdery mildew but not curative control of a heavy infestation of the fungi. Photosynthesis was increased by soybean oil for the first month of spraying in 1999, but did not differ after that. Repeated applications of even the high rates of oil did not cause phytotoxicity.

013

Investigations of Curative and Preventive Control Strategies for Fairy Ring Disease in Turfgrass

M. Fidanza¹, P. Colbaugh², H. Couch², M. Elliott⁴, and S. Davis¹; ¹Aventis Environmental Science, ²Texas A&M, College Station, Texas; ³Virginia Tech, Blacksburg, Va; ⁴Univ. of Florida, Gainesville, Fla.

Fairy ring has become a troublesome and persistent disease on golf course putting greens and other turf areas in most regions of the United States. Many basidiomycete fungi are associated with this destructive disease in turfgrass. Recent widespread epidemics of fairy ring have led investigators to examine possible management and control options. Curative approaches include topical flutolanil fungicide applications in conjunction with soil surfactants, the application of flutolanil under high-pressure injection, and the use of nitrogen fertility programs. These curative programs were effective at suppressing visual symptoms and turfgrass injury. A preventive approach evaluated repeat applications of flutolanil plus a soil surfactant prior to disease development. This preventive program was effective at eliminating visual disease symptoms on bermudagrass putting greens. Information presented will review results from field research studies conducted over the past 3 years in Florida, North Carolina, Ohio, Texas, and Virginia.

014

Effects of Preemergence Herbicides on Weeds and Eighteen Containerized Crops

Robert H. Stamps* and Daniel W. McColley, MREC, IFAS, Univ. of Florida, 2725 Binion Road, Apopka, FL 32703-8504

Five preemergence herbicides (proflam 0.5 G, proflam 65 WDG, dithiopyr 0.27 G, thiazopyr 2.5 G, and oxyfluorfen + pendimethalin 3 G) were evaluated for weed control and crop safety on 18 plants (*Acer rubrum*, *Agapanthus africanus*, *Asparagus densiflorus*, *Camellia sasanqua*, *x Cupressocyparis leylandii*, *Cycas revoluta*, *Galphimia gracillis*, *Gelsemium sempervirens*, *Illicium parviflorum*, *Lantana camara*, *Loropetalum chinense*, *Myrtis communis*, *Ophiopogon jaburan*, *Plumbago*, *Quercus virginiana*, *Rhododendron*, *Viburnum suspensum*, and *Zamia floridana*). Herbicides were applied at 1.7 kg a.i./ha, except for oxyfluorfen + pendimethalin, which was applied at 3.4 kg a.i./ha. Treat-

ments were applied twice at 4-month intervals. Untreated and weed-free controls were used to determine herbicide effects on weeds and crops, respectively. All herbicide treatments reduced weed growth (dry-weight basis) and weeding times. Major weeds were dogfennel [*Eupatorium capillifolium* (Lam.) Small], southern crabgrass [*Digitaria ciliaris* (Retz.) Koeler], yellow woodsorrel (*Oxalis stricta* L.), tasselflower (*Emilia* spp.), and hairy crabweed [*Fatoua villosa* (Thumb.) Nakai]. Based on weed dry weights, overall weed control for the first 4 months was higher for diazopyr, thiazopyr, and proflam G than for the combination treatment. At 8 months, weed growth was similar for all herbicide treatments. The combination treatment was acutely phytotoxicity to more crops than the other treatments; however, phytotoxicity varied with crop, active ingredient, and formulation.

015

Susceptibility of Atlantic White Cedar, *Chamaecyparis thyoides* (L.) B.S.P., to *Botryosphaeria* and *Seiridium* Cankers

David R. Sandrock*, Jean Williams-Woodward, and Michael A. Dirr, Dept. of Horticulture, University of Georgia, Athens, GA 30602

Five taxa of Atlantic white cedar [*Chamaecyparis thyoides* (L.) B.S.P.], 'Blue Sport', 'Okfenokee', Raulston Form, 'Emily', and 'Rachel', and one cultivar of Leyland cypress [*x Cupressocyparis leylandii* (Jacks. and Dallim.) Dallim.], 'Haggerston Grey', were screened for resistance to *Botryosphaeria* and *Seiridium* cankers. Treatments consisted of *Seiridium unicorne* (Cke. and Ell.) Sutton, *Botryodiplodia* Sacc. sp., *Fusicoccum Corda* sp. and the non-inoculated control. After 8 weeks, plants were measured for change in caliper at the wound site, change in plant height, and length and width of surface and interior cankers. *Seiridium* and *Botryosphaeria* canker development on Atlantic white cedar taxa was not significantly different than that on Leyland cypress. *Seiridium unicorne* was more pathogenic than *Botryodiplodia* sp. and *Fusicoccum* sp. on Atlantic white cedar and Leyland cypress with infection percentages of 100%, 84%, and 80%, respectively. Well-defined, sunken, resinous cankers developed on Leyland cypress plants infected with *Seiridium unicorne*, whereas Atlantic white cedar showed no visible surface canker.

016

Assessment of Insecticide Efficacy for Root Weevil Control

Robin Rosetta, Sven E. Svenson*, and Neil Bell, North Willamette Research and Extension Center, Department of Horticulture, Oregon State University, 15210 NE Miley Road, Aurora, OR 97002-9543.

In July 1999, adult stages of root weevils were established in 1-gal containers planted with *Rhododendron* 'PJM.' Each pot was inoculated with one black vine weevil, three rough strawberry root weevils, and four strawberry root weevils. On 12 July, insecticide spray treatments were applied. Treatments were evaluated for percent adult mortality at 7 and 14 days after treatment (DAT). Black vine weevils were more sensitive to the insecticides studied than either strawberry root weevil or rough strawberry root weevil. There was considerable mortality of the black vine weevils and rough strawberry root weevils in the untreated plots by 14 DAT. Talstar Flowable (bifenthrin), Alta (deltamethrin), Topside (lamda cyhalothrin), and CGA 293 343 (thiamethoxam) all gave 100% control 7 DAT. Additionally, Closure (bendiocarb) and acephate gave 75% or better control at 7 DAT. Rough strawberry root weevil had 100% mortality in only the Alta-treated plots at 7 DAT, followed by 93% and 80% mortality in Topside and acephate-treated plots, respectively. Mortality of the strawberry root weevils in the untreated plots by 14 DAT remained relatively low. Strawberry root weevils were more resistant to the applied insecticide treatments. Only Topside-treated plots had 90% or greater mortality at 7 DAT, followed by Talstar (60%), Alta (58%), and acephate (54%). Topside-treated plots had 90% or greater mortality at 14 DAT followed by Talstar (76%), Alta (68%), and Closure (60%). Combined root weevil species mortality showed highest mortality at 7 DAT in Topside-treated plots (87% or greater), followed by Alta (74% or greater), and acephate (73%).

017

Evaluating Best Management Practices for Spring Dead Spot Suppression in Bermudagrass

F. Iriarte, J. Fry*, and N. Tisserat, Division of Horticulture, Kansas State Univ., 2021 Throckmorton, Manhattan, KS 66506

Bermudagrass turf quality is commonly reduced in the transition zone by *Ophiopogon herpotricha*, a root-infecting fungus that causes spring dead spot (SDS). Fungicides applied in autumn typically result in poor to moderate disease

suppression. Earlier research has indicated that some cultural practices, including core aeration or fertilization with soil acidifying nitrogen fertilizers, may suppress SDS. Our objective was to evaluate several treatment combinations for reducing disease severity. Treatments were arranged in a split-plot design, with whole plots being aeration + verticutting, or no cultivation. Subplots within whole plots consisted of a factorial arrangement of azoxystrobin (one September application of at 0.6 kg·ha⁻¹), trinexapac-ethyl (three summer applications at 6.1 kg·ha⁻¹), and ammonium sulfate (three summer applications with N at 49 kg·ha⁻¹). After 1 year of treatment, spring turf quality was improved in all treatments that included trinexapac-ethyl. Diseased area was reduced from 34% to 21% in plots receiving azoxystrobin + trinexapac-ethyl.

018

Use of Commercial Rhizobacteria for Root-knot Nematodes (*Meloydogyne arenaria* and *M. incognita*) Management in Acerola Plants

J. Farias-Larios*, J.G. López-Aguirre, J.L. Miranda, and L.A. Bayardo-Vizcaino; Facultad de Ciencias Biológicas y Agropecuarias, Universidad de Colima, Apartado postal 36. 28100 Tecmán, Colima, México

Acerola (*Malpighia glabra* L.) is a small, red fruit that is native to the West Indies, but is also grown in South and Central America. In western Mexico, this crop is very important because acerola is the richest known natural source of vitamin C, with a content of 1000 to 4500 mg/100 g of fruit. In nursery and field conditions, acerola growth is severely affected by root-knot nematode. The objective of this study was to evaluate the use of commercial formulations of *Bacillus* spp. on root-knot nematode management. This study was carried out in the Farm Santa Clara Maria in Colima State. Acerola plants, 60 days old were used. They were grown in 3-L pots with soil, compost, and pumice stone mixture as substrate. Treatments evaluated were: 5, 10, 15 and 30 mL/pot of Activate 2001, Tri-Mat (5 mL/pot) and control, without application. Activate 2001® is a concentrated liquid in water suspension of *Bacillus chitinosporus*, *B. laterosporus*, and *B. licheniformis*. Initial nematode population was of 3,305 in 50 g of roots. Acerola plants were harvested at 30, 60, and 90 days after application. Results show that Activate 2001 at 10 and 30 mL rates reduce significantly root-knot populations in acerola plants 60 days after application with 135 and 178 nematodes/50 g of roots, respectively. Diameter stem, shoot fresh and dry weight and root production were also increased by rhizobacteria application. These results are promising and confirmed the potential of *Bacillus* as a biological agent for nematode management.

019

Effect of Fungicidal Spray Program on Resveratrol Production of Muscadine Grapes (*Vitis rotundifolia* Michx.)

J.B. Magee¹, B.J. Smith¹, and Agnes Rimando²; USDA-ARS, ¹Small Fruit Research Station, Poplarville, MS 39470; ²Natural Products Utilization Research Unit, University, MS 38677

Control of muscadine diseases is necessary to minimize yield loss and is especially important for highest quality if the berries are to be marketed fresh. Throughout the 1998 growing season, vines of five muscadine cultivars ('Noble', 'Summit', 'Coward', 'Higgins', and 'Carlos') were treated under a systematic disease control spray program; four fungicides registered for use on grapes were applied sequentially at 10- to 20-day intervals from early bloom until just before harvest. Control plants received no fungicide. The objectives of the study were to determine the effects of the spray schedule on foliage and berry diseases and to study the relationship between disease incidence and resveratrol content of the berries. Resveratrol is a phytoalexin and has been favorably implicated in cardiovascular disease and certain cancer processes. Foliar diseases were rated visually twice during the season. Berry disease ratings were made at harvest. All fungal foliage and berry diseases were significantly reduced by the fungicide treatments. Resveratrol concentrations were determined separately on berry skins, seed and pulp/juice by GC/MS. Overall, resveratrol levels in berry skins from unsprayed vines were much higher than those of sprayed vines. Concentrations varied by cultivar and within cultivar by treatment. The relationship of skin concentration and total disease score or scores of specific diseases has not been established. Seed resveratrol concentrations differed by cultivar but were not affected by the fungicide treatments. Mean concentration of seed was lower than that of skins. Accumulation of resveratrol in juice/pulp was much lower than in skins and seeds.

020

A Survey of Strawberry Inflorescence Injury Caused by Strawberry Bud Weevil, *Anthonomus signatus*

David T. Handley¹, Andrew Wheeler², and James F. Dill¹; ¹University of Maine, Highmoor Farm, Monmouth, ME 04259; ²Bates College, Maine

Three strawberry fields in Maine were surveyed to determine what level of blossom injury was caused by strawberry bud weevil: whether different orders of blossoms were effected differently; and whether injury was influenced by the location of the plants in the field. Three strawberry fields which had no insecticide applications were surveyed. A sample of 200 inflorescences were examined in four different locations in each field. The number of inflorescences in a field that had injury from strawberry bud weevil varied from 10% to 64%. Most flower clusters showing injury had one bud girdled, but many had two or more buds girdled. The tertiary and secondary order buds had the highest levels of injury, while the primary and quaternary buds had the lowest levels of injury. Location of the plants in the field did not show any obvious effects on injury levels.

021

Strawberry Fruit Phyllody Caused by Phytoplasmas

R. Jomantiene^{1,3}, J.L. Maas¹, E.L. Dally², and R.E. Davis²; USDA, ARS, ¹Fruit Laboratory and ²Molecular Plant Pathology Laboratory, Beltsville, MD 20705; ³Institute of Botany, Vilnius, Lithuania

Strawberry fruit phyllody, production of leaves and other vegetative organs from fruit tissue around achenes, has been ascribed to physiological causes due to temperature conditions during transplant cold storage, plant response to changing seasonal conditions at flower initiation time, and to phytoplasma infection. In examination of phyllod fruits from different strawberry clones and from different locations and sources, we found four distinct phytoplasmas associated with phyllody of strawberry fruit: strawberry multicapita (SM) phytoplasma (16S rRNA group VI, subgroup B), STRAWB2 phytoplasma (16S rRNA group I, subgroup K), clover yellow edge phytoplasma (16S rRNA group III, subgroup A), and a new group III phytoplasma. The SM and STRAWB2 phytoplasmas were detected in plants with phyllod fruit that also exhibited stunting and crown proliferation (SM phytoplasma) or stunting and leaf chlorosis (STRAWB2 phytoplasma). In no instances did we fail to detect phytoplasmas in phyllod fruit. To our knowledge, this is the first report to associate strawberry fruit phyllody with the presence of these phytoplasmas and to report that phytoplasmas other than those belonging to 16S rRNA group I (aster yellows group) can also be associated with strawberry fruit phyllody.

146 POSTER SESSION 15 (Abstr. 022–031) Crop Protection Wednesday, 26 July, 1:00–2:00 p.m.

022

Manipulation of the Greenhouse Microclimate to Improve the Efficacy of Entomopathogens for Control of Greenhouse Pests

J.L. Shipp and Yun Zhang*; Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON NOR 1G0, Canada

Application of entomopathogenic fungi by inundative releases has been attempted for control of a wide range of insect pests, with generally poor results. This is largely because entomopathogens are often treated as direct substitutes for chemical insecticides and applied without an adequate knowledge of their interactions with the local environment. Humidity of greater than 90% RH has long been regarded as the a critical condition for germination and infection by the spores. With both temperature and humidity controlled, greenhouse crops offer an excellent potential for pest control using entomopathogens. The long-term maintenance of >90% RH, however, is not standard practice in greenhouse production. This study explored the possibility of improving the efficacy of the fungi by temporarily changing greenhouse humidity without adversely affecting crop growth. The study included laboratory and greenhouse trials. In laboratory trials, four humidity levels of 75%, 80%, 89%, and 97.5% RH were evaluated over a 48-h period. Three commercial products of *Beauveria bassiana* were evaluated (Naturalis-O, Botanigard 22 WP, and Botanigard ES). Greenhouse pests of green

peach aphid, melon aphid, western flower thrips, whitefly, and two-spotted spider mite were used as target insects. The infection rate of *B. bassiana* was found to increase when the sprayed adult insects were exposed to higher humidity levels with the maximum infection obtained at 97.5% RH. Percent infection and difference between humidity levels, however, were formulation- and host-dependent. The highest overall control efficacy was obtained by using Botanigard ES. Botanigard ES was highly effective to adult green peach aphid, melon aphid, and greenhouse whitefly at high humidities. Effects of *B. bassiana* against biological control agents for greenhouse vegetable crops were also evaluated. Greenhouse trials were conducted in two adjacent greenhouse compartment with high and low humidity conditions for 48 h, respectively, for selected pest insects to valid laboratory results.

023

Field Evaluations of Meadowfoam Seedmeal to Control Clubroot Disease (*Plasmodiophora brassicae*) in Cruciferous Crops

Sven E. Svenson*, Robert B. McReynolds, and Wes A. Deuel; North Willamette Research and Extension Center, Oregon State Univ., 15210 NE Miley Road, Aurora, OR 97002-9543

Field evaluation of meadowfoam (*Limnanthes alba*) seedmeal as a soil amendment to control clubroot caused by *Plasmodiophora brassicae* was conducted using cauliflower seedlings and seeded mustard grown in naturally infested soils. Ionic surfactant drench was applied as a comparative treatment. Meadowfoam seedmeal (MSM) incorporation at a rate of 15,000 kg·ha⁻¹ resulted in greatest control of clubroot incidence and severity. This treatment also resulted in significantly greater fresh weight yield of cauliflower compared to controls and surfactant drench application. Some phytotoxicity symptoms were observed at high rate (30,000 kg·ha⁻¹) of MSM treatment. MSM glucosinolate products may have an important role in regulating plant-pathogen interactions.

024

Evaluation of Reflective and Cover Crop Mulches in Fresh-market Tomato Production Systems

Jeff Mitchell¹, Charlie Summers², and Jim Stapleton³; Depts. of ¹Vegetable Crops and ²Entomology, and ³Integrated Pest Management Program, Univ. of California, Davis, CA 95616

Three systems for fresh-market tomato production (transplanting into reflective mulch, transplanting into a cover crop that had been chopped and killed, and standard transplanting into fallow beds) were evaluated in two field experiments in California's San Joaquin Valley in 1999. The first study was a spring tomato planting (April) and summer (July) harvest in which a mixture of rye, triticale, and vetch was used as the cover crop mulch. The second trial consisted of a summer tomato planting (July) and fall (September) harvest in which a sorghum/sudan hybrid was used as the mulch. In both experiments, tomato plants growing over the reflective mulches accumulated significantly more biomass than did plants growing in the other production systems. These larger, more-robust plants growing over reflective mulch also produced significantly higher yield. In the summer planting, there was almost no tomato biomass accumulation in the cover crop plots due to the fact that the sorghum-sudan hybrid we chose as the cover crop turned out to be allelopathic to tomatoes when shredded and used as a mulch.

025

Pea Leafminer, a New Pest of Leafy Vegetables in Ontario, Canada

M.R. McDonald¹, M.K. Sears², T. Clarke³, J. Chapu³, and S.A. Marshall²; Depts. of ¹Plant Agriculture and ²Environmental Biology, Univ. of Guelph, Guelph, Ontario, Canada; ³Ontario Ministry of Agriculture, Food and Rural Affairs, Guelph, Ontario, Canada

A new pest of leafy vegetables was responsible for considerable reductions in marketable yield of several late-season crops in the Holland/Bradford Marsh area (44°5'N, 79°35'W) of Ontario in 1999. The pea leafminer, *Lyriomyza huidobrensis*, was present in high populations (25/sweep) in fields of celery, Asian crucifer crops, and spinach during the months of August and September. The high populations were associated with extensive leaf mining of celery, root parsley, and edible dandelion. On other crops, including spinach and flat-flowering Chinese cabbage (*Brassica chinensis* group var. *utilis*) damage consisted of stippling of the leaves, as a result of feeding and possibly oviposition, but no leaf mining. The stippling was extensive and rendered these crops unmarketable. An other Asian

crucifer, Chinese broccoli (*Brassica alboglabra*) exhibited high numbers of stipples on the leaves, but very low numbers of mines. The leaves of red beets exhibited a low incidence of mines, not enough to affect yield. This is the first report of the pea leafminer affecting field vegetables in this area and causing crop losses. Pictures of the pest and symptoms of damage to the crops will be presented.

026

The Effect of Temperature on the Development of Fusarium Stem Rot in Greenhouse Peppers in South Florida

E.M. Lamb¹, R.M. Sonoda¹, E.F. Oxman¹, and E.N. Rosskopf²; ¹University of Florida, Institute of Food and Agricultural Sciences, Indian River Research and Education Center, Fort Pierce, FL 34945; ²USDA/ARS US Horticultural Research Laboratory, Fort Pierce, FL 34945

Hydroponic greenhouse production of sweet peppers is a well-established and growing industry in South Florida. Plants are in the greenhouse from about October until June, and the long season makes disease problems particularly costly to producers. A stem rot caused by *Fusarium solani* (anamorph of *Nectria haematococca*) and previously unreported in South Florida was found on greenhouse peppers in March 1999. Black lesions occurred at nodes where the plant was pruned or fruit was harvested. Tissues above the lesion appeared normal until the lesion girdled the stem, at which point the tissues above the lesion wilted and died. Greenhouse surveys over a 4-month period suggested that environmental factors played a role in number of infected plants and lesion size. A controlled environment chamber test was conducted to evaluate the effect of temperature and cultivar on disease development and severity. Three greenhouse pepper cultivars: Cubico, Triple 4, and Kelvin, were stem inoculated with *F. solani* at the 3- to 4-week stage. Noninoculated plants were included as a control. Fifteen plants of each cultivar plus control plants were incubated at ≈35, 32, and 29 °C for 2 weeks. The test was run twice. All inoculated plants developed lesions while no control plants developed disease symptoms. Lesion length and diameter were measured for all plants and wilting associated with disease development was noted. Temperature had a significant effect on disease severity with larger lesions and more frequent wilting occurring at higher temperatures. Cultivar did not affect the development of the disease.

027

Tomato Plant Size and Fruit Yield as Affected by the Date of Symptom Appearance of Tomato Spotted Wilt Virus

Juan C. Diaz-Perez*, D. Bertrand, and D. Giddings; Department of Horticulture, Coastal Plain Experiment Station, University of Georgia, Tifton, GA 31794

Tomato spotted wilt virus (TSWV) can cause serious damage to tomato, pepper, lettuce, and other crops. The virus is transmitted by several species of thrips. The objective of this study was to determine the effect of the time (t, days after transplanting) when TSWV symptoms first appeared on tomato plant size and fruit yield. Tomato (Florida-47) plants were drip-irrigated and planted over black plastic mulch. The experiment was carried out in Tifton, Ga., during Spring 1999. High populations of thrips were detected since early stages of plant development, which resulted in a high incidence of TSWV. Plant fresh weight was significantly higher ($r^2 = 0.632$, $n = 216$) the later in plant development TSWV symptoms first appeared (i.e., with increasing t values). Total fruit production of individual plant linearly increased with increasing t values ($r^2 = 0.664$, $n = 216$). As with total fruit production, fruit marketable yield was also higher with increasing t values; however, marketable yield was significantly reduced even when plants were infected later in the season ($t > 55$ days after transplanting). Our results suggest that it is important to keep tomato plants free from TSWV as long as possible. This applies to both developing and developed plants.

028

Amaranthus dubius Interference in Sweetpotato

Maria de L. Lugo*, Carlos E. Ortiz, and Evelyn Rosa-Marquez; University of Puerto Rico, College of Agricultural Sciences, Agr. Expt. Sta., P.O. Box 1306, Gurabo, PR 00778 USA

Amaranthus dubius is a common weed in sweetpotato production throughout the Caribbean Basin. A field study was conducted in the Agricultural Experiment Station at Juana Diaz, P.R., during 1998 to determine the effect of *A. dubius* interference in sweetpotato production under tropical conditions. Interference was evaluated by using a randomized complete-block design with four replications. Plots were four 6.1-m rows divided into two sections for yield and growth determinations. Intraspecific and interspecific interference was measured for both spe-

cies. *A. dubius* was grown at 15 and 30 plants per meter of row. Plant dry weight and leaf area were determined at 3, 6, 9, 12, 15, and 18 weeks after planting (WAP). Sweetpotato yield was determined at 29 WAP. *A. dubius* growing alone reached a maximum leaf area index (LAI) of 8.5 at 12 WAP. Sweetpotato, however, did not attain maximum LAI. When grown with *A. dubius*, sweetpotato biomass was reduced at 15 WAP. This reduction was 62% and 66% for 15 and 30 *A. dubius* plants per meter of row, respectively. Sweetpotato yield in weed-free plots was equivalent to 9232 kg/ha. Yield reduction was 96% for 15 *A. dubius* per meter of row and 100% for 30 plants.

029

Synergism of Fumigant Combinations for Nutsedge Control

Chad Hutchinsor¹, Milit McGiffen, Jr.², James Sims³, and J. Ole Becker⁴; ¹Univ. of Florida/IFAS, Hastings Research and Education Center, P.O. Box 728, Hastings, FL 32145-0728; Departments of ²Botany and Plant Sciences, ³Plant Pathology, and ⁴Nematology, Univ. of California, Riverside, CA 92521-0124

As of 2005, methyl bromide will no longer be produced or imported for agricultural use in industrialized countries. The uncertain future of methyl bromide as a soil fumigant has stimulated research into the use of other soil fumigants for weed control. Laboratory experiments were conducted to determine the efficacy of methyl bromide (MB), methyl iodide (MI), propargyl bromide (PB), 1,3-dichloropropene (1,3-D), and metham sodium (MS) alone and in combination with chloropicrin (PIC) against *Cyperus esculentus* L. (yellow nutsedge). The experimental design was a randomized complete block with three replications. All experiments were repeated. Tubers were imbedded for 24 h and mixed with soil adjusted to 14% moisture (w/w). Soil/tuber samples were fumigated for 48 h with MB, MI, 1,3-D, and PIC at 0.0, 3.1, 6.3, 12.5, 25, 50, 100, and 200 μM of active ingredient. Samples were fumigated with PB and MS at 0.0, 0.8, 1.6, 3.1, 6.3, 12.5, 25, and 50 μM of active ingredient. After fumigation and venting, each soil/tuber sample was wetted and placed in a Petri plate for 5 days. Shoot emergence was recorded. Additionally, to determine synergism response with PIC, 17% PIC was added to each fumigant/rate combination. Fumigation and data collection were performed as described above. Dose-response curves were constructed to determine the effective dose to control 50% of nutsedge emergence (ED_{50}). PB and MS were the most efficacious fumigants with ED_{50} 's of 3.7 and 6.5 μM , respectively. EC_{50} values for all the fumigants were significantly lower than MB except for 1,3-D. All the fumigant-PIC combinations resulted in synergistic control of nutsedge.

030

Use of *Beauveria bassiana* for Silverleaf Whitefly (*Bemisia argentifolii* Bellows & Perring) Management in Muskmelon

J. Farias-Larios¹, M. Orozco-Santos, and N.R. Ramirez-Vazquez; Facultad de Ciencias Biológicas y Agropecuarias, Universidad de Colima, Apartado postal 36, 28100 Tecoman, Colima, México

Bemisia argentifolii is a major pest of melon crop in key production areas of Mexico. Foliar applications of chemical insecticides for their management have been ineffective. The purpose of this research was to evaluate the use of commercial formulations of *Beauveria bassiana* and different rates for biological control of silverleaf whitefly in cantaloupe melon grown under tropical conditions. Experimental plots were treated with three rates of Mycotrol ES and only an of Naturalis-L or Endosulfan as conventional insecticide. Treatments were arranged in a randomized complete-block design with four replicates. Effects of the treatments on *B. argentifolii* larval and adult populations and the amount of damage to the foliage and yield melon were recorded. There was not a significant difference between Mycotrol ES rates in nymphs and adults killed. Mycotrol ES, Naturalis and Endosulfan have a similar effect on nymphs and adults control. The nontreated control melon plants had significantly greater number of silverleaf whitefly nymphs and adults than Mycotrol ES, Naturalis-L and Endosulfan treatments. Also, marketable yield was lower for the nontreated control melon plants due to higher whitefly infestations. Results from this study indicate that *B. bassiana* use resulted in consistently lower whitefly infestations compared to the control. The field results are promising and confirmed the potential of *B. bassiana* as a microbial control agent against *B. argentifolii* in melon crop under tropical conditions.

031

Effects on the Supercooling Capacity of *Capsicum annum* L. by Epiphytic Bacteria Population

A. Rascon-Chur¹, A.A. Gardea¹, V. Guerrero-P¹, J. Martinez-T¹, C. Rivera¹, and R. Garcia²; ¹Centro de Investigacion en Alimentacion y Desarrollo, Unidad Cuauhtemoc, Apdo. Postal 781, Cuauhtemoc, Chih., Mexico; ²Centro de Investigacion en Alimentacion y Desarrollo, Unidad Culiacan, Apdo. Postal 32-A, Culiacan, Sin., Mexico

The effect of epiphytic bacteria population with different ice nucleation activity (INA) on the extent of supercooling of in vitro and leaf tissue disks of greenhouse-grown *Capsicum annum* L. plants was determined. Bacterial strains were isolated on PDA and King's B medium from foliar samples of weeds from commercial apple orchards in Cuauhtemoc, Chihuahua, Mexico. Bacteria were screened by colony morphology, fluorescence under UV light, while grown on King's B medium plates and screened for ice-nucleating capability at -5°C in suspensions of 10^8 cfu/mL. Ice nucleating (Ice+) and non-ice-nucleating (Ice-) active strains with fluorescent capacity were isolated from symptomless leaf samples. Four bacterial strains were used with different ina as epiphytic population models. Two *Pseudomonas syringae* strains, Pss29A and PD, from Oregon State Univ., with high Ice+ capability; *P. fluorescens* A-506, in its Blight BanTM commercial lyophilized presentation; and UC001, a native fluorescent strain from CIAD-Cuauhtemoc; both Ice- strains. Freezing tests were carried out under controlled conditions. The high Ice+ strains Pss29A and PD increased the temperature of supercooling 2 and 1 $^{\circ}\text{C}$ compared to control samples. The non-inoculated tissue showed damage over 50% at -3°C and below. Inoculated tissue with Ice+ strains (*P. syringae* 29A and PD), showed damage superior to 50% at -1 and -2°C , respectively. Conversely, at none of the temperatures assayed, Ice- strains surpassed 50% damage. These results are of interest for further development of passive strategies towards minimizing damage due to low-temperature exposure of tropical vegetable crops.

39 POSTER SESSION 2 (Abstr. 032-048)

Genetics/Breeding/Biotechnology

Monday, 24 July, 1:00-2:00 p.m.

032

Co-transformation with Two Vectors and Regeneration of Transgenic Plants on the Base of High-efficient *Agrobacterium*-mediated Gene Transfer in Grape Embryogenic Cell Suspension

Violeta Colova-Tsolova¹, Rachel Gollop², Sharon Farchie², Sylvie Ever², Nahman Shaha², and Avi Per²; ¹Florida A&M University, Center for Viticulture, Tallahassee, FL 32307; ²ARO Volcani Center, Dept. Tree Fruit Breeding & Molecular Genetics, P.O. Box 6, Bet Dagan, 50 250, Israel

Embryogenic cell suspension was developed from in vivo anthers of seedless grape cv. Sugarone. *Agrobacterium* genetic co-transformation was realized with two vectors carried respectively two different reporter genes: *hpt* and *npIII*, and three (1+2) agronomically beneficial genes encoding for proteins that are involved in fungus disease resistance. The efficiency of transformation procedure and integraton of foreign genes was verified by histochemical assay as a first step after insertion in embryogenic suspension two different constructs with *Gus*-reporter gene under control of different promoters. PCR assay and Southern blot analysis were used to confirm the co-transformation in regenerated grape plants.

033

Improved Seed and Embryo Development of Seedless Grapevine by Plant Growth Regulators

Hiroshi Iwanami¹, Nobuyuki Hirakawa², Hiroyasu Yamane³, and Akihiko Sato⁴; ¹Apple Research Center, National Institute of Fruit Tree Science, Ministry of Agriculture, Forestry and Fisheries, Shimokuriyagawa, Morioka 020-0123, Japan; ²Fukuoka Agricultural Research Center, Chikushino, Fukuoka 818-8549, Japan; ³National Institute of Fruit Tree Science, Ministry of Agriculture, Forestry and Fisheries, Fujimoto, Tsukuba 305-8605, Japan; ⁴Persimmon and Grape Research Center, National Institute of Fruit Tree Science, Ministry of Agriculture, Forestry and Fisheries, Akitsu, Hiroshima 729-2494, Japan

Crosses between seedless cultivars had been conducted to produce seedless table grape efficiently by combining with ovule and embryo culture in *Vitis vinifera* L. But very few plants grew normally in this method. Four plant growth regulators (Cycocel, B-Nine, Uniconazole-P, Ethrel) were applied to shoots 4 weeks before anthesis to develop the seeds of two seedless cultivars 'Flame seedless' and 'A1706'. Correlation was significant in each cultivar between the shoot length at anthesis and the number of seed traces per berry in all combined treatments. Analysis of covariance revealed that the number of seed traces per berry was significantly higher when the shoots were applied with Uniconazole-P (240 ppm) than B-nine (2000 ppm), Cycocel (500 ppm) and Ethrel (400 ppm) in 'Flame seedless' and Uniconazole-P and B-nine than Ethrel in 'A1706'. Ovules of these two seedless cultivars crossed with seedless cultivar 'Perlette' after the application of four plant growth regulators were cultured on half-strength MS medium with 10 μ M IAA and the percentage of developed embryos in ovules was higher when the shoots were applied with Uniconazole-P and B-nine than Cycocel, Ethrel in 'Flame seedless' and B-nine than others in 'A1706'. These results indicate that the use of certain plant growth regulators promotes the embryo development.

034

Resistance to Root-knot Nematode in *Vitis champinii*

Peter Cousins* and M. Andrew Walker; USDA-ARS, Plant Genetic Resources Unit, Cornell Univ., Geneva, NY 14456; Dept. of Viticulture and Enology, Univ. of California, One Shields Ave., Davis, CA 95616

The grape *Vitis champinii* Planchon is one source of nematode resistance in grape rootstocks. Several selections valued for their resistance to the root-knot nematode (*Meloidogyne incognita*), a serious pest of grape production, are used as rootstocks and in rootstock variety development. However, *V. champinii*-based rootstock varieties are faulted for their excess vigor and susceptibility to other root pests. Root-knot nematode populations with the ability to damage important *V. champinii*-based rootstocks have been identified and may become more common. Other *V. champinii* accessions might be sources of nematode resistance genes with different specificities or might have more suitable horticultural characteristics than *V. champinii* varieties in commercial use. Nine *V. champinii* accessions from the National Clonal Germplasm Repository, Davis, Calif., and a *V. champinii* rootstock variety were screened for resistance to *M. incognita*. Resistance was assessed by counting eggs produced per root system. Eight of ten *V. champinii* accessions did not support nematode reproduction. Susceptible accessions supported lower nematode reproduction than susceptible *V. vinifera* control varieties. Progeny testing from crosses of resistant and susceptible accessions suggests that a dominant and a recessive gene may condition root-knot nematode resistance.

035

Effectiveness of RAPD Markers at Distinguishing Somaclonal Variants of Strawberry Derived from Meristem Tip Culture

Stan C. Hokanson, Kelvin G. Grant, Elizabeth L. Ogden, and Lisa J. Rowland*; USDA-ARS, Fruit Laboratory, Beltsville Agricultural Research Center, Beltsville, MD 20705

Commercial strawberry plantings in the mid-Atlantic region are often quickly infected with one or more aphid-transmitted viruses, resulting in the loss of plant vigor, stunting, lowered yields, etc. To produce virus-free plant material for the strawberry industry and for cultivar development programs, heat therapy and/or meristem tip culture protocols are generally employed. One of the problems associated with meristem culturing is the potential for somaclonal mutations to occur in the meristem or surrounding proliferating tissue. As a result, distinct "bud lines" displaying functionally insignificant to distressingly high levels of phenotypic variation can arise from individual meristems. It would be desirable to differentiate these off-types by genetic fingerprinting to maintain trueness-to-type. Randomly amplified polymorphic DNA (RAPD) markers were evaluated for the potential to differentiate six pairs of strawberry bud lines that exhibit slight to fairly extreme levels of phenotypic variation. Reproducible RAPD marker profiles were generated using 10 primers in amplification reactions with genomic DNA obtained from multiple extractions. While five of the bud line pairs remained indistinguishable, three primers distinguished two variants of the Mohawk cultivar that are now in existence in the strawberry industry. Results suggest that typical somaclonal variation produced in the meristem culture process is of a magnitude that is not readily detectable with the RAPD protocol. The two Mohawk lines were probably produced by a higher magnitude mutation event than generally occurs or a cultivar mix-up.

036

Antioxidant Capacity and Anthocyanin and Phenolic Content of Highbush Blueberries of Different Maturities

W. Kalt*, C. Lawand, and C.F. Forney; Agriculture and Agri-Food Canada Research Centre, Atlantic Food and Horticulture Research Centre, 32 Main St., Kentville, Nova Scotia, B4N 1J5, Canada

Highbush blueberry (*Vaccinium corymbosum*) fruit of the cultivars 'Bergitta', 'Bluegold', and 'Nelson' were harvested at six stages of maturity and evaluated for their antioxidant capacity and anthocyanin and phenolic content. Fruit of the four earliest maturities were also stored at 20 °C for up to 8 days. At the time of harvest, fruit of different maturities had substantial differences in their anthocyanin content, and less marked differences in phenolic content and antioxidant capacity. Substantial anthocyanin synthesis occurred in under-ripe fruit during 20 °C storage, and varied depending on fruit maturity at harvest. Total phenolic content changed very little during storage, and there was no change in fruit antioxidant capacity. The results suggest that anthocyanin phenolics are formed on or off the plant, primarily from other pre-existing phenolic components. Whether phenolics are present as anthocyanins or other colorless forms, has relatively little impact on antioxidant capacity.

037

In Vitro Plant Regeneration for 'Marion' Blackberry

Rengong Meng*^{1,2}, Tony H.H. Cher², and Chad E. Finn^{1,2}; ¹USDA/ARS HCRL, 3420 NW Orchard Ave., Corvallis, OR 97330; ²Dept. of Horticulture, 4017 ALS, Oregon State Univ., Corvallis, OR 97331

'Marion' is the most important blackberry cultivar in the world, primarily due to its outstanding processing characteristics. Ideally, 'Marion' could be enhanced via transformation while maintaining its fruit quality. As a successful in vitro regeneration is the prerequisite for genetic transformation, a series of experiments were conducted to optimize the conditions for in vitro regeneration for 'Marion' blackberry. Parameters studied included types (three cytokinins: BA, kinetin, and zeatin; four auxins: IBA, IAA, NAA, and 2,4-D) and concentrations of plant growth regulators, explants (leaf and petiole), medium formulations (MS, WPM, and BMM), and the duration of TDZ pretreatment (3 to 6 weeks) of in vitro-grown stock plants. The highest shoot regeneration rate (65.7%) and highest number of shoots (5.1 shoots/explant) were obtained under the following conditions: stock plants were pretreated with TDZ (1 mM) for 3 weeks, followed by leaf explants dark pretreatment for 1 week on the regeneration medium (WPM with 5 mM BA and 0.5 mM IBA). After dark treatment, regeneration plates were placed under 16-h photoperiod at light intensity of $\approx 50 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ at 23 ± 2 °C for 4 weeks.

038

Development of SCARs for DNA Fingerprinting of Cranberry

James Polashock and Nicholi Vorsa*; Rutgers Blueberry/Cranberry Research Center, 123A Lake Oswego Road, Chatsworth, NJ 08019

We have used RAPDs (Randomly Amplified Polymorphic DNAs) to successfully fingerprint cranberry. Although this method is simple and inexpensive, disadvantages include limited reproducibility in other labs and it is not easily computer-analyzed. RAPDs can also be labor-intensive because multiple primers are required to adequately fingerprint a single sample. As an alternative, we have utilized a method called SCARs (Sequence Characterized Amplified Regions). Clear polymorphic RAPD markers were cloned and sequenced. Primers were designed to amplify each polymorphic band and contained the original 10-mer RAPD primer sequence and 10 to 12 additional "clone-specific" bases. Primer sets were tested on eight common cranberry cultivars to determine if the desired polymorphic marker was amplified. The success rate of developing good primer sets was $\approx 25\%$. The most common problem was loss of polymorphism, suggesting that selectivity was contained within the original 10-mer RAPD primer. The amplification of many similarly sized markers, suggesting the primer set amplified a repeat region, was another problem. Useful primer sets were multiplexed in PCR reactions to establish a "fingerprint." The SCARs system we developed to fingerprint cranberry is powerful enough to distinguish individual clones in both crosses and selfed progeny. To further simplify the system, computer automation for detection and analysis using fluorescently labeled primers is underway. One problem we are addressing is reduced product in the labeled multiplex reactions. Reduced product yield is presumably because the dye molecule (Cy5) is very large and may reduce primer binding and/or polymerization efficiency. This problem has been somewhat alleviated using a patented form of Taq DNA polymerase.

Hardy Actinidia Genetic Resources at the Corvallis Repository

Kim E. Hummer*, USDA ARS NCGR, 33447 Peoria Rd., Corvallis, OR 97333

In 1999, the National Clonal Germplasm Repository at Corvallis, Ore., was assigned to preserve the hardy *Actinidia* Lindl. resources for the U.S. Dept. of Agriculture, Agricultural Research Service, National Plant Germplasm System. The fuzzy kiwifruit [*A. deliciosa* (A. Chev.) C. F. Liang et A. R. Ferguson] and other less cold-hardy *Actinidia* species, remain at the Davis Repository. The hardy *Actinidia*, commonly called Chinese gooseberries or hardy kiwifruit, encompass two taxonomic sections, Leiocarpae and Maculatae, and include about 13 described species. These perennial vines are natives of Asia and have been developed and cultivated in Lushan, Wuhan, and Guilin, China; Motueka, New Zealand; Kagawa Prefecture, Japan; Vladivostok, Russia; and California, Maryland, Michigan, Minnesota, New Hampshire, and New York in the United States. Thus far, the Corvallis Repository has established representatives of six species, *A. arguta* (Siebold & Zucc.) Planch. ex Miq., *A. callosa* Lindl., *A. kolomikta* (Maxim. & Rupr.) Maxim., *A. melanandra* Franch., *A. polygama* (Siebold & Zucc.) Maxim., *A. purpurea* Rehder and 60 cultivars. These clones will be preserved as potted plants under screen. They will also be fruited and evaluated as trellised plants in the field. The repository plans to expand the species diversity of the collections. Plant requests for dormant scionwood or spring softwood cuttings are available by contacting the Corvallis Repository Curator.

040

Identification of *Itea virginica* Cultivars using DNA-based Techniques

Jon T. Lindstrom* and Matthew C. Peltó, Department of Horticulture, University of Arkansas, 316 Plant Sciences Bldg., Fayetteville, AR 72701

Itea virginica (Virginia Sweetspire) is a woody landscape shrub that has recently gained much popularity in the landscape. Several cultivars of *Itea* have been selected for fall leaf color and plant habit. Visual identification of some of these cultivars is difficult and confusion exists in the trade. RAPDs (randomly amplified polymorphic DNA) were used to identify *Itea virginica* cultivars. A single 10-base primer was sufficient to separate the cultivar Saturnalia from the cultivar Henry's Garnet. Two dwarf cultivars of *I. virginica*, 'Merlot' and 'Sprinch' (= Little Henry), were separable from 'Henry's Garnet' using a single 10-base primer. A primer that distinguishes between these two dwarf cultivars has not yet been found. The technique of RAPDs appears sufficiently sensitive and repeatable to resolve questions of identity that may exist among several cultivars of *Itea*.

041

Dehydrins as Drought-stress Mechanisms in Leaves of Red Maple and Seaside Alder

Carol M. Foster* and William R. Graves, Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Desiccation damage in ornamental plant species is of particular concern to the nursery and landscape industry. Species in two genera, *Acer* and *Alnus*, display fundamental differences in how drought affects leaves. The same soil moisture content that causes foliar desiccation and abscission in *Alnus maritima* (Marsh.) Nutt. (seaside alder) causes neither response in *Acer rubrum* L. (red maple). Understanding molecular mechanisms associated with plant response to drought stress can be an important factor in developing strategies for improved sustainability in urban landscapes. Our objective was to characterize expression of drought-induced dehydrin genes in leaves of 'Red Sunset' red maple (desiccation-resistant) and seaside alder (desiccation-sensitive) in response to dehydration and rehydration. Potted cuttings grown in a glasshouse were subjected to four cycles of drought and rehydration. Stomatal conductance and volumetric moisture content of rooting medium were used to determine when drought cycles ended. During the second and fourth cycles, leaves were sampled for RNA and protein extraction. Dehydrin probes were generated from genomic DNA of both species by using PCR with primers designed from conserved regions in dehydrin genes. Southern blot analyses revealed the presence of dehydrin genes in seaside alder and red maple genomes. Reverse transcriptase (RT)-PCR was used to isolate desiccation-induced dehydrin cDNAs from total RNA extracted from drought-stressed leaves. The cDNA clones show 61% to 66% identity at the nucleic acid level with dehydrin genes of soybean, sunflower, radish, and potato. Accumulation of dehydrin transcripts and proteins in leaves in response to dehydration and rehydration are being studied through northern and western blot analy-

ses, respectively. Our results may lead to a rapid screening technique for seedlings with improved mechanisms of drought resistance.

042

Efficient Transformation of Elite Aspen Hybrids

Wenhao Dai*, Zong-Ming Cheng, and Wayne Sargent, Dept. of Plant Sciences, North Dakota State Univ., Fargo, ND 58105

A high-efficiency regeneration/transformation system was developed for three elite aspen hybrids (*Populus tremuloides* x *P. tremula*, *P. tremuloides* x *P. davidiana*, and *P. x canescens* x *P. grandidentata*). On both modified MS medium for aspen (MSA) and Woody Plant Medium (WPM) supplemented with zeatin (2.0 mg/L) and NAA (1.0 mg/L), nearly 100% leaf explants formed calli, of which 80% to 100% regenerated into shoots on both media with 2.0mg/L zeatin and 0.01 mg/L TDZ. Bacterial concentration, pH value of the co-cultivation medium, and acetosyringone were evaluated for enhancing transformation efficiency. Agrobacterial concentration at 1.0 Absorbance at OD600 was better than at 0.1, 0.5 Abs, yielding 80% and 75% of callus induction rates from agrobacterium harboring CaMV35s and Heat shock promoter constructs, respectively. The pH of co-cultivation medium, ranging 5.0 to 5.9, did not have any effect on transformation frequency. Acetosyringone was added to the co-cultivation medium and/or to the callus induction medium, the induction of kanamycin-resistant callus increased from 70% to 80% to 90% to 100%, and the size of callus also increased. Acetosyringone had no effect on shoot regeneration from kanamycin-resistant calli. Regenerated aspen shoots were screened on the kanamycin-containing medium, and confirmed by GUS histochemical assay. The GUS-positive plants were further confirmed by polymerase chain reaction, showing that the *npIII*, *uidA*, and *rolB* genes were integrated into the aspen genomes.

043

Interspecific Hybridizations between the Native Bittersweet *Celastrus scandens* and the Introduced Invasive Species *C. orbiculatus*

Margaret R. Pooler*, Ruth L. Dix, and Joan Feely, USDA-ARS-U.S. National Arboretum, 3501 New York Ave., N.E., Washington, DC 20002

The issue of invasive plants has become a concern to a variety of groups, including environmentalists, policymakers, and nurserymen. Although many surveys of invasive plants have been made, little research on the biology of hybridization has been conducted. Bittersweet (*Celastrus*) species serve as a good model system to test the effects of interspecific hybridizations since native and introduced species are found in the U.S. The American bittersweet (*Celastrus scandens* L.) is a deciduous climbing or twining shrub native to eastern and central North America. Although the bark has been used for medicinal purposes, the plant is cultivated as a nursery crop primarily for its bright red berries. In its natural habitat, native bittersweet is also an important source of food and cover for wildlife. Over the past several decades, populations of native bittersweet have declined to such low levels that some states are considering listing it as a threatened species. One reason for the rarity of American bittersweet in the wild is thought to be competition and possibly hybridization with an aggressive introduced species, oriental bittersweet (*Celastrus orbiculatus* Thunb.), which was introduced from Asia into the U.S. in 1860 as an ornamental. This plant can form dense, tangled, impenetrable thickets or climb small trees to girdle and smother them. It has been seen in at least 21 states since it was first recorded as an escape plant in 1912. Our objective was to determine whether oriental bittersweet can hybridize with native bittersweet, thus contributing to the loss of native populations in the United States. We performed controlled pollinations using *C. scandens* as the female parent and *C. scandens* or *C. orbiculatus* as the male parent. Although the intraspecific pollinations resulted in significantly more germinating seedlings than the interspecific crosses, the seedlings from the interspecific crosses had less seed dormancy and were more vigorous and more quick to vine than the intraspecific seedlings. These results indicate that the decline of the American bittersweet may be due to interspecific hybridizations with the invasive introduced species.

044

Screening for Resistance to Azalea Lace Bug among Deciduous Azalea Progeny from a Cross between a Highly Susceptible to a Highly Resistant Genotype

Carol D. Robacker*¹ and S.K. Braman²; Depts. of ¹Horticulture and ²Entomology, Univ. of Georgia, Georgia Station, Griffin, GA 30223

Azalea lace bug, *Stephanitis pyrioides* (Scott), is a major pest on azalea. Adults and nymphs feed and oviposit on the underside of the leaves, causing a stippled appearance when viewed from above. Previous field and laboratory screenings of 17 taxa of deciduous azalea, including representatives of 11 species, have identified a range of resistance to lace bug. One of the most resistant plants observed was of the species *R. canescens*. The interveinal region on the underside of the leaves of this plant is highly pubescent. This plant was crossed to a susceptible plant of *R. viscosum* (formerly *R. serrulatum*), which was glabrous on the lower leaf surface. The resulting seeds were planted in 1996, and the seedlings were transplanted to the field in 1998. In Sept. 1999, a laboratory bioassay was conducted to determine the resistance levels of these progeny. Five cuttings, each with two leaves, were collected from each plant, including the parental genotypes. Two female lace bugs were transferred onto the leaves of each cutting and the leaves were enclosed in a plastic cup with mesh for ventilation. After 5 days, the number of live bugs and number of eggs per cutting were counted. The percent damage from feeding was estimated. To determine whether pubescence was correlated with lace bug resistance, two terminal leaves were collected from each plant, and interveinal leaf hair density was calculated. Results from the laboratory bioassays revealed a high degree of susceptibility to lace bug among these seedlings. Most of the progeny were pubescent, indicating no relationship between leaf hair density and resistance.

045

'African Beauty': A New Ornamental Camphor Basil

Mario R. Morales* and James E. Simon; Center for New Crops and Plant Products, Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 47907

'African Beauty', a new ornamental camphor basil cultivar, was developed through three cycles of selfing and selection from USDA accession PI 500942, originally collected in Zambia, Africa. 'African Beauty' was field-evaluated and compared with PI 500942 (the original population), PI 500954 (another accession from Zambia), a camphor cultivar from Companion Plants, and three other related lines in 1997 and 1998. Most commercial camphor basil plants are tall (50 to 60 cm), late-flowering, and unattractive. Our goal was to develop a new cultivar that had a short stature (≈40 cm), an early flowering, and an attractive appearance. The outcome was 'African Beauty', which has the following characteristics: plant height: 30 to 35 cm, plant spread: 50 to 55 cm, leaf length: 6.3 to 6.7 cm, days to flower: 76 days, inflorescence length: 25 cm, essential oil yield: 3 mL/100 g dw. The essential oil of 'African Beauty' is also highly aromatic, with 72% camphor, 12% camphene, and 9% limonene. The plant is a fast-growing, semi-compact aromatic plant that produces small leaves and large quantities of long and slender inflorescences that, when fully developed, curve at the tip like the tail of a cat. Blooming usually lasts from 20 to 25 days, when the plant looks most beautiful. 'African Beauty' is an attractive ornamental that would be excellent as a garden border plant, or as an indoor potted plant.

046

Database Management of the Breeding Program at the USDA-ARS Sugarcane Research Station

E.T. Stafne* and J.S. Brown; USDA-ARS, Sugarcane Research Station, Canal Point, FL 33438

A computerized relational database is an efficient and powerful way to store, retrieve, query, and manipulate data. Databases have been prevalent in the scientific community for several years but, recently, have become more immediately available. Personal computers and local area networks (LAN) have revolutionized the accessibility of shared data. At the USDA-ARS Sugarcane Field Station, a database has been created to streamline the entry and recovery of data for the breeding program using Microsoft (MS) Access 2000, a readily available and inexpensive product, which makes it highly adaptable to a variety of breeding programs. Data collection from the sugarcane breeding program has previously consisted of field books and separate computer files. This method of documentation can lead to errors and lost data, therefore a multi-user database was needed to avoid continued problems in data handling. Data entry is performed through a

series of self-explanatory forms. Once entered, data can be accessed through the LAN and easily sorted or grouped as desired or queried for items of interest. Reports can then be output as a means of storing important hard copy records. Data from stage I and stage II (the first two clonally propagated selection stages) of the breeding program have currently been included in the database, as well as the seedling stage (true seed planting). Future plans are to incorporate data from stage III and IV (the final two clonally propagated selection stages). The database also handles the Canal Point breeding collection inventory, crossing information, seed (fuzz) inventory, and pedigree tracking. This type of database has widely applicable properties that can be implemented to handle data for any crop, either agronomic or horticultural.

047

Response to Selection for Anthocyanin Pigment Concentration in Wisconsin Fast Plant Populations by University of Wisconsin Students

I.L. Goldman*; Department of Horticulture, University of Wisconsin-Madison, Madison, WI 53706

Wisconsin Fast Plants are rapid-cycling versions of various *Brassica* species amenable to a variety of genetic studies due to their short life cycle and ease of handling. I have recently developed a model system using *Brassica rapa* L. Fast Plants for teaching the cyclical selection process known as recurrent selection in the context of a course on plant breeding. The system allows for up to three cycles of recurrent selection during a 15-week semester and enables students to gain experience in planting, selection, pollination, and seed harvest during each cycle. Fourteen cycles of replicated, recurrent mass selection for high (H) and low (L) levels of anthocyanin pigment expression in hypocotyl tissue were practiced by students in Horticulture 502 during a period of four semesters. In addition to bi-directional selection; replicated unselected (D) control populations were maintained for comparative purposes. Over 14 cycles, highly significant gains and losses in hypocotyl pigment production were realized for H and L populations, respectively. Plants in D populations showed no directional response to random selection and therefore did not exhibit genetic drift. Plants in H populations exhibited production of anthocyanin pigment in organs other than hypocotyls, suggesting selection goals could be modified to include pigmentation of specific organs or whole plants. Results from this selection program suggest significant gains from recurrent selection can be visualized through student-based selection activities in the classroom.

048

Effects of Inbreeding in a "Wisconsin Fast Plants" *Brassica rapa* Population

Federico L. Iniguez Luy* and James Nienhuis; Dept. of Horticulture, Univ. of Wisconsin, 1575 Linden Drive, Madison, WI 53706

Wisconsin Fast Plants (WFP) are small, rapid-cycling *Brassica rapa* populations that were developed by Paul Williams in the Dept. of Plant Pathology at the Univ. of Wisconsin, to facilitate classroom demonstration of biological principals. WFP exist as heterogeneous populations, which have been selected for expression of different mutant phenotypes. Because of self-incompatibility mechanisms, it has been difficult to develop inbred lines of WFP via self-fertilization. Our objective was to inbreed a WFP population through full-sib mating. Genetic diversity was calculated for eight individuals from each of eight different WFP population, using 69 polymorphic RAPD (molecular marker) bands. The eight different WFP populations were randomly mated (via chain crossing) for two generations. Six cycles of full-sib mating were initiated on 130 random families. After six cycles of full-sib mating, 79 families remain. The loss of families, during the process of inbreeding, may have been due to selection or drift. However, the expectation is that genetic variance will increase. The 79 inbred families express an array of different WFP phenotypes, e.g., anthocyanin pigmentation, yellow cotyledon, plant height, and seed color at different combinations in different inbred lines.

91 POSTER SESSION 9 (Abstr. 049–069)
Genetics/Breeding/Biotechnology
Tuesday, 25 July, 1:00–2:00 p.m.

049

Thickness and Weight of Watermelon Seed Produced from a Cross Between Tetraploid and Diploid Plants

Marietta Loehrlein¹ and Dennis T. Ray²; ¹Department of Agriculture, Western Illinois University, Malcomb, IL 61455-1390; ²Department of Plant Sciences, The University of Arizona, Tucson, AZ 85721

Triploid watermelon seed are produced by crosses between tetraploid female and diploid male plants. When open-pollinated, the resultant seed can be either tetraploid due to self-pollination or triploid from pollination by a diploid. This work was done to test if triploid and tetraploid seed can be separated on the basis of seed thickness and weight. Open-pollinated seed from a 4n x 2n cross were separated by either thickness (grouped into 0.1-mm increments) or weight (5-mg increments). Seed were germinated in a greenhouse and transplanted into the field. Plants were scored as either triploid or tetraploid by use of a genetic marker system. When separated by either thickness or weight, triploid and tetraploid seed were found in essentially each size category. There were no significant differences between populations for thickness, and the mean weights were essentially equal between triploid and tetraploid seed.

050

Comparative Analysis of Cultivated Melon Groups (*Cucumis melo* L.) using Random Amplified Polymorphic DNA and Simple Sequence Repeat Markers

Jack E. Staub¹, Gennaro Fazio¹, Thomas Horejs¹, Yael Danin-Poleg², Noa Reis², and Nurit Katzi²; ¹USDA-Agricultural Research Service, Vegetable Crops Unit, Department of Horticulture, 1575 Linden Dr., University of Wisconsin, Madison, WI 53706 USA; ²Newe Ya'ar Research Center, Agricultural Research Organization, Ramat Yishay, 30095 Israel

Random amplified polymorphic DNA (RAPD) and simple sequence repeat (SSR) markers were used to characterize genetic relationships among 46 accessions in two *C. melo* L. subsp. *melo* (*Cantalupensis*, *Inodorus*) and subsp. *agrestis* (*Conomon* and *Flexuosus*) groups. Genetic distance (GD) estimates were made among and between accessions in four melon market classes [Galia, Ogen, Charentais, and Shipper (European and U.S. types)] of *Cantalupensis*, one market class of *Inodorus* (Cassaba and Honey Dew), one accession of *Conomon*, and one accession of *Flexuosus* by employing three GD estimators: simple matching coefficient, Jaccard's coefficient, and Nei's distance-D. Differences detected among 135 RAPD bands and 54 SSR bands (products of 17 SSR primers) were used to calculate GD. Band polymorphisms observed with 21 RAPD primers and 7 SSR primers was important in the detection of genetic differences. Estimators of GD were highly correlated ($P > 0.0001$; $r_s = 0.64$ to 0.99) when comparisons were made between estimation methods within a particular marker system. Lower correlations ($P > 0.001$; $r_s = 0.17$ to 0.40) were detected between marker systems using any one estimator. The GD of the *Conomon* and *Flexuosus* accessions was significantly different from the mean GD of all the market classes examined, and market classes were distinguishable from each other. Although lower coefficients of variation can be attained in the estimation of GD when using RAPDs compared to SSRs, the genetic relationships identified using these markers were generally similar. Results of RAPD marker analysis suggest that 80 marker bands were adequate for assessing the genetic variation present in the accessions examined.

051

WITHDRAWN

052

In Vitro Culture Initiation and Proliferation of *Exochorda racemosa*

Guochen Yang* and Marihelen Kamp-Glass; Dept. of Natural Resources and Environmental Design, North Carolina A&T State Univ., Greensboro, NC 27411

Exochorda racemosa is an ornamental shrub with white flowers that is spirea-like, deciduous, and hardy. The buds resemble pearls. Normally it is propa-

gated by seeds, layers, and cuttings of softwood. However, it is a slow process that takes a few years to produce a reasonable size plant for the demanding market. Our objective was to establish a successful in vitro culture and to rapidly multiply this ornamental species. Softwood explant materials were collected from a local nursery and were disinfested with 15% bleach solution and rinsed three times with sterile distilled and deionized water. In vitro cultures were established and maintained in woody plant medium (WPM) supplemented with BA at 0.1 mg·L⁻¹, 3% sucrose, and 0.7% agar with the pH adjusted to 5.8. Then shoots were transferred to the multiplication medium containing BA, CPPU, or thidiazuron (TDZ) at various concentrations. Preliminary results show that explants cultured on medium containing TDZ produced the best shoot proliferation.

053

The Origin of *Raphanus sativus* Based on the DNA Sequences from Different Organelles

Yau-Wen Yang*, Pai-Yean Tai, and Ying Chen; Institute of Botany, Academia Sinica, Taiwan 11529

There are two evolutionary pathways in the genus of *Brassica*, one is *rapa/oleracea* lineage and the other is *nigra* lineage. Based on the morphological characteristics and nuclear RAPD or RFLP markers, genus *Raphanus* was thought more closely related to *nigra* lineage than to *rapa/oleracea* lineage (Song et al., 1990; Thormann et al., 1994). RFLP data of both chloroplast and mitochondria revealed that *Raphanus* is more closely related to *rapa/oleracea* lineage (Palmer and Herbon, 1988; Warwick and Black, 1991; Pradhan et al., 1992). We have previously demonstrated that *Raphanus sativus* is more closely related to *nigra* lineage using nuclear intergenic spacer between 5S rDNA and internal transcribed spacer region between 18S and 25S rDNA. In this study, we analyzed DNA sequences from different regions of chloroplast and showed that *Raphanus sativus* was closely related to *rapa/oleracea* lineage than to *nigra* lineage. These results suggest that *Raphanus sativus* is a hybrid between *B. rapa/oleracea* and *B. nigra* lineages as proposed by Song et al (1990). The split time between these two lineages and the divergent time of *Raphanus* was also determined based on these chloroplast DNA sequences.

054

A New Fresh Market Spinach

T.E. Morelock¹, J.A. Kirkpatrick¹, D.R. Motes¹, J.C. Correll², and F.J. Daniello³; Departments of ¹Horticulture and ²Plant Pathology, University of Arkansas, Fayetteville, AR 72701; ³Texas Agriculture and Extension Service, Texas A&M University, College Station, TX 77843

The current national trends in nutrition have resulted in a very high interest in the benefits of proper diet. It is very apparent that adding foods high in antioxidants to the human diet can have drastic effects on human health by reducing the risk of cancer, cardiovascular and pulmonary disease, as well as age-related degenerative diseases. It is well-known and well-documented that spinach is one of the very best vegetables in antioxidant potential. It is high in beta-carotene (provitamin A) and is also very high in lutein (a carotenoid that is a strong antioxidant but with no vitamin A activity). Lutein has also been documented to have the potential to significantly reduce macular degeneration in humans when added to the diet on a regular basis. With these health benefits in mind the Univ. of Arkansas is releasing the spinach breeding line that has been tested as 88-310. It is a slow-growing semi-savoy that exhibits excellent color and has a moderate level of white rust resistance. It has excellent plant type, producing a very attractive compact rosette plant that is very desirable for root cut whole plants or for various types of clipped spinach. It is best-suited to both fall and overwinter production in Arkansas and for winter production in the Texas wintergarden. Seed for tests can be obtained by contacting T.E. Morelock, Dept. of Horticulture, Univ. of Arkansas, Fayetteville, AR 72701.

055

Transformation of Chinese Cabbage *Glutathione Reductase (GR)* Gene into Lettuce (*Lactuca sativa* L.) with Microparticle Bombardment

J.D. Chung¹, B.J. Lee¹, H.S. Lee², and C.K. Kim³; Depts. of ¹Horticulture ²Animal Science and Biotechnology, Kyungpook National Univ., Taegu 702-701, Korea; ³Dept. of Horticulture, Sangju National Univ., Sangju 742-711, Korea

Lettuce (*Lactuca sativa* L.) were transformed using microparticle bombardment with two different genes, *alpha-glucuronidase (GUS)* gene and Chinese cabbage *Glutathione Reductase (GR)* gene. The adventitious shoots of cotyledonary

explant from 4-day-old seedlings were formed (46.7%) in MS basal media supplemented with 5.0 μM IAA and 1.0 μM 2ip. When 1100 psi helium pressure, 9 target distance, and coating with tungsten 10 microparticles were used and explants were treated with osmoticum-conditioning medium (0.6M sorbitol/mannitol), 4 h prior to and 16 h after bombardment, it was identified by GUS assay that these conditions were the most efficient for transformation of foreign genes into cotyledon tissue of lettuce with particle bombardment. PCR confirmed that the band observed in the transgenic plants were originated from T-DNA transfer with strong hybridization. The genomic Southern analysis showed that the 1.5-kbp fragment was hybridized with radiolabeled 1.5-kbp GR probe. To know whether the expression of the GR gene can be stably maintained in the next generation, when T2 selfing seeds that were obtained from the transformed mother plants were sowed on MS medium supplemented with 200 μM kanamycin, 70% of seedlings were revealed resistance to kanamycin.

056

Genetic Evaluation of Onion-induced Antiplatelet Activity and Soluble Solids of F_3 Families Derived From a Mild by Pungent Onion (*Allium cepa*) Cross

Kathryn S. Orvis* and Irwin L. Goldman; Department of Horticulture, University of Wisconsin–Madison, Madison, WI 53706

Heart attack and stroke, a leading cause of death in the United States, have been associated with blood platelet aggregation. Onion extract inhibits blood platelet aggregation both in vitro and in vivo. Current trends toward natural foods and health remedies may point to the importance of onion-induced antiplatelet activity (OIAA). The genetic control of OIAA has yet to be revealed. One-hundred-eighty-three F_3 families were derived from a long-day mild inbred line crossed to a long-day pungent inbred line that differ by for OIAA by 67%. Families were grown in a RCB design with two replications in muck soil (Randolph, Wis.) in 1997. Extracts were made from crushing bulb tissue in a mechanical juicer. F_3 families were evaluated for OIAA and soluble solids (SS). OIAA was measured by electrical impedance aggregometry using two human blood donors. Endpoint (ohms) and slope of the aggregation curve were recorded. SS were measured by refractometry. F_3 families were significantly different for OIAA and SS ($P < 0.0001$) in the ANOVA. A strong positive correlation of 0.96 was revealed for slope of curve and endpoint across families, replications, and blood donors. This correlation has not been previously reported for onion and suggests that for these families, descriptions of OIAA based on either rate of aggregation or endpoint are functionally equivalent. Both SS and OIAA exhibit transgressive segregation in this group of F_3 families. Twenty percent exhibit OIAA stronger than the pungent parent and 5% were less than the mild parent. The family with the highest OIAA was 4-fold higher than the pungent parent of the cross, which could be useful in future onion breeding efforts. In addition, transgressive segregation in these families aids in QTL investigations for OIAA, SS and other economically important traits.

057

Hybrid Performance of Male-sterile and Pollinator Inbred Onion Lines

Christopher S. Cramer*, Jose L. Mendoza, and Joe N. Corgan; Department of Agronomy and Horticulture, Box 30003, MSC 3Q, New Mexico State University, Las Cruces, NM 88003-0003

Current emphasis of onion breeding programs has been to develop male-sterile, maintainer, and pollinator inbred lines for the production of hybrid cultivars. Five short-day, male-sterile inbred lines from the New Mexico State Univ. Onion Breeding Program were crossed to four short-day, pollinator inbred lines in all possible combinations. In addition, six intermediate-day male-sterile inbred lines were crossed with seven intermediate-day, pollinator inbred lines in all possible combinations. The resulting hybrid lines from all crosses were evaluated for maturity, bolting resistance, pink root resistance, Fusarium basal rot resistance, percentage of marketable bulbs, marketable yield, average bulb weight, and percentage of bulbs with single centers. The average performance among male-sterile and among pollinator lines within each group was determined by averaging over hybrid lines that pertained to the respective male-sterile or pollinator line. Among the short-day inbred lines, NMSU 97-28-2 and NMSU 97-109-2 as female parents produced the best hybrid lines, while NMSU 96-17-1 and NMSU 96-51-1 as male parents produced the best hybrid lines. The best hybrid combinations among the short-day parents were NMSU 97-28-2 x 96-17-1 and 97-46-2 x 96-51-1. Among the intermediate-day inbred lines, NMSU 96-

196-2 and 96-300-2 as female parents produced the best hybrid lines, while NMSU 96-280-1, NMSU 96-274-1 and 96-395-1 as male parents produced the best hybrid lines. Some of the best intermediate-day hybrid combinations included NMSU 96-300-2 x 96-335-1 and NMSU 96-300-2 x 96-274-1.

058

Variation in β -carotene and Total Carotenoid Content in *Capsicum* Germplasm

Marisa Wall*, Cynthia Waddell, Paul Bosland, and Stephanie Walker, Dept. of Agronomy and Horticulture, New Mexico State Univ., Las Cruces, NM 88003

The β -carotene and total carotenoid content of different *Capsicum* fruit types and species were analyzed using HPLC. This information is useful for breeding high carotenoid chiles (New Mexican type) for the food industry, and also provides nutritional data for the range of fruit types within the *Capsicum* genus. Fresh fruit from 25 accessions and dried fruit from 39 accessions were evaluated in 1996 and 1997. β -carotene levels varied from 0 to 16.6 mg/100 g fresh weight, and carotenoid levels were from 0.1 to 89.6 mg/100 g in red ripe fruit in 1996. The range of values for β -carotene was similar in 1997, but a wider range in total carotenoids (0.4 to 117.3 mg/100 g fresh weight) was observed. Fresh fruit (100 g) of the cultivars 'Greenleaf Tabasco', 'Pulla', 'Guajillo', 'NuMex Conquistador', 'Ring-O-Fire', and 'Thai Dragon' contained greater amounts of β -carotene than the RDA for vitamin A for the average adult. For dried *Capsicum* entries, New Mexican, aji, pasilla, ancho, and guajillo types had the highest levels of β -carotene. In 1996, β -carotene levels among the dried *Capsicum* germplasm ranged from 0 to 739.2 $\mu\text{g/g}$ dry weight, and carotenoid levels were from 21.3 to 6,225.9 $\mu\text{g/g}$. Values were higher in 1997, and ranged from 23.7 to 1,198.1 $\mu\text{g/g}$ dry weight for β -carotene and from 76.9 to 10,120.6 $\mu\text{g/g}$ for total carotenoids. A pasilla type (*C. annuum*) had the highest total carotenoid content among the dried entries in both years.

059

Molecular Markers Linked to the *Ur-6* Gene Controlling Specific Rust Resistance in Common Bean

Soon O. Park*¹, Dermot P. Coyne¹, and James R. Steadman²; ¹Dept. of Horticulture, ²Dept. of Plant Pathology, Univ. of Nebraska, Lincoln, NE 68583

Bean rust, caused by *Uromyces appendiculatus*, is an important disease of common bean (*Phaseolus vulgaris* L.). The objective was to identify RAPD markers linked to the gene (*Ur-6*) for specific resistance to rust race 51 using bulked segregant analysis in an F_2 segregating population from the common bean cross pinto 'Olathe' (resistant to rust) x great northern Nebraska #1 selection 27 (susceptible to rust). A single dominant gene controlling specific resistance to race 51 was hypothesized based on F_2 segregation, and then was confirmed in the F_3 generation. A good fit to a 3:1 ratio for band presence to band absence for each of three markers was observed in 100 F_2 plants. Three RAPD markers were detected in a coupling phase linkage with the *Ur-6* gene. Coupling-phase RAPD marker OAB14.600 was the most closely linked to the *Ur-6* gene at a distance of 3.5 cM among these markers. No RAPD markers were identified in a repulsion phase linkage with the *Ur-6* gene. The RAPD markers linked to the gene for specific rust resistance of Middle American origin detected here, along with other independent rust resistance genes from other germplasm, could be utilized to pyramid multiple genes into a bean cultivar for more durable rust resistance.

060

Differential Responses of Egyptian Faba Bean Genotypes to *In Vitro* Callus Induction

F. Nekouei* and J.O. Kuti; Horticultural Crops Research Laboratory, Texas A&M University–Kingsville, Kingsville, TX 78363

Callus induction in 12 genotypes of faba bean (*Vicia faba* L.) genotypes from Egypt were examined. Cotyledon, leaf petiole, and stem explants were cultured on two basal agar media; Murashige and Skoog (MS) and Gamborg (B5). The media contained 0.5 mM 2,4-D, 0.25 mM NAA, and 30 g of sucrose/L. Calli were easily formed in B5 media and induction rate was significantly dependent on the genotype. The highest induction rates occurred mostly in genotypes from Assiut Univ., Egypt, and in a local variety 'Goya'. These callus cultures will be used for *in vitro* screening of the faba bean genotypes for tolerance to salt and drought, respectively.

Examining the *Phaseolus coccineus* Collection for White Mold Resistance

Barbara Gilmore* and James R. Myers; Dept. of Horticulture, Oregon State University, 4017 ALS, Corvallis, OR 97331-7304

White mold, (*Sclerotinia sclerotiorum*), is an aggressive pathogen of beans and is capable of inflicting devastating damage on yield. Finding resistance is a major concern to bean breeders. The scarlet runner bean (*Phaseolus coccineus*) is generally known to have greater resistance to white mold than does the common bean, (*P. vulgaris*). Since it is possible to cross these two species, we have started to examine the NPGS core collection of *P. coccineus* for resistance to this pathogen. A straw test was used to measure physiological resistance of bean stems to white mold. A rating of one equates to a small lesion, resulting from contact with inoculum, and a rating of nine describes total plant collapse. Controls that were used were two common beans, 91G, a commercially produced, blue lake type snap bean and ExRico, a small, white dry bean. The bean 91G received a straw test rating of 8.3, which correlates to a field test rating of 8.5. ExRico rated 7.4 with the straw test and had a field test score of 6.5. Within the *P. coccineus* collection we found very strong resistance, with straw test values of 1 and 2 in several individual plants and in some accessions. Accessions that had individuals that displayed the strongest resistance of all the plants tested were: PI201299, PI361302, PI406938, and PI535278. These accessions appeared to be segregating for white mold resistance. Accessions showing the best average resistance were: PI313221, PI361372, PI361539, and PI583553. Because *P. coccineus* is outcrossed, we expected to find variation within accessions for white mold resistance. Some accessions had uniformly high levels of resistance, while other accessions showed variability.

062

Development of Southernpea [*Vigna unguiculata* (L.) Walp.] Cultivars with an Enhanced Persistent Green Seed Phenotype

R.L. Fery* and J.A. Thies; U.S. Vegetable Laboratory, ARS, USDA, 2875 Savannah Highway, Charleston, SC 29414-5334

The development of southernpea cultivars with a persistent green seed color has been the subject of much interest in the U.S. horticultural industry for more than two decades because seeds of such cultivars can be harvested at the dry seed stage of maturity without loss of their fresh green color. Two genes, *gt* (green testa) and *gc* (green cotyledon), are known that condition a persistent green seed color in southernpea. The *gt* gene was identified more than 25 years ago, but cultivars containing this gene have not been well-accepted by the industry because of the frequent occurrence of discolored (brown stains) seeds. Cultivars containing the more recently discovered *gc* gene, however, do not produce the discolored seeds and are used extensively in the frozen food industry. Efforts to develop cream-, blackeye-, and pinkeye-types of cultivars containing both the *gt* and *gc* genes are nearing completion. The dry seeds harvested from candidate cultivars homozygous for both the *gt* and *gc* genes are stain free and exhibit a deeper and more uniform green color than seeds harvested from cultivars homozygous for just one of the genes. It is anticipated that newer cultivars containing both of the genes that condition a persistent green seed color will not only have an enhanced value to the frozen food industry, but will also have great potential for use in the dry pack industry.

063

Detection of Putatively Stress-activated Ty1-copia-like Retrotransposon Sequences in Virus-infected Sweetpotato [*Ipomoea batatas* (L.) Poir.] Clones

A.Q. Villordon*¹, C.A. Clark¹, R.A. Valverde¹, R.L. Jarre², and D.R. LaBonte¹; LSU Ag. Center, Louisiana State Univ., Baton Rouge, LA 70803; ²USDA-REE-ARS-SAA-PGRRCR, Griffin, GA 30223

Previous work by our group has detected the presence of a heterogeneous population of Ty1-copia-like reverse transcriptase retrotransposon sequences in the sweetpotato genome. Recently, we detected the presence of putatively active Ty1-copia-like reverse transcriptase sequences from a virus-infected 'Beauregard' sweetpotato clone. In the current study, we report the differential detection of putatively stress-activated sequences in clones from seedling 91-189. The clones were infected with different combinations of virus isolates followed by extraction of leaf RNA samples at three sampling dates (weeks 2, 4, and 6) after inoculation. After repeated DNase treatments to eliminate contaminating DNA, the RNA samples

were subjected to first strand cDNA synthesis using random decamer primers followed by PCR analysis utilizing Ty1-copia reverse transcriptase-specific primers. Through this approach, we detected amplified fragments within the expected size range (280–300 bp) from clones infected with isolates of sweetpotato leaf curl (SPLC) and feathery mottle viruses (FMV) (week 2 and 6) and FMV (week 4). We were unable to detect PCR products from the noninfected clones or the other infected samples. The data suggests that specific viruses may be involved in the expression of these Ty1-copia-related reverse transcriptase sequences. It also appears that sampling at various dates is necessary to detect putative activity over time. This preliminary information is essential before proceeding to the construction and screening of cDNA libraries to isolate and fully characterize the putatively active sweetpotato Ty1-copia-like retrotransposon sequences. Through the partial or complete characterization of sweetpotato Ty1-copia elements, sequences that correspond to cis-regulatory element(s) can be identified and further studied for their roles in responding to specific stress factors.

064

Sugars in Tropical-type Sweetpotato

Tania Hernández-Carrion, Carlos E. Ortiz*, Rafael Montalvo-Zapata, Milca I. Mercado-Olivieri, and Luis E. Rivera; Department of Agronomy and Soils, University of Puerto Rico, College of Agricultural Sciences, Agr. Expt. Sta., P.O. Box 21360, San Juan, PR 00928

Tropical-type is a general description for sweetpotato cultivars with intermediate sweetness that have light-fleshed roots. This type is commonly grown and consumed across the Caribbean Basin. Systematic efforts for the genetic improvement of the tropical-type sweetpotato have been limited. Cultivars available for being grown in Puerto Rico lack either the sweetness or attractiveness demanded by producers and consumers. Defining optimum sweetness in this type is important because this characteristic is totally dependent on the root's sugar content and cannot be modified as in processed products. The objective was to obtain data on sugar content for the development of quantitative selection criteria for sweetness. Raw, boiled and baked roots were evaluated for glucose, sucrose, fructose, and maltose. 'Mina' and 'Miguela', tropical-type cultivars widely accepted for sweetness and table quality but poor yielders were used. 'Viola', a substaple type, was the check. Sugars were detected by HPLC. Sugar-Pak (Waters) and LC-NH2 (Phenomenex) columns and a refractive index detector were used for the analyses. Across cultivars and type, sucrose (4.0% to 6.5%) was more concentrated than glucose (0.4% to 0.8%) and fructose (0.3% to 0.4%). Concentration of sucrose in the tropical type (7.7%) was higher than in the substaple type check (4.4%). Boiling or baking did not markedly change the concentration of the above sugars. Maltose was not detected in raw samples; however, both boiling and baking increased maltose concentration from 9.0% to 15.4%. In the development of a practical quantitative selection criteria for sweetness, both sucrose and maltose must be considered.

065

Genetic Stability of Potato Leafroll Virus Coat Protein Gene in Transgenic Potatoes

Hyo-Won Seo*, Jung-Yoon Yi, Young-Il Hahn, Hyun-Mook Cho, and Kuen Woo Park; National Alpine Agricultural Experiment Station, Hoengke Doam, Pyongchang, Kangwon, South Korea

Three potato (*Solanum tuberosum* L.) cultivars 'Superior', 'Irish Cobbler', and 'Jopung' were transformed by co-cultivation with tuber discs and disarmed *Agrobacterium tumefaciens* LBA4404 carrying modified vector pBI121, that contained PLRV coat protein (CP) gene and controlled by CaMV35S promoter. Putative transformants were selected and their genomic DNA and RNA transcripts were analyzed for the confirmation of genetic stability by RT-PCR, PCR, southern, and northern blot. The growth characteristics and viral resistance of progenies of transgenic potato plants were investigated. Twelve lines among the different seven-times manipulated transgenic lines were grown in greenhouse and isolates trial field. PLRV coat protein gene was stably inherited in 'Superior', but not in 'Jopung'. 'Jopung' was less stable than 'Irish Cobbler' and 'Superior' at genetic stability of PLRV CP gene. And some of these transgenic lines were highly resisted in PLRV multiplication. The yield of transformants was reduced in 'Irish Cobbler' but not in 'Superior'. Possible explanations for these types of resistance are gene silencing and positional effects of transformed PLRV CP genes and that had cultivar specificity. We consider the appearance of escaped transformants in 'Jopung' for emergence of chimeric explants from early selection stage.

066

Determination of Genetic Diversity of Potato Varieties by Random Amplified Polymorphic DNA Analysis

Hyo-Won Seo, Jung-Yoon Yi, Eung-Soo Kim, Hyun-Mook Cho, Young-Eun Park, and Kuen-Woo Park; National Alpine Agricultural Experiment Station, RDA, Hoengke Doam Pyongchang, Kangwon, South Korea*

This study was carried out to prove the new variety's originality by using Random Amplified Polymorphic DNA (RAPD) Analysis and to develop the specific markers for distinction new variety from others to database for improving the efficiency of germplasm conservation. The RAPD procedure was used to determine genetic diversity of 13 potato varieties including seven recommended varieties of Korea and six genotypes. Genomic DNAs from the 13 genotypes were amplified using PCR and URP 2F, 4R and 8R primers. URP primers which were 20-mers were received from NIAST (National Institute of Agricultural Science and Technology, Suwon, Korea) and they were shown very high reproducibility because of the high annealing temperature above 55 °C. So, they were known to be very desirable primers to examine the specificity between inter and intra species in various spectra. These 13 lines have many resemblances in plant characteristics each other because 'Jopung', '92N09-6', 'Daekwan 68', and 'Daekwan 70' were originated from 'Superior', 'Atlantic', 'Namsuh', and 'Irish Cobbler' respectively. So, there are many difficulties to distinct new variety by the naked eye. The results of this study show that 2 sets of URP primers are very useful to distinct new variety and mutants from others.

067

Analysis of Protein Expression and Resistance to Bacteria in Transgenic Potatoes with Antimicrobial Gene

Jung-Yoon Yi, Hyo-Won Seo, Ji-Hong Cho, and Kuen-Woo Park; National Alpine Agricultural Experiment Station, Pyongchang, Kangwon, South Korea*

Anti-bacterial peptide gene (shiva) was introduced into potato plants to improve the resistance to bacterial diseases. The 21 potato clones were selected in the medium containing 50 mg/L kanamycin and 13 transformants were confirmed by GUS activity assay using 4-methylumbelliferyl glucuronide (MUG) and PCR by NPTII specific primer sets. A 0.5-kb band was confirmed by PCR in the most transformants of T0, T1, and T2 generations. As a result of PCR with primer set chosen at shiva and GUS, expected 690-bp fragments were produced in the most transformants of T0, T1, and T2 generations. For southern blot analysis, potato genomic DNA digested with HindIII was separated on 0.7 % agarose gel, transferred to nylon membranes, and detected with nitroblue tetrazolium salt (NBT). As a result of southern analysis, different single bands were detected in the transformants with tPAL5 promoter and 1 to 3 bands were acquired in the transformants with CaMV35S promoter. To analysis protein level of transformants, NPTII ELISA kit were used. In several transformants, optical density (O.D.) values were 10- to 20-fold higher than non-transformants. Tubers were screened for resistance to *Erwinia carotovora* subsp. *carotovora*. The concentration of the inocula was 10^6 cells/mL. After inoculation, tuber slices were incubated aerobically for 48 h at 20 °C. The symptoms of soft rot in transgenic plants were considerably weakened in comparison with non-transformants.

068

Development of the Bacterial Disease Resistant Potatoes by Introduction of Shiva Gene

Jung-Yoon Yi, Hyo-Won Seo, Kwan-Soo Kim, Hyun-Mook Cho, and Kuen-Woo Park; National Alpine Agricultural Experiment Station, Pyongchang, Kangwon, South Korea*

Antimicrobial peptide gene (shiva) under the promoter of tomato phenylalanine ammonia-lyase (tPAL5) was transformed into potato (*Solanum tuberosum* L.) plants. Antimicrobial peptide gene was isolated originally from giant silk moth (*Hyalophora cecropia*) and modified its nucleotide sequence to increase antimicrobial activity. Phenylalanine ammonia lyase 5 (PAL5) gene was known to express highly by wounding, irradiation, and infection by pathogens. It also expresses specifically on vessel tissues of young roots, stems, and leaves. The vector with shiva and CaMV35S promoter was also introduced into potatoes. The efficiency of regeneration was maximized at the medium containing Zeatin 2 mg/L, NAA 0.01 mg/L, GA3 0.1 mg/L. Putative transgenic potato plants were cultured on the media containing kanamycin 50 mg/L. From the tissue extracts of putative transgenic plants, GUS activity was assayed using 4-methylumbelliferyl glucuronide (MUG) as a substrate for GUS enzyme. In several transformant, GUS activity was 20- to 40-fold higher than non-transformants. Especially, one clone

with CaMV35S promoter expressed \approx 400-fold higher GUS activity than non-transformants. For histochemical in situ localization of GUS activity, chromogenic substrate 5-bromo-4-chloro-3-indolyl-beta-D-glucuronide(X-gluc) was used for staining. GUS was highly expressed in the whole tissue of the transformants under CaMV35S promoter, but the other side GUS was expressed especially in the vascular tissues of stems and leaves of transformants with tPAL5 promoter. PCR was carried out at 94 °C for 20 s, 52 °C for 20 s, and 72 °C for 60 s with 45 cycles, using NPTII gene-specific primer set. PCR amplification by NPTII-specific primers confirmed 0.5-kb band in most transformants.

069

Preservation of Lettuce Seed for 30 Years: Cryopreservation Retarded Deterioration

P.C. Stanwood, L. Wheeler, and L.E. Towill; USDA-ARS National Seed Storage Laboratory, Fort Collins, CO 80521*

Long-term preservation of seed germplasm is a high agricultural priority. It assures that genetic diversity will be available for future generations for continued plant improvement. This experiment reports on the affect that storage temperature had on the viability of 65 selections of lettuce seed stored for 30 years. The average seed moisture content was $5.5\% \pm 0.5\%$ (fresh weight basis). Fresh seed samples were placed at 5 °C storage in 1969. In 1975 they were then transferred to -18 °C storage. Viability remained at $98\% \pm 5\%$ for the first 14 years of 5/-18 °C storage, then viability declined. At 17 years storage, the average viability had dropped to 75% and continued to drop at about 4%/year. At the 17-year mark, individual samples were split, one-half remained at -18 °C the other half was placed under liquid nitrogen vapor (Inv) conditions (about -150 to -190 °C). The -18 °C stored samples continued to deteriorate to 14% viability at the 30 year test period (1999). The samples placed in Inv did not decrease further in viability and remained at 75% viability at the 30-year mark. Seed vigor was reduced in the -18 °C stored seeds that were still viable. The Inv-preserved samples were significantly more vigorous. It is clear from this experiment that Inv preservation was significantly superior to -18 °C storage and, in fact, stopped or significantly reduced the rate of viability loss in samples that are rapidly deteriorating.

147 POSTER SESSION 16 (Abstr. 070-091)

Genetics/Breeding/Biotechnology

Wednesday, 26 July, 1:00-2:00 p.m.

070

Genetic Identification of *Oncidium* Varieties by RAPD Markers

*Fure-Chyi Chen*¹, Wan-Ling Wu¹, Chun-Hua Pa², Irwin Yau-Yuan Chu², and Yau-Wen Yang³; ¹National Pingtung University of Science & Technology, Pingtung, Taiwan; ²Taiwan Flower Biotechnology Co., Taiwan; ³Institute of Botany, Academia Sinica, Taiwan*

Molecular markers by random amplified polymorphic DNAs were used to evaluate the genetic variation among different *Oncidium* accessions. It is possible to distinguish different registered *Oncidium* hybrids, including Gower Ramsey, Sweet Sugar, and Taka using nine random primers. Furthermore, variation was also detected within different cultivars derived from same hybrids. For example, several cultivars of Gower Ramsey could be distinguished based on molecular markers. Based on dendrogram, the investigated cultivars were clustered into several groups. Onc. Gower Ramsey and its selected cultivars were in one group. Onc. Sweet Sugar, Onc. Taka and Onc. Sharry Baby 'Sweet Fragrance' were clustered in separate groups.

071

Partial Sequence of Ethylene Receptor Genes in Carnations with Different Ethylene Sensitivity

Masayasu Nagata, Natsu Tanikawa, and Takashi Onozaki; National Research Institute of Vegetables, Ornamental Plants and Tea, Ano, Mie, 514-2392, Japan*

The plant hormone ethylene plays an important role in the senescence process of carnation flowers. Recently, various genes that concern ethylene responses have been cloned from many sources of plants. Our main aim is to compare the

sequences of ethylene receptor genes among carnations with different ethylene sensitivities. Four carnations, 'White Sim' (ethylene sensitive control), 'Chinera' (lower ethylene sensitivity), 64-13 and 64-54 were used. The carnations temporarily named as 64-13 and 64-54 are our breeding lines with less ethylene sensitivity, thus better flower retention. Total RNA was extracted using SDS-phenol method. Putative ethylene receptor genes were cloned by RT-PCR using degenerate primers that correspond to the highly conserved regions of ETR1 and ERS genes. Two kinds of DNA fragments, ≈ 1 kb in the length encoding putative ethylene receptor genes were cloned from all samples. An ERS-type gene was cloned that is identical to the gene, known as DC-ERS2 (Accession No. AF034770). Another was ETR1-type gene, which has not been reported in carnations yet. That was 91% identical to the ETR1 gene from melon or apple at the translated amino acid level. The deduced amino acid sequences of ERS-type genes among four samples were almost the same. However there were five mutations in 'Chinera', one mutation in 64-13 and two mutations in 64-54, compared to 'White Sim' at the translated amino acid level. As they located rather conserved regions of the gene, it is expected to affect the less ethylene sensitivity of the carnations.

072

New Pepper Germplasm for Ornamental and Ornamental/Culinary Applications

John R. Stommel^{*1} and Robert J. Griesbach²; ¹USDA-ARS, Vegetable Laboratory, Plant Sciences Institute, Beltsville, MD 20705; ²U.S. National Arboretum, Beltsville, MD 20705

Ornamental peppers are a novel and growing segment of the ornamentals industry. Currently available varieties are utilized as pot plants and in bedding plant applications. Utilizing unimproved populations developed from initial crosses with Indian *Capsicum* land races, germplasm lines with unique gene combinations for multiple fruiting, fruit orientation, leaf pigmentation and leaf variegation were developed and released by USDA-ARS. Via introgression of diverse *Capsicum* species accessions and heirloom varieties into these populations, more recent efforts seek to exploit abundant genetic variation for fruit shape, size, color and pungency, foliar attributes, and plant growth habit to develop new pepper germplasm for ornamental and dual ornamental/culinary applications. Fruit pungency of selected material may range from mild to extremely pungent. Fruit shape may be round, conical, or lobed. Whereas small fruit size is generally well suited for ornamental applications, ornamental/culinary types exploit larger upright conical or small bell-shaped fruit. Plant foliage may be uniformly green in color, exhibit varying degrees of anthocyanin accumulation, or display variegation. Inheritance of selected attributes, potential barriers to development of select recombinants, and examples of representative advanced selections in the breeding program will be presented.

073

Stomatal Density as a Correlated Trait to Postharvest Longevity in *Antirrhinum majus* L. (Snapdragon)

William J. Martin^{*} and Dennis P. Stimart; Department of Horticulture, University of Wisconsin-Madison, Madison, WI 53706

Stomatal density is being investigated as a highly correlated trait to postharvest longevity (PHL) and subsequently may be used for selection in early generations of breeding germplasm. To this end, leaf imprints were created from *Antirrhinum majus* L. (snapdragon) P₁, P₂, F₁, BC₁ (F₁xP₁), BC₂ (F₁xP₂), F₂, and F₃ plants and evaluated for stomatal densities. Cut flowers of P₁, P₂, F₁, BC₁ (F₁xP₁), BC₂ (F₁xP₂), and F₃ were harvested after the first five flowers opened and evaluated for PHL. Additionally, cut flowers from these lines were evaluated for leaf surface area. Populations for evaluation were grown in the greenhouse in winter and spring 1999–2000 in a randomized complete-block design according to standard forcing procedures. Twenty-five cut flowering stems of each genotype were held in the laboratory in deionized water under continuous fluorescent lighting at 22 °C for PHL assessment. The end of PHL was defined as 50% of the flowers drying, browning, or wilting. Data will be presented on the correlation between stomatal density and PHL.

074

The Effects of Leaching and Stratification Media on *Rosa* spp.

Natalie Anderson^{*} and David H. Byrne; Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77867-2133 USA

Poor germination in *Rosa* spp. has hindered breeding programs for years. Several methods exist to increase germination of rose seed. Unfortunately no

consensus exists on the best method, or if any one method is best for all rose types. Rose seeds from a *R. wichuraiana* x Old Blush hybrid were broken into 3 replications with an average of 400 seeds per replication. Seeds were leached at room temperature with tap water for a period of 0, 3, 7, or 14 days. Constant filtration and aeration were supplied. After leaching, seeds were placed on either moist milled sphagnum moss or agar. Seeds were then placed in a cold stratification (≈ 2.8 °C) treatment for 8 to 12 weeks. Individual seedlings were planted when a root was visible. The combination of no leaching plus the moist milled sphagnum moss treatment significantly increased germination over leaching for 3 or more days and agar.

075

Effects of Temperature during Germination on the Germination and Survival of Embryo Cultured Peach Seed

David H. Byrne, Natalie Anderson^{*}, Jonathan Sinclair, and A. Millie Burrell; Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133 USA

Embryo culture techniques are employed in early ripening peach and nectarine cultivars. Generally, the embryos in these varieties are not mature by the time the fruit matures, thus rendering normal stratification procedures ineffective. In 1998 and 1999, immature embryos from multiple peach genotypes were cultured in an embryo rescue media (WPM, 3% Sucrose) at 5 °C for 45 days in the dark. Embryos were then placed under lights at either a cool temperature (18 °C in 1999 and 20 °C in 1998) or a warm temperature (30 °C in 1999 and 28 °C in 1998) treatment with a photoperiod of 12 h for germination and initial growth. After 2 to 4 weeks embryos were rated for germination, root number, and top growth. The embryos incubated at the cool temperature regime not only had better germination, but also had a higher rate of greenhouse survival.

076

Determining Gene Numbers and the Potential for Transferring Long Postharvest Longevity of *Antirrhinum majus* L. Cut Flowers to Short-lived Colored Lines

Kenneth R. Schroeder^{*} and Dennis P. Stimart; Department of Horticulture, University of Wisconsin, Madison, WI 53706

Postharvest longevity (PHL) is important in determining quality and consumer preference of cut flowers; thus, it remains a pressing problem for the florist industry. Information on genetics and heritability of cut flower PHL is lacking. This study focused on determining gene numbers and inheritance of *Antirrhinum majus* L. cut flower PHL. An inbred backcross population was generated from a yellow short-lived (YS: 6d PHL) and a white long-lived (WL: 14 d PHL) inbred. F₁ hybrids were backcrossed reciprocally three times to each parent. Parental backcross (BC) populations contained 55 to 65 lines. Lines within each BC generation were self-fertilized three generations by single-seed descent without selection to produce BC₁S₃, BC₂S₃, and BC₃S₃ generations. Cut flowers from all generations were evaluated together for PHL in deionized water. Gene numbers were estimated using confidence intervals and the proportion of non-parental BC lines. Continuous variation, estimates of a minimum of two to four genes controlling PHL, and significant environmental variation suggest selection for increased PHL would be successful, but slow. A negative correlation between PHL and yellow flower color was detected in this study. In spite of that fact, mean PHL of the yellow flowered inbred lines improved 1 to 2 d when backcrossing to YS and 3 to 4 d when backcrossing to WL without selection. Thus, inbred backcrossing to a long-lived parent with selection for flower color should make acquisition of long-lived colored lines attainable.

077

In Vitro Growth of Immature Peach [*Prunus persica* (L.) Batsch] Embryos Related to Carbohydrate Source

Jonathan W. Sinclair^{*} and David H. Byrne; Dept. of Horticultural Sciences, Texas A&M Univ., College Station, TX 77843-2133

Carbohydrate energy source of various tissue culture media has an effect on growth and survival of the explants. Sucrose is the standard carbohydrate used in most tissue culture systems. The objective of the study was to determine the effect of five carbohydrate sources (fructose, glucose, maltose, sorbitol, and sucrose) at two levels (2% and 3%) on germination, growth, and survival of immature peach embryos (9.7 to 14.7mm) in vitro. Five cultivars were used. Overall, fructose, maltose, and sucrose each stimulated germination and growth as the primary carbohydrate energy source of peach embryo culture to the same degree;

glucose and sorbitol were inferior. However, fructose was superior to sucrose in one cultivar. In general, sugar level did not affect survival, although cultivars did vary somewhat. Survival was found to be highly dependent upon embryo maturity.

078

New Dwarf Cultivar, 'Andong', of *Hibiscus syriacus* L.

Kyung-Ku Shim*, Yoo-Mi Ha, and Jae-Ho Ha; Dept. of Landscape Architecture, Sung Kyun Kwan University, Suwon 440-746, South Korea

This cultivar originated from a grafting mutant in grafted plants of a selected 100-year-old seedling of *Hibiscus syriacus* L. for 5 years. In 1999, the plant is named *H. syriacus* 'Andong'. *Hibiscus syriacus* 'Andong' is a deciduous, erect-growing, multiple-stemmed, dwarf type that, in 7 years, has grown 120 cm high and 65 cm wide, with dense branching to the base. It has more than 200 flowers in a 7-year-old tree. The alternate, leathery, waxy, dark green leaves are 5.3 cm long, 3.8 cm wide. But it is 0.48 mm thick and 34.42 mg/cm² of fresh weight and then is thicker and heavier than that of other cultivars. Therefore, the plant is rarely damaged by aphids and is reliably hardy to -20 °C. The flowers are white with a prominent dark red eye spot that radiates along the veins to midpetal, 5-7 cm in diameter, and blooms profusely from July to October. Total flowering time of 'Andong' was 36 h in both 1998 and 1999. It sets very little fruit. Alt does not only germinate by pollen, but also by seeds. This cultivar can be readily propagated by softwood (on 24 July with 7000 ppm IBA in the mist) or hardwood cutting (1000 ppm IBA) and by grafting on seedling *H. syriacus* understock.

079

Production of Microprotoplast from *Swiglea glutinosa* for Chromosome Transfer in Citrus

Eliezer Louzada*, Sonia Del Rio, and Dianren Xia; Texas A&M University-Kingsville Citrus Center, Weslaco, TX 78599-1150

The development of improved orange and grapefruit varieties via conventional breeding is not possible due their high degree of apomixis. The currently available varieties originated through natural or induced mutation. The development of an alternative breeding method is urgently needed for these citrus group. Microprotoplast Mediated Chromosome Transfer (MMCT) provides a direct way to transfer a very limited portion of the genome (one or more chromosome) from a donor species to a recipient species. In mammalian cells this procedure has been a powerful tool for gene mapping and to study the regulation of gene expression. Until recently, no chemical treatment was known for an efficient induction of microprotoplast in plants. Recently, amiprothosmethyl (APM) and cremart was found to be very efficient for the mass production of microprotoplasts in the Solanaceae family enabling a single chromosome to be transferred from potato to tomato and tobacco. To establish this technology in citrus, the efficiency of APM for the mass induction of microprotoplast from *Swiglea glutinosa*, a wild relative of citrus, was studied. APM ranging from 16 to 32 µmol was effective on promoting the scattering of the chromosomes and to create multinucleated cells. The microprotoplasts will be used in chromosome transfer experiments.

080

Genetic Transformation of Grapefruit (*Citrus paradisi*) and Sweet Orange (*C. sinensis*) With the Coat Protein Gene of CTV

Elvia C. Palacios-Torres¹, M. Alejandra Gutiérrez-Espinosa², Gloria A. Moore³; Gustavo Mora-Aguilera¹, Daniel L. Ochoa-Martínez¹, and Angel Villegas-Monter²; Colegio de Postgraduados, Especialidades de ¹itopatología, ²Fruticultura, Km 35.5 Carretera México-Texcoco, Montecillo, 56230. Mexico; ³University of Florida, Gainesville, FL 32611

Citrus Tristeza Closterovirus (CTV) induces mild and/or severe symptoms on *Citrus* species. It may cause death of trees if the rootstock-scion combination is susceptible. It has been found in other plant/ virus combinations that transformation with partial or complete viral genes (e.g., coat protein genes) can confer resistance to the resulting transgenic plants. We previously reported *A. tumefaciens* mediated transformation and production of two sour orange (*C. aurantium* L.) plants expressing the coat protein gene of CTV, which was the first report of production of transgenic *Citrus* using a viral gene. However, in order to properly evaluate resistance, it is necessary to obtain as many transgenic *Citrus* plants from single transformation events as possible. Therefore, we are currently transforming grapefruit (*Citrus paradisi*) 'Marsh' and 'Star Ruby' and sweet orange (*C. sinensis*) 'Valencia' with CTV coat protein genes. These species are susceptible to CTV and more amenable to transformation than sour orange. Epicotyl seg-

ments of etiolated seedlings were inoculated with *A. tumefaciens* strain EHA101 harboring binary plasmid pGA482GG containing the coat protein gene of mild Florida CTV strain T30 (CP-T30) or severe Florida strain T36 (CP-T36). Putatively transformed shoots were regenerated on selection medium containing kanamycin. Regenerated shoots were evaluated with GUS assays; those shoots positively identified by GUS were then evaluated with PCR. We have currently identified 17 'Marsh' grapefruit, 20 'Star Ruby' grapefruit, and seven sweet orange putatively transformed plants.

081

New Hardy Apple Selections from the Québec Apple Breeding Program

S. Khanizadeh, Y. Groleau, J.R. DeEll*, J. Cousineau, R. Granger, and G. Rousselet; Agriculture and Agri-Food Canada, Horticultural Research and Development Centre, 430 Gouin Blvd., St-Jean-sur-Richelieu, Québec, Canada J3B 3E6

The objectives of the Québec apple breeding program are to develop hardy and disease-resistant varieties for the production of juice and cider and/or varieties with an excellent fruit quality and long shelf-life. Almost 90% of the research in apple breeding is funded by a *Partnership Program*, in which the partners cover ≈50% of the research costs. The short-term objectives of the program are to evaluate the existing genotypes at the AAFC Frelighsburg sub-station and name worthy selections, remove unworthy material, and transfer potentially interesting genotypes to other AAFC research stations for further evaluations. Three selections—SJC7713-1, SJC686-1, and O-5410—are very hardy, scab-resistant, and have good yields of pleasantly flavored fruit, which can be stored long-term while retaining good quality. Selections SJCA14R3A108 and SJCA36R7A87 are not scab-resistant, but they are hardy, and the fruit have an excellent flavor, store very well for >5 months, and have a flesh that does not darken after cutting. The above selections are currently being evaluated for use by commercial growers. Selections SJC7172-1 and SJC7911-1, along with four crabapple genotypes, are of potential interest to home gardeners.

082

Identification and Partial Characterization of Seasonally Regulated Proteins in Apple Bark Tissues

Michael Wisniewski¹ and Les Fuchigami²; ¹USDA-ARS, 45 Wiltshire Rd. Kearneysville, WV 25430; ²Oregon State Univ., Dept. of Horticulture, Corvallis, OR 97331-7304

During autumnal leaf senescence, leaf nitrogen is translocated to bark and root tissues for storage. By definition, proteins that accumulate in large amounts in winter and are absent in summer are called storage proteins. These storage proteins are believed to play an important role in spring growth and helping trees to tolerate and/or recover from both abiotic and biotic stress. Little knowledge exists regarding storage proteins in apple, their physiological function, or how management practices impact them. Our objectives in this research was to characterize seasonally regulated proteins in apple, develop knowledge about their physiological function, and determine how they are affected by management practices. Results of the first-year studies have identified four major proteins that exhibit a seasonal pattern of accumulation in bark tissues of apple. One of these is a pathogenesis-related protein, meaning that it plays a role in disease resistance. Another of these proteins is a stress-related protein important in the use of carbohydrates under stress conditions. A third protein is a vegetative storage protein serving as a reserve for nitrogen. The last protein has not been completely identified. Greatest seasonal fluctuation of these proteins occurred in current season and 1-year-old bark tissues. Experimental studies that achieved varying levels of nitrogen in shoot tissues of young Fuji apple trees were examined for the effect on the accumulation of these proteins. Results indicated that despite a significant increase in total nitrogen, increases in the accumulation of these proteins were only slight. Instead, it appears that most of the nitrogen was present as free amino acids rather than stable proteins. These data indicate that more knowledge is required to determine the benefits and feasibility of elevating the levels of specific proteins in dormant apple trees or trying to manipulate the type of amino acids that accumulate.

Is HMGR the Key Regulator of α -Farnesene Biosynthesis of Apple?

H.P.V. Rupasinghe¹, K.C. Almqvist², G. Paliyath², and D.P. Murr¹; Depts. of ¹Plant Agriculture (Horticultural Science) and ²Food Science, Univ. of Guelph, Guelph, ON N1G 2W1 Canada

We tested the hypothesis that conversion of 3-hydroxy-3-methylglutaryl co-enzyme A (HMG CoA) to mevalonate (MVA) catalyzed by HMG CoA reductase (HMGR) is the rate limiting step for α -farnesene biosynthesis of apples. In higher plants, isopentenyl pyrophosphate (IPP) is derived via two pathways: 1) the classical mevalonate pathway, and 2) the novel glyceraldehyde-3-phosphate (GAP)/pyruvate pathway independent of HMGR action. When apple skin discs were incubated with MVA, or GAP and pyruvate, MVA increased α -farnesene levels in the skin but not GAP and pyruvate. Treating apple fruits with Lovastatin (1000 ppm), a competitive inhibitor of HMGR, inhibited α -farnesene accumulation in the skin by 20% to 50% during storage. Content of α -farnesene in the skin increased during the first 2 to 4 months in storage, and then decreased. In contrast, HMGR activity, as determined by the conversion of [4-³H]HMG CoA to MVA in the total membrane and soluble fraction, was the highest at the time of harvest and gradually decreased during 5 months of storage in air at 0 °C. The potent ethylene action inhibitor 1-MCP inhibited ethylene production and α -farnesene evolution by 99% and 97%, respectively. The effect of 1-MCP on in vitro activity of HMGR was marginal (\approx 30% inhibition). 1-MCP inhibited respiratory CO₂ evolution by 50%, which suggests also that inhibition by 1-MCP of α -farnesene synthesis in apple could be regulated by the acetyl CoA pool. In plants, HMGR is encoded by a small gene family and differentially expressed. As the first step of studying the molecular mechanism of HMGR regulation, we have isolated a 444-bp fragment of apple hmgr gene using apple skin mRNA and degenerate oligonucleotides designed against conserved regions of plant hmgr genes.

084

Response of Transgenic 'Royal Gala' Apple (*Malus x domestica* Borkh.) Shoots, Containing the Modified Cecropin MB39 Gene, to *Erwinia amylovora*

Q. Liu¹, S. Salih¹, J. Ingersoll¹, R. Meng², L. Owens¹, and F. Hammerschlag¹; ¹USDA-ARS, BARC-W, Bldg.010A, Beltsville, MD 20705; ²USDA-ARS, HCRL, 3420 NW Orchard Ave., Corvallis, OR 97330

Transgenic 'Royal Gala' apple (*Malus x domestica* Borkh.) shoots were obtained by *Agrobacterium*-mediated gene transfer using the plasmid binary vector pGV-osm-AC with a T-DNA encoding a chimeric gene consisting of a secretory sequence from barley-amylase joined to the modified cecropin MB39 coding sequence. Shoots were placed under the control of a wound-inducible, osmotin promoter from tobacco. The integration of the cecropin MB39 gene into apple was confirmed by Southern blot analysis. The transformation efficiency was 1.5% when internodes from etiolated shoots were used as explants and 2% when leaf explants were used. Both non- and transgenic tetraploid plants were produced by treatment of leaf explants with colchicine at 25 mg·L⁻¹, and polyploidy was confirmed by flow cytometry. Of the diploid transgenics, three of seven were significantly more resistant to *Erwinia amylovora* than the non-transgenic 'Royal Gala' control. Also, in one instance, a tetraploid transgenic was significantly more resistant than the diploid shoot from which it was derived.

085

Development of a Cleaved Amplified pPolymorphic Sequence (CAP) and Restriction Fragment Length Polymorphisms (RFLPs) Linked to the *Mi* Root-knot Nematode (*Meloidogyne incognita*, race 1) Resistance Gene in Peach [*Prunus persica* (L.) Batsch]

Anne M. Gillen¹ and Fredrick A. Bliss²; ¹Univ. of California, Dept. of Pomology, Davis, CA 95616; ²Seminis Vegetable Seeds, Inc., Woodland, CA 95695

Peach rootstock breeding may be accelerated by utilization of molecular markers linked to the root-knot nematode resistance locus (*Mi*) to screen segregating populations. A genetic linkage map was constructed using RFLP markers in an F₂ population (PMP2) that is segregating for this locus. PMP2 is derived from a controlled cross of the relatively diverse peach rootstocks Harrow Blood (susceptible) and Okinawa (homozygous resistant). Bulk Segregant Analysis was applied using RAPD markers. A single small (227 base pairs) RAPD marker was found to be linked to the dominant resistant allele of *Mi* at a distance of 10 cM. This new marker joined the *Mi* locus to the RFLP linkage map and showed that

two dominant RFLP markers are located between the RAPD marker and *Mi*. RFLPs are expensive, time-consuming and RAPD markers are unreliable, and therefore both are unsuitable for screening breeding populations. We attempted to convert the RAPD marker to a more breeder-friendly CAPS marker. The converted CAP marker was dominant. Attempts to convert the CAP marker to a co-dominant marker were not successful. The utility of the CAP marker was tested in an open pollinated F₂ population derived from the F₁ parent of PMP2 and in several rootstocks. The genetic linkage map was compared to other *Prunus* maps. The PMP2 linkage group containing the *Mi* locus can be related to the peach x almond linkage group which contains the phosphoglucosyltransferase *Pgm-1* locus.

086

A Willow-leaf Mutant of Peach

W.R. Okie¹ and R. Scorza²; ¹USDA-ARS, Byron, GA 31008; ²USDA-ARS, Kearneysville, WV 25430

Willow-leaf peaches, reported by Lesley (1957) as a product of inbreeding but also mentioned as far back as 1887 (Hedrick, 1917), are characterized by a narrow leaf shape. We received willow-leaf germplasm from Wayne Sherman (Univ. of Florida, Gainesville), who selected a peach seedling with unusually narrow leaves from a group of seedling rootstocks. His original willow-leaf tree bore very small, poor-quality fruit. In 1983, it was used in breeding at the USDA-ARS breeding program at Byron to develop willow-leaf peaches with improved fruit types. After four generations, current selections are approaching commercial fruit standards in size, color, firmness, and attractiveness. Inheritance studies indicate the character is at least partially dominant and is expressed in some F₁ seedlings of crosses with wild-type parents. However, the precise mode of inheritance remains unclear as the ratios do not fit common patterns. Progeny show a range of leaf narrowness, complicating characterization of genotype. The character may be useful in standard-type trees to enhance spray penetration, speed drying of the foliage to reduce disease, improve light penetration and photosynthetic efficiency, and make the fruit more visible to speed picking.

087

Determining S-genotype of Japanese Apricot (*Prunus mume*) Cultivar

H. Yaegaki^{*}, T. Shimada, H. Hayaman, T. Haji, and M. Yamaguchi; National Institute of Fruit Tree Science, Fujimoto 2-1, Tsukuba 305-8605, Japan

Japanese apricot (*Prunus mume*) originated in south-eastern China and is one of the major fruit trees in Japan. The major cultivars of Japanese apricot are self-incompatible. Self-incompatibility of Japanese apricot is gametophytic, the same as other *Prunus* species. Since S-genotype of every cultivar remained unclear until now, we examined molecular markers to determine S-genotype which was explored based on the information about S-RNase of other *Prunus* species. Total DNA isolated from six cultivars was PCR-amplified by oligonucleotide primers designed from conserved region of *Prunus* S-RNase. Every six cultivars yielded two amplified bands. In total, seven kind of polymorphism in molecular size were determined among those six cultivar, controlled pollination tests were carried out among cultivars that showed same band pattern, and these cross-combinations indicated cross-incompatibility. So, we were made clear that S-genotype of Japanese apricot could effectively and easily be determined by PCR method, and that there exists seven S-gene at least.

088

Differential Expression of Expansin Genes Isolated from Sweet Cherry (*Prunus avium* L.) during Fruit Ripening

Zhencai Wu^{*} and Paul A. Wiersma; Agriculture and Agri-Food Canada, Pacific Agri-Food Research Canada, Summerland, BC V0H 1Z0, Canada

Expansins are a class of proteins that stimulate the extension of plant cell walls. Expansins have been found in nearly all growing plant tissues, such as hypocotyls, young seedlings, fibers, internodes, flower petals, and ripening fruits. We isolated two full-length expansin cDNA clones, *Pruav-Exp1* and *Pruav-Exp2*, from sweet cherry (*Prunus avium* L.) fruit. *Pruav-Exp1* has 1048 nucleotides encoding 254 amino acids, while *Pruav-Exp2* has 1339 nucleotides encoding 250 amino acids. Deduced amino acid sequences of sweet cherry *Pruav-Exp1* and *Pruav-Exp2* share 72% identity. A Blast search of the GenBank database with the deduced amino acid sequences of *Pruav-Exp1* and *Pruav-Exp2* indicated a high sequence identity with other plant expansin genes. Interestingly, *Pruav-Exp1* shares 99% identity of amino acid sequence with that of apricot expansin *Pav-Exp1*. Fragments from the 3' ends of *Pruav-Exp1* and *Pruav-Exp2* were cloned to gener-

ate gene-specific probes. These probes were used to study expansin gene expression in different tissues and during fruit development. Northern blot analysis showed different mRNA expression patterns for each gene. The mRNA of *Pruav-Exp1* was expressed at the pink and ripe stages, but not at the early green and yellow stages of fruit development. The mRNA of *Pruav-Exp2* was present earlier, from a low level in yellow expanding fruit, increasing to a high level at the pink stage and remaining at this level through the ripe stage. Both mRNAs were also expressed at a low level in flower, but not present in other tissues such as roots, leaves and peduncles. Our study indicates an expansin gene family is present in sweet cherry and suggests that two expansin genes may have different roles during fruit development and ripening.

089

Inheritance of Powdery Mildew Resistance in Sweet Cherry (*Prunus avium* L.)

James W. Olmstead¹, Gregory A. Lang¹, and Gary G. Grove²; ¹Washington State University Irrigated Agriculture Research and Extension Center, Prosser, WA 99350; ²Washington State University Tree Fruit Research and Extension Center, Wenatchee, WA 98801

Most sweet cherry (*Prunus avium* L.) cultivars grown commercially in the Pacific Northwest U.S. are susceptible to powdery mildew caused by the fungus *Podosphaera clandestina* (Wall.:Fr.) Lev. The disease is prevalent in the irrigated arid region east of the Cascade Mountains in Washington State. Little is known about genetic resistance to powdery mildew in sweet cherry, although a selection (PMR-1) was identified at the Washington State Univ. Irrigated Agriculture Research and Extension Center that exhibits apparent foliar immunity to the disease. The objective of this research was to characterize the inheritance of powdery mildew resistance from PMR-1. Reciprocal crosses between PMR-1 and three high-quality, widely-grown susceptible cultivars ('Bing', 'Rainier', and eVan) were made to generate segregating progenies for determining the mode of inheritance of PMR-1 resistance. Progenies were screened for susceptibility to powdery mildew colonization using a laboratory leaf disk assay. Assay results were verified by natural spread of powdery mildew among the progeny seedlings in a greenhouse and later by placement among infected trees in a cherry orchard. Progenies from these crosses were not significantly different ($P > 0.05$) when tested for a 1:1 resistant to susceptible segregation ratio, indicating that PMR-1 resistance is conferred by a single gene, which we propose to designate as PMR-1.

090

Identification and Genetic Relatedness among Pecan Cultivars Detected by Randomly Amplified Polymorphic DNA (RAPD) Analysis

Patrick J. Conner¹ and Bruce W. Wood²; ¹Dept. of Horticulture, Univ. of Georgia Tifton, GA 31794; ²USDA-ARS SE Fruit & Nut Lab., Byron, GA 31002

Genetic variation among pecan [*Carya illinoensis* (Wangenh.) K. Koch] cultivars was studied using randomly amplified polymorphic DNA (RAPD) markers. Using a combination of primers, a unique fingerprint was produced for each of the pecan genotypes studied. The genetic relatedness between 44 cultivars was estimated using more than 100 RAPD markers. Genetic distances based on the simple matching coefficient varied from 0.91 to 0.59. The phenetic dendrogram developed from cluster analysis showed relatively weak grouping association. However, cultivars with known pedigrees usually grouped with at least one of the parents and genetic similarity estimates appear to agree with known genetic relationships. Using RAPD information in determining genetic relationships among pecan cultivars with unknown or questionable pedigrees and the integration of that knowledge into the breeding program is discussed.

091

Feeding Preferences of Black-margined Pecan Aphids

William Reid^{*}; Pecan Experiment Field, Kansas State University, Chetopa, KS 97336-0247

Field resistance to the black-margined pecan aphid [*Monellia caryella* (Fitch)] was evaluated for 12 pecan [*Carya illinoensis* (Wangenh.) K. Koch.] cultivars in 1995 and 19 cultivars in 1999. Each year, aphid populations were sampled from four trees of each cultivar by counting the number of aphids on 10 mid-shoot leaves per tree each week throughout the growing season. On leaves of several cultivars, populations of black-margined aphids peaked above the economic threshold level (20 aphids/leaf) during the month of August in both years. 'Pawnee' and 'Greenriver' demonstrated field resistance to aphids by maintaining fewer

than 10 aphids/leaf throughout the season. 'Hirschi' and 'Posey' maintained among the highest aphid populations in both years—2 to 5 times higher than threshold levels. By avoiding cultivars susceptible to aphid feeding, growers can avoid aphid-induced yield reductions.

40 POSTER SESSION 3 (Abstr. 092–104) Postharvest Physiology/Storage/Food Science

Monday, 24 July, 1:00–2:00 p.m.

092

Evaluating Seasonal Color Changes and Storage Conditions for Woody Plant Branches Used in the Floral Trade

K.S. Kleeberger^{*} and B.C. Moser; Dept. of Horticulture and Landscape Architecture, Purdue Univ., West Lafayette, IN 47907-1165

A number of deciduous woody ornamental plants experience seasonal changes in stem pigmentation. The resulting coloration yields plants desirable for use as cut branches in the florist trade. The dynamics of color change are particularly important in identifying harvest periods based on optimum color. The characterization of this process has been investigated for *Cornus* (*Cornus baileyi*, *Cornus sericea* 'Cardinal', *Cornus sericea* 'Flaviramea', *Cornus alba* 'Bud's Yellow') and *Salix* (*Salix matsudana* 'Tortosa', *Salix* 'Golden Curly', *Salix* 'Scarlet Curly') cultivars. Seasonal color changes are presented in relation to date. These data were compared to chlorophyll and anthocyanin levels to further characterize pigmentation change. Because size and round stem shape are not conducive to traditional tristimulus color measurement techniques, L*a*b* measurements were obtained from images imported via computer scanner as CIELAB images. L*a*b* values then were used to determine hue angle and chromaticity for each sample date. Postharvest storage duration and conditions are evaluated with regard to moisture content and color retention in cut branches.

093

Miniature Rose Flower Longevity in Response to Ethylene Is Not Affected by Seasonal Growing Conditions

Jose Antonio S. Grossi^{*}, H. Brent Pemberton, and William E. Roberson; Texas A&M Univ. Agricultural Research and Extension Center, P.O. Box 200, Overton, TX 75684

The effect of exogenous ethylene was investigated on single-stemmed plants of *Rosa* L. 'RUIldodo', 'RUIrosora', 'RUIjef', 'MEIferjac', 'MEIshulo', 'MEIghivon' and 'MEIlgagul' grown in controlled environment growth chambers simulating summer-like and winter-like conditions. When the flower on each plant reached developmental stage 2 (showing color, calyx reflexing, no petals reflexed), the plants were placed for 18 h in plexiglass chambers with ethylene at 0, 0.1, 0.5, 1.0 and 5.0 $\mu\text{L}\cdot\text{L}^{-1}$ under a simulated interior environment at 21 °C with 14 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ fluorescent light. Under the same interior environment, the plants were kept for postharvest evaluation. Response to ethylene of all cultivars was not affected by the difference in growing conditions. As shown previously by other authors, however, the ethylene reduced flower longevity. Treatment with 0.1 $\mu\text{L}\cdot\text{L}^{-1}$ of ethylene reduced flower longevity by 1 day in comparison to the control (0 $\mu\text{L}\cdot\text{L}^{-1}$). The ethylene concentrations of 1.0 $\mu\text{L}\cdot\text{L}^{-1}$ and 5.0 $\mu\text{L}\cdot\text{L}^{-1}$ reduced flower longevity by 3 days. Regardless of ethylene concentration or growing conditions, 'RUIjef' and 'MEIferjac' exhibited the longest flower longevity and 'MEIghivon' and 'MEIlgagul' the shortest flower longevity. All cultivars, except 'RUIrosora', exhibited the longest flower longevity under summer-like vs. winter-like conditions, with the difference ranging from 1.5 to 5 days. 'RUIrosora' exhibited similar flower longevity regardless of growing conditions. Differences in flower longevity in response to seasonal growing conditions have been found by us and other authors, but the cultivars used in this study have not been previously studied. This difference in flower longevity as a response to growing conditions cannot be explained by differences in response to ethylene so that other factors must be involved.

094

Efficacy of Water Source on Vase Life of Cut *Anthurium* cv. Large Pink

Chris Ramcharan*; Univ. of the Virgin Islands Agr. Expt. Station, P.O. Box 10,000, Kingshill, St. Croix, USVI 00850

Three sources of water—WAPA, potable water produced by the Virgin Islands Water and Power Authority, cistern or rain water collected in below-house concrete tanks and bottled water were evaluated with and without addition of Flora Life (FL) preservative under greenhouse conditions for keeping cut *Anthurium* blooms. Significant differences in water source effects were recorded with untreated WAPA water having the longest vase life (VL) (29 days) followed by cistern and bottled water (23 days). Collectively, blooms in untreated water had a VL life of 24 days in contrast to 21 for FL-treated water. Untreated cistern and bottled water produced similar VL days, but the addition of FL significantly lowered the VL of cut flowers in bottled water. The apparent suitability of WAPA water for preserving cut *Anthurium* is significant since it is the least desirable for drinking and cooking in the VI and is less expensive than bottled water, but more so than cistern water.

095

Vase Life of Cut Roses Grown in Coal Bottom Ash-amended Media: A Correlation with Tissue Calcium

Marlene Cross*, Bradford Bearce, and Rajeev Arora, Division of Plant and Soil Science, West Virginia University, Morgantown, WV 26508-6108

The vase life of roses grown in coal bottom ash (CBA)-amended media was evaluated. CBA is enriched in calcium, a nutrient implicated in delaying senescence. Two rose cultivars, Cara Mia and Dakota, were grown (from started eye plants) in four media: a 50% CBA medium and a peat:vermiculite medium amended with calcitic and dolomitic lime (1:1) were used as "high calcium" media, whereas a 25% CBA medium and a peat:vermiculite medium amended with dolomitic lime only were used as "low calcium" media. Vase life of the freshly harvested roses was evaluated. Elemental analysis of the leaves showed that roses grown in the "high calcium" media had greater calcium in the leaf tissue as well as longer vase lives (12.6 and 13.5 days) when compared to those grown in the "low calcium" media (12.1 and 10.9 days). However, petal tissue Ca was not affected by media and was not correlated with vase life. Petal tissue calcium was ≈ 15 times lower than leaf tissue calcium. Calcium and magnesium increased in the petal tissue over the vase life of the senescing petals. A comparison of 'Cara Mia' roses (vase life of 14 days) and 'Dakota' roses (vase life of 8.5 days) showed that the longer-lived 'Cara Mia' had lower leaf and petal calcium levels. Both varieties followed a similar kinetics of electrolyte leakage (total E.C. and K) during their respective vase lives.

096

Disease Incidence in Fresh-cut Peony Flowers after Long-term Cold Storage

Karen L.B. Gast*; Department of Horticulture, Forestry and Recreation Resources Kansas State University, Manhattan, KS 66503

Fresh-cut peonies are one of few cut flowers that can be stored for weeks and still provide a marketable flower. Peonies are usually marketed by color: reds, pinks, whites, and corals. Several different cultivars may be included in each color depending on their country of origin and time during the harvest season. Previous work with peonies has shown that different cultivars of the same color may behave differently during postharvest handling, whether it is storage life, vase life, opening time, storage temperature, etc. One problem of long-term cold storage is diseases that may render flowers unmarketable. This study evaluated the effect of four storage disease prevention treatments on seven peony cultivars, two reds, two pinks, and three whites, stored at 1 °C. The four disease prevention treatments included a control, methyl jasmonate during storage, a pre-storage calcium chloride pulsing for 2 h at room temperature, and a pre-storage fungicide spray. Flowers were evaluated for disease incidence on leaves and flowers, and for flower bud openness after 4, 8, and 12 weeks of cold storage. Overall results support previous work that shows peony cultivars react differently to postharvest treatments. Two cultivars were greatly affected by the disease prevention treatments and three were moderately affected, while there were few treatment effects seen with the other two. The calcium chloride pulse produced the greatest disease incidence and resulted in the flowers being more opening, which is not desirable. There was often no difference in the control, methyl jasmonate, and fungicide treatments. It appears that pre-storage treatments may not be beneficial for some fresh-cut peony cultivars.

097

Growth Regulator Application Improves Postharvest Quality of Cut Lilies

Susan S. Han*; Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Effects of the duration of cold storage, as well as the concentrations, timing, and means of application of a growth regulator solution on the postharvest quality of cut Oriental and Asiatic lilies were evaluated. Without cold storage, lower leaves of Oriental lily 'Stargazer' began to turn yellow ≈ 1 week after placing stem in an interior environment. The development of leaf yellowing continued to progress upward until the end of the vase life when there was an average of $>25\%$ chlorotic leaves. Cold storage worsened the leaf disorder. The longer the duration of cold storage, the earlier the development of leaf yellowing and the higher the percentage of leaves that were chlorotic. Spraying leaves with a solution containing 25 $\text{mg}\cdot\text{L}^{-1}$ each of BA and GA_{4+7} significantly reduced cold-storage-induced leaf yellowing and bud abortion in both Oriental and Asiatic lily. Concentration of the growth regulator solution was inversely related to the development of leaf yellowing. Timing of the growth regulator application was not critical, as there were no differences in leaf yellowing or bud development when the growth regulator solution was sprayed before or after the cold storage. Addition of the growth regulators to the preservative solution completely prevented leaf yellowing but also induced bud abortion. For practical application, spraying growth regulators prior to or after the cold storage would significantly improve the postharvest quality of cut lilies.

098

Effect of Storage Duration on Easter Lily Carbohydrate Concentration and Postharvest Flower Longevity

H. Brent Pemberton¹, Yin-Tung Wang², Garry V. McDonald³, Anil P. Ranwala⁴, and William B. Miller⁴; ¹Texas A&M Univ., Agricultural Research and Extension Center, ²Overton, ³Weslaco, Texas; ⁴Cornell University, Ithaca, N.Y.

Case-cooled bulbs of *Lilium longiflorum* 'Nellie White' were forced to flower. When the tepals on the first primary flower bud split, plants were placed at 2 °C in the dark for 0, 4, or 21 days. After storage, plants were placed in a postharvest evaluation room with constant 21 °C and 18 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ cool-white fluorescent light. Lower leaves, upper leaves, and tepals of the first primary flower from a concurrent set of plants were harvested for carbohydrate analysis using HPLC. Storage time did not affect carbohydrate levels in the lower leaf or tepal samples, but sucrose and starch levels decreased while glucose and fructose levels increased in the upper leaf tissue with increasing storage time. These changes were correlated with a decrease in postharvest longevity for the first four primary flowers. Longevity of the fifth primary flower and total postharvest life of the five primary flowers was unaffected by storage.

099

Browning Inhibition of Fresh-cut 'Anjou' and 'Bartlett' Pears

Judith A. Abbot* and J.G. Buta; Horticultural Crops Quality Laboratory, Agricultural Research Service, U.S. Department of Agriculture, 10300 Baltimore Avenue, Beltsville, MD 20705-2350

A treatment to inhibit browning and maintain quality of fresh-cut 'Anjou' and 'Bartlett' pears (*Pyrus communis* L.) was developed. Slices of 'Anjou', and 'Bartlett', pears with a range of initial firmness values were dipped in mixtures of 4-hexylresorcinol, isoascorbic acid, potassium sorbate, and N-acetylcysteine before refrigerated storage. Browning, as indicated by visual observation and by colorimeter readings, was inhibited for 14 d. Pears receiving the antibrowning treatment maintained firmness as well or better than the control slices.

100

Microbial Evaluation of Electrolyzed Water Treated Fresh-cut Carrots in CA/MA Storage

Hidemi Izumi* and Akihiro Suzuki; School of Biology-Oriented Science and Technology, Kinki Univ., Naga, Wakayama 649-6493, Japan

The effect of electrolyzed water on bacterial count was evaluated on CA/MA stored carrot shreds. Electrolyzed water (pH 6.8) containing 50 ppm available chlorine, was generated by electrolysis of 2.5% NaCl solution using an electrolyzed neutral water generator, Ameni Clean (Matsushita Seiko, Osaka, Japan). Electrolyzed water treatment reduced counts of total bacteria and lactic acid bacteria on surface of carrot shreds by about 1 log CFU/g as compared to water-rinsed control. Microbial population increased on treated carrot shreds stored in

air or 3% O₂ atmosphere at 10 or 20 °C. The increasing count of lactic acid bacteria was less on electrolyzed water treated samples than on control samples during storage at 10 °C. Electrolyzed water did not affect respiration rate of carrot shreds during storage at 10 and 20 °C. For MA study, the treated carrot shreds were packaged and stored in a polymeric film in which the O₂ and CO₂ concentrations equilibrated to about 10% and 3% at 10 °C and about 6% and 7% at 20 °C, respectively. The lactic acid bacterial count on shreds in MAP was lower with electrolyzed water treated samples than water treated controls during storage at 10 and 20 °C.

101

Postharvest and Flavor Quality of Fresh-cut 'Gala' Apples after Harvest and CA Storage

J.C. Beaulieu*, J.A. Miller, D.A. Ingram, and K.L. Bett: United States Department of Agriculture, Agricultural Research Service, Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179

Much fresh-cut apple research has focused on browning, yet little sensory and flavor analysis has been performed. We therefore evaluated postharvest and flavor changes in stored fresh-cut 'Gala' apples prepared after harvest or after CA storage (3 months, 1.4% CO₂ and 3% O₂). Apples were washed, cored, sliced, dipped in browning inhibitors (BI: Na-erythorbate + CaCl₂), packaged in LLDPE bags, and evaluated for descriptive flavor attributes, GC volatiles, firmness, CO₂ and O₂ and color after 0, 2, 7, and 14 days at 1 °C. Initial apple firmness pre-CA vs. post-CA was 38.3N and 32.7N. Bag O₂ concentration dropped to 1% to 2% by day 14 and day 7 for pre- vs. post-CA, respectively. CO₂ concentration in bags increased linearly through day 14 in both pre- and post-CA. All pre-CA Hunter L values were higher than post-CA for all treatments on all sampling days. Both BI treatments maintained color for 14 days, but freshly cut (FC) wedges were generally superior whereas stored untreated fresh-cut (SFC) wedges browned markedly by day 2. There was no apparent difference between BI levels in terms of browning or flavor. BI-treated wedges were rated more astringent than FC and SFC, especially after CA. With few exceptions, "fruity", "raw/ripe apple," and "sweet" attributes were higher in all pre- vs. post-CA treatments. This trend was conserved through 14 days of storage per treatment. "Sour" and "citrus" scores were higher after CA only in BI-treated wedges. Major compounds recovered were butanol, butyl acetate, hexanol, 2-methylbutyl acetate, amyl/isoamyl acetate, hexyl acetate, 2-hexenyl acetate, butyl 2-methylbutanoate, butyl hexanoate, hexyl butanoate, hexyl 2-methylbutanoate, hexyl hexanoate, isobutyl octanoate and α -farnesene. Flavor-related compounds varied markedly through storage and after CA. The GC volatile analysis will be presented along with any possible correlation to trained sensory evaluations.

102

Cultivar Evaluation of Sweetpotatoes for Minimal Processing

Celso Luiz Moretti*: Postharvest Laboratory, Embrapa Vegetables, Brasília, DF, 70359-970, Brazil

Sweetpotatoes (*Ipomoea batatas* L.) 'Brazil,ndia Roxa', 'Brazil,ncia Branca', and 'Princesa' were minimally processed and evaluated for enzymatic browning during a 5-day storage period. Selected roots were washed and then sliced, sanitized (NaClO, 200 mg·kg⁻¹), and centrifuged inside a cold-room (14 ± 1 °C). After centrifugation, roots were packed inside plastic films (multi-layer nylon), vacuum was added, and bags were stored inside cold-rooms at 3 °C. Daily, sweetpotato roots were evaluated to enzymatic browning according to the following scale of notes: 5 = no browning; 4 = slightly browned; 3 = few browning; 2 = browned; 1 = very browned; 0 = extremely browned. Roots showing notes below 3 were considered unsuitable for commercialization. 'Brazil,ndia Roxa' and 'Brazil,ncia Branca' were the cultivars that showed less browning, being significantly superior than 'Princesa', which showed the highest index of enzymatic browning among the studied cultivars. At the 5th day of storage, 'Princesa' showed a pronounced browning, being considered unsuitable for commercialization, according to standards employed in the present work. On the other hand, 'Brazil,ndia Roxa' and 'Brazil,ncia Branca' could still be commercialized after the 5-day storage period.

103

Tomato Cultivation using Black Polyethylene or Hairy Vetch Mulches and Various Foliar Disease Management Systems: Effect on Subsequent Quality of Fresh-cut Slices

Ji Heun Hong¹, Douglas J. Mills², C. Benjamin Coffman², James D. Anderson², Mary J. Camp³, and Kenneth C. Gross¹: ¹Horticultural Crops Quality Laboratory, Bldg. 002, and ²Weed Science Laboratory, Bldg. 001, Plant Sciences Institute, Beltsville Agricultural Research Center, ARS, USDA, 10300 Baltimore Avenue, Beltsville, MD 20705-2350; ³Biometrical Consulting Service, Bldg. 005, Beltsville Area, Beltsville Agricultural Research Center, ARS, USDA, 10300 Baltimore Avenue, Beltsville, MD 20705-2350 USA

Experiments were conducted to compare changes in quality of slices of red tomato (*Lycopersicon esculentum* Mill., cv. Sunbeam) fruit from plants grown using black polyethylene or hairy vetch mulches under various foliar disease management systems including: no fungicide applications (NF), a disease forecasting model (Tom-Cast), and weekly fungicide applications (WF), during storage at 5 °C under a modified atmosphere. In this study, we used the fourth uniform slice from the stem end and analyzed for firmness, soluble solids content (SSC), titratable acidity (TA), pH, electrolyte leakage, molds, yeasts and occurrence of water-soaked areas. With both NF and Tom-Cast fungicide treatments, slices from tomato fruit grown with hairy vetch mulch showed greater firmness than those from tomato fruit grown with black polyethylene mulch after 12 d of storage. Ethylene production of slices from tomato fruit grown using hairy vetch mulch under Tom-Cast was about 1.5- and 5-fold higher than that of slices from tomato fruit grown under the WF and NF fungicide treatments after 12 d, respectively. Within each fungicide treatment, slices from tomato fruit grown using hairy vetch mulch showed less chilling injury (water-soaked areas) than those from tomatoes grown using black polyethylene mulch. The percentage of water-soaked areas for slices from tomato fruit grown using black polyethylene mulch under NF was over 7-fold that of slices from tomato fruit grown using hairy vetch under Tom-Cast. These results suggest that, under our conditions, fruit from plants grown using hairy vetch mulch may be more suitable for fresh-cut slices than those grown using black polyethylene mulch.

104

A Dip in Chlorine Water Supplemented with Calcium Propionate Extends the Shelf life of Fresh-cut Honeydew

Jin-He Bai¹, Robert A. Saffner¹, and Yuen S. Lee²: ¹Horticultural Crops Quality Laboratory, Beltsville Agricultural Research Center, ARS, USDA, Beltsville, MD 20705; ²Dept. of Biological and Environmental Science, Univ. of the District of Columbia, Washington, DC 20008

The development of tissue translucency of fresh-cut honeydew cubes adversely affects product quality and primarily occurs in cubes that have been sanitized by dipping in chlorine water (sodium hypochlorite solution) following processing. Chlorine water dips containing calcium propionate as an antimicrobial salt were tested to decrease tissue translucency and extend the marketable shelf life of honeydew (2-cm cubes) sealed in a rigid container with a film overlap and stored at 10 °C for 7 days. Honeydew cubes not dipped following processing had higher respiration rates and microbial populations than cubes that had been dipped, and lost their marketability on day 5 due to off-odor development. Dipping in chlorine water decreased the initial population and growth of microorganisms on the cubes, compared to dipping in water or not dipping. However, translucency developed in cubes dipped in water, with or without chlorine, and became unsalable by day 5. Chlorine water dips containing calcium propionate were devised that maintained excellent antimicrobial characteristics and prevented translucency in honeydew cubes kept 7 days at 10 °C. Quality analyses revealed that calcium propionate treatments decreased respiration and ethylene production rates, maintained tissue firmness, the lightness and brightness of cube surfaces, melon aroma and overall visual quality through 7 days of storage. The calcium propionate dips did not impart or induce any detectable off-flavors or off-odors to the cubes.

92 POSTER SESSION 10 (Abstr. 105–119)
Postharvest Physiology/Storage/Food
Science
Tuesday, 25 July, 1:00–2:00 p.m.

105

Mechanisms of Chestnut Rotting during Storage

Xiaoming Wang*, Changzhu Li, Shijun Tang, and Wei Tang. Dept. of Economical Forestry, Hunan Forestry Institute, Changsha, Hunan, China 41004

Chestnut (*Castanea mollissima* Bl.) is a popular nut in Chinese and International market. However, storage of chestnut is difficult. In this study, the relationships of respiration rate, metabolic pathway, key enzymatic activities, metabolites, and membrane peroxidation with chestnut rotting during storage at room temperature (25 °C) and low temperature (0–3 °C) were investigated. The results show that the respiration rate of chestnut gradually decreases during storage at room temperature. Under the lower temperature, the respiration rate reduced 67.53% within 1 day, then gradually increased. Compared with room temperature, the lower temperature also significantly inhibited glycolysis, maintained higher level of tricarboxylic acid cycling, and reduced the conversion of pyruvate to ethanol and lactate. In addition, chloramphenicol acetyltransferase activities were inhibited while superoxide dismutase activities were high under the lower temperature, which resulted in the reduction of membrane peroxidation. Subsequently, the chestnut rotting rate was significantly reduced. In conclusion, the primary reason for chestnut rotting is the reduction of proper physiologic function and then bacteria and pathogen infection. Chestnut rotting rate during storage can be significantly reduced through an appropriate environment and new techniques and chemicals.

106

Cellulose Coatings Reduce Rancidity of Pecans

E.A. Baldwin*¹ and Bruce W. Woods²; ¹USDA/ARS Citrus & Subtropical Products Lab., 600 Ave S.N.W., P.O. Box 1909, Winter Haven, FL 33883-1909; ²Southern Tree Nut Research Laboratory, 21 Dunbar Rd., Byron, GA 31008

Pecans (*Carya illinoensis*) are full of unsaturated fatty acids, which are subject to oxidative cleavage. This results in the development of rancid off-flavors, which render the nuts unmarketable. For this reason, pecans must be stored under costly refrigerated conditions. Furthermore, pecans usually undergo retail distribution and marketing at ambient conditions, which promote development of off-flavors. Application of cellulose-based edible coatings reduced off-flavor, and improved overall flavor scores while adding shine to the nuts during 14 months of storage under ambient conditions. Development of rancidity involves hydrolysis of glycerides into free fatty acids, oxidation of double bonds of unsaturated fatty acids to form peroxides and then autooxidation of the free fatty acids once the peroxides reach a sufficient level to perpetuate this reaction. One of the products of autooxidation is hexanal which is, thus, a good indicator of rancidity. Analysis of pecans by gas chromatography revealed that hexanal levels were reduced in coated nuts by 5- to over 200-fold compared to uncoated controls, depending on the coating treatment. Some of the coating treatments affected nut color, but overall flavor and appearance were improved by certain formulations.

107

Postharvest Storage Profile of *Spondias mombim* Fruit

L.P. Martins¹ and S.M. Silva*²; ¹Depto Fitotecnia, UFPB, Campus III, Areia-PB, Brazil; ²Depto Tecnologia Rural, Universidade Federal da Paraíba (UFPB), Campus IV, C.P. 11, 58220-970, Bananeiras-PB, Brazil

Spondias mombim L. fruit, commonly known in the Brazilian Northeast as "caj," has increased its acceptance locally and abroad in recent years due to its exotic and delicious pulp. *Spondias mombim* fruit can be eaten raw or as juice, jellies, and sweet. Trade in *S. mombim*, however, has been limited by the highly perishable nature of the fruit. Comprehensive studies on proper postharvest technologies for its storage and enhanced shelflife are required to improve its commercial performance. The determination of proper storage temperature allows reducing the rate of metabolism without causing chilling injury. In addition, modified atmosphere packaging, by using low-density polyethylene (LDPE), may delay fruit ripening. Combination of proper temperature and film O₂ and CO₂

permeabilities, therefore, may enhance the postharvest shelflife of *S. mombim* fruits. Ripened fruits were stored with and without film, at temperatures varying from 16 °C to 5 °C, at 0.5 °C steps, in order to set proper storage temperature and shelflife. Changes in fruit weight loss, firmness, soluble solids, pH, titratable acidity, sugars, CO₂ production, ascorbic acid, and carotenoids contents were measured during storage. Storage of *S. mombim*, wrapped with LDPE, at 8 °C allowed quality maintenance and increased the fruit postharvest shelflife by 12 days, without causing chilling injury.

108

Maintaining Postharvest Quality of Mango Fruit with Methyl Jasmonate

G.A. González-Aguilar*^{1,2}, J.G. Buta¹, and C.Y. Wang¹; ¹Horticultural Crops Quality Laboratory, U.S. Department of Agriculture, Beltsville, MD 20705-2350; ²Centro de Investigación en Alimentación y Desarrollo, AC, AP 1735, Hermosillo, Mexico 83000

Treatment of mango (*Mangifera indica* cv Kent) with methyl jasmonate (MJ) vapor for 20 h at 20 °C was effective in reducing chilling injury (CI) symptoms and decay, and enhancing skin color development. MJ (10-4 M) was the most effective concentration for reducing CI and decay in fruit stored at 5 °C followed by 7 days at 20 °C (shelf life period). The use of 10-5 M MJ enhanced yellow and red color development of mango kept at 20 °C. These fruit possessed higher L*, a* and b* values than controls and those treated with 10-4 M MJ. Ripening processes were inhibited by cold storage in control fruits. After cold storage (5 °C) and the shelf life period, fruit treated with 10-5 M MJ fruit ripened normally and contained the highest total soluble solids (TSS). These fruit maintained higher sugar and organic acid levels than those in other treatments. We concluded that MJ treatment could be used to reduce decay and CI symptoms, and also to improve color development of mango fruit without adversely affecting quality.

109

Evaluation of Postharvest Quality Parameters in Lulo (Naranjilla) Stored at Different Temperatures

J.G. Diaz* and J.E. Manzano-Méndez; Posgrado de Horticultura, Decanato de Agronomía, P.O. Box 815, Universidad Centroccidental Lisandro Alvarado, Barquisimeto 3001, Lara, Venezuela S.A.

Lulo (*Solanum quitoense* L.) fruits grown at the Andes farms, T-chira State in Venezuela, were harvested at the mature green stage, selected, washed, and transported to the postharvest Lab. Fruits were stored in small commercial carton boxes in storage rooms at 5, 10, and 15 °C during 3 weeks. Chemical parameters such as solid soluble concentration (SSC), pH, titratable acidity (TA), ratio SSC/TA, and physical parameters such as Color: L*, Hue, Chroma, color index (a+b)/L x 100, texture and fresh fruit weight loss (FFWL), in pulp extract and from the whole fruit were analyzed at the initial and at the end of each storage week. These characteristics ranged in the following way: SSC: 74.9% ± 8.09% and its media of 8.02%, TA: 1.05%–1.18% for temperature and 1.01–1.27 for storage time with an average of 1.16% (expressed as citric acid), color index: 4.54–5.22 for storage time and 4.30–5.13 for storage temperatures with an average of 4.86, chroma: 6.21–6.63 for storage time and 6.00–6.55 for storage temperatures with an average of 6.36, FFWL: 1.30%–1.44% for storage temperature and 0.67%–2.11% for storage time. The SSC decreased with increasing the storage temperature. The TA, color index, and chroma decreased with the storage time and increased with storage time, the FFWL values increased with storage temperatures and with storage time.

110

Postharvest Quality of Tamarillo Fruits under Different Storage Temperatures

J.E. Manzano-Méndez* and J.G. Diaz; Posgrado de Horticultura, Decanato de Agronomía, P.O. Box 815, Universidad Centroccidental Lisandro Alvarado, Barquisimeto 3001, Lara Venezuela S.A.

Tamarillo (*Cyphomandra betacea* L.) fruits, grown in the Venezuela Andes farms, were harvested at mature-green stage, graded, selected, washed, and transported to the postharvest lab. for analysis. Fruits were stored into plastic containers in storage rooms at (5, 10, and 15 °C for 3 weeks. The soluble solid concentration (SSC), pH, titratable acidity (TA), ratio SSC/TA, color: L*, Hue, Chroma, color index (a+b)/L x 100, texture, and fresh fruit weight loss (FFWL) in pulp extract and in the whole fruit were determined on the first day of harvest and at the end of each storage week. These parameters ranged as follows: SSC: 7.92–8.84%,

pH: 4.06–4.35, TA: 1.14%–1.21% (expressed as citric acid), SSC/TA: 1.58–1.75, Chroma 42.72–45.54, FFWL: 0.83% at the second storage day to 4.39% at the 3rd storage week. Also, FFWL was 1.03%–1.40% for 10 and 15 °C, respectively. Fruits stored at the highest temperature increased pH values, the TA decreased with stored time, the Chroma and FFWL values increased with the increasing temperature and storage time.

111

Effect of Harvesting Methods, Waxes, Storage Temperature, and Fruit Size on Stem End Rind Breakdown (SERB) of Valencia Oranges

Huating Dou*, Mohamed A. Ismail, and Peter D. Petracek; Florida Dept. of Citrus, Lake Alfred, FL 33850 and Abbott Laboratories, Long Groves, IL 60047

The effect of clipping vs. pulling, wax application, storage temperature, and fruit size on Stem End Rind Breakdown (SERB) of Valencia oranges was studied in four experiments during the 1998–1999 and 1999–2000 seasons. For harvesting methods, clipping reduced SERB rate of Valencia oranges over pulling from 10.2% to 5.9%. Wax application increased fruit SERB compared to non-waxed fruit. However, there was no consistent difference in effect on SERB incidence between shellac and carnauba waxes in all studies. Small fruit (size 100#) tended to be associated with high incidence of SERB, whereas large fruit (size 64#) were less susceptible to SERB of Valencia oranges. The most significant factor that influenced SERB incidence was storage temperature. Fruit stored at 70 °F had 23% and 96% SERB if fruit were examined in the 2nd and 8th weeks after packing; whereas 0.5% and 2% SERB was found if fruit were stored at 45 °F and examined at the same times. The effect of the above treatments on fruit peel anatomy and postharvest physiological behavior will also be discussed.

112

Effects of Edible Plant Oil Emulsions on Storage Disorders in 'Elegant Lady' Peaches

Yousheng Duan¹, Zhiqiang Ju¹, and Zhiguo Ju²; ¹Fruit Research Lab, Dept. R&D, Eureka Biotechnology Co. Shandong, P. R. China; ²Laiyang Agricultural College, Shandong, P.R. China

Effects of different plant oils (soybean, corn, peanut, cottonseed, conola, sunflower, safflower, rape seed, and linseed) on mealiness, leatheriness, and flesh browning (FB) in 'Elegant Lady' peaches (*Prunus persica* Batsch) were studied. Fruit were harvested at three dates (10 days apart) with the second harvest concomitant to commercial harvest, dipped in a 5% or 10% oil emulsion for 3 min, and stored at 0 or 5 °C, respectively. After 6 weeks at 0 °C, fruit developed more leatheriness and FB but less mealiness in early harvested compared to late-harvested fruit. When stored at 5 °C, fruit did not develop any leatheriness regardless of harvest dates, but fruit from the last harvest developed high levels of mealiness and FB compare with fruit from the other two harvests. FB was found only, but not in all, leathery or mealy fruit. None of the oils affected leatheriness, but all reduced mealiness to the same extent at the same concentration. Oil treatments controlled FB completely in both leathery and mealy fruit. Oil at 10% was more effective in controlling mealiness and FB than at 5%. Oil-treated fruit had higher flesh firmness and titratable acidity and developed less decay than the controls at removal from storage.

113

Ethylene Mediates Responses of 'Gala' Apple Fruit to Ionizing Irradiation

Xuetong Fan¹, David Buchanan², Luiz Argenta², and James Mattheis²; ¹U.S. Dept. Agriculture, Agricultural Research Service, Eastern Regional Research Service, Wyndmoor, PA 19038; ²U.S. Dept. Agriculture, Agricultural Research Service, Tree Fruit Research Laboratory, Wenatchee, WA 98801

Pre-climacteric 'Gala' apple fruit treated with air (control) or 2 $\mu\text{mol}\cdot\text{L}^{-1}$ 1-methylcyclopropene (MCP) were exposed to gamma irradiation at 0, 0.5, 1, or 1.5 kGy at 23 °C. Fruit were held at 20 °C for 3 weeks after treatment during which respiration rate, production of ethylene and other volatile compounds, fruit firmness, soluble solid content, titratable acidity, and irradiation injury were determined. MCP treatment reduced respiration and ethylene production and slowed loss of fruit firmness and titratable acidity. Irradiation induced increased respiration of MCP-treated fruit in a dosage-dependent fashion. Irradiation caused a decrease in ethylene production by control (non-MCP) fruit, and the magnitude of the decrease was dependent on irradiation dosage. Irradiation at 0.5, 1, and 1.5 kGy stimulated ethylene production of MCP-treated fruit for only 1 day after treat-

ment. Irradiation induced internal browning and the injury severity increased with dosage. The severity and incidence of irradiation damage were higher in MCP-treated fruit than control fruit. The results indicate that ethylene is involved in mediating apple fruit responses to irradiation.

114

Multiple Applications Extend Duration of 1-Methylcyclopropene-induced Responses of Apple and Pear Fruit

J. Mattheis*, L. Argenta, and X. Fan; USDA, ARS Tree Fruit Research Laboratory, 1104 N. Western Avenue, Wenatchee, WA 98801

The ethylene action inhibitor 1-methylcyclopropene (MCP) reduces the rate of ripening of many apple and pear cultivars. The longevity of MCP responses induced by a single application at harvest is dependent in part on MCP treatment concentration and post-application storage conditions. Experiments were conducted using several apple and pear cultivars to evaluate the efficacy of repeated application to prolong the duration of MCP responses. Fruit were treated with MCP at harvest then stored in air at 0 °C. After various storage durations, MCP was reapplied at the same or higher concentrations. Control fruit not exposed to MCP were stored at the same temperature in either air or a controlled atmosphere (CA). Reapplication prolonged MCP responses compared to fruit treated only at harvest and fruit quality after storage was similar to that of fruit stored in CA. Reapplication was most effective when fruit ethylene production was below 0.1 $\mu\text{L}\cdot\text{L}^{-1}$ at the time of reapplication. The use of low concentration MCP treatments at harvest may allow for more predictable ripening of fruit after storage, particularly for pear fruit where softening is desired.

115

Performance of Various Apple Scion Cultivar/Rootstock Combinations and Postharvest Fruit Quality

Maria J. Sindoni V.* and Frank B. Matta; Dept. of Plant and Soil Sciences, Box 9555, Mississippi State Univ., Starkville, MS 39762

Several cultivar/rootstock combinations were evaluated for overall performance in Mississippi. This study included postharvest fruit quality during storage as influenced by the various rootstocks. Parameters measured were fruit set, scion and stock trunk cross-sectional area, fire blight tolerance, fruit drop, and maturity indices such as fruit size, firmness, fresh fruit weight, soluble solids content, and juice pH. Cultivar/rootstock combinations were 'Earligold'/EMLA 7, 'Jonagold'/EMLA 111, 'Improved Golden'/EMLA 7, 'Improved Golden'/EMLA 111, 'Scarlet Gala'/EMLA 7, 'Jonafree'/Mark, 'Macspur'/M 7A, 'Royal Gala'/MM 111, and 'Williams Pride'/M 7A. Cultivar and rootstock influenced fruit set. 'Royal Gala', 'Scarlet Gala', 'Improved Golden', and 'Earligold' showed maximum fruit set among the various cultivars. MM 111 and EMLA 7 rootstocks increased fruit set. Scion cultivars had the greatest trunk diameter on EMLA 111 and MM 111 and the smallest diameter on Mark. Scion cultivars on Mark and M 7A rootstocks showed less susceptibility to fire blight compared to MM 111 and EMLA 111. Cultivars on EMLA 7 showed moderate susceptibility to fire blight. Cultivars 'Jonafree', 'Williams Pride', 'Macspur', and 'Scarlet Gala' were least susceptible to fire blight compared to 'Royal Gala'. The remaining cultivars were intermediate in susceptibility to fire blight. Fruit size, firmness, fresh fruit weight, soluble solids content, and juice pH were influenced by cultivar. 'Jonagold' and 'Williams Pride' produced the largest fruit, while 'Jonafree' and 'Macspur' yielded the smallest fruit. Total soluble solids were not influenced by cultivar and rootstock combinations. Sugar content of the juice increased as the apples matured and ranged from 12% to 14% among the cultivar/rootstock combinations. Firmness was influenced by cultivar but not rootstock. 'Jonafree', 'Macspur' had firm fruit, while fruit of 'Scarlet Gala', 'Williams Pride', and 'Earligold' was not as firm. After harvest, the cultivars were stored at 2 °C for \approx 4 months under controlled conditions and evaluated for soluble solids content, titratable acidity, pH, and firmness at monthly intervals. Overall, firmness, soluble solids content, and titratable acidity in all cultivars decreased with time in storage. 'Improved Golden'/EMLA 7, 'Royal Gala'/MM 111, and 'Jonagold'/EMLA 111 maintained quality during storage, compared with the remaining cultivars/rootstock combinations, and had a longer storage life.

116

Preharvest Fruit Drop Studies, Harvest Quality, and Cold Storage of 'Golden Delicious' and 'Rome' Apples

R.E. Byers*, D.H. Carbaugh, and L.D. Combs; Virginia Polytechnic Inst. and State Univ., Alson H. Smith, Jr. Agricultural Research and Extension Center, 595 Laurel Grove Road, Winchester, VA 22602

Combinations of aminoethoxyvinylglycine (AVG, ReTain) and NAA gave better control of fruit drop of 'Golden Delicious' than either alone. When the full rate of ReTain (50 g/A) was compared to a reduced rate of ReTain (86 g/ha) plus NAA, equivalent control of fruit drop of 'Golden Delicious' resulted. ReTain delayed softening and starch depletion of 'Golden Delicious' fruit. NAA in some cases promoted earlier fruit maturity; but when used in combination with ReTain, maturity was similar to ReTain-treated fruit. Fruit with the highest firmness and starch came out of cold storage in the best condition. Neither 1-methylcyclopropene (MCP, EthylBloc) or NAA inhibited fruit drop of 'Golden Delicious' fruit when applied at harvest; but previous ReTain and NAA data indicate that late applications are frequently much less effective than if applied 4 weeks before harvest. Ethephon spray treatments caused more rapid and extensive fruit drop than the control. Trees gassed or sprayed with EthylBloc before ethephon sprays also dropped rapidly. 'Golden Delicious' fruit on the tree were dramatically maintained firmer by the EthylBloc gas, and to a lesser extent by EthylBloc sprays by 19.1 N and 10.2 N firmness, respectively, tested on 28 Oct. Starch was maintained by the EthylBloc gas, but not by the sprays. These data indicated that EthylBloc applied as a gas or spray did have a physiological affect but did not control fruit drop. Fruit diameter, soluble solids and color did not appear to be affected. Further study of earlier applications of EthylBloc or combinations with fruit drop control agents may be needed to get fruit drop control. NAA plus Silwet L-77 inhibited fruit drop of 'Law Rome', but none of the EthylBloc sprays inhibited fruit drop when applied at harvest. Previous data with ReTain and NAA indicated that late applications are frequently much less effective than if applied 4 weeks before harvest. EthylBloc sprays applied 21 Oct. dramatically maintained fruit firmness tested on 3 Nov. Starch was not maintained by the EthylBloc gas, but starch had almost disappeared by the application time on 21 Oct. Fruit diameter, soluble solids, and color did not appear to be affected. Further study of earlier applications of EthylBloc may be needed to demonstrate fruit drop control. Shading trees with 92% polypropylene shade material for 3 or 7 days caused more rapid fruit abscission at 7 days than 3 days and both were greater than the control.

117

Ethanol Production and Chlorophyll Fluorescence Indicate Freezing and Heat Stress in Apple Fruit During Storage

Jun Song, Lihua Fan, Charles F. Forney*, and Michael A. Jordan; Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main Street, Kentville, N.S., B4N 1J5, Canada

Ethanol production and chlorophyll fluorescence were measured as signals of freezing and heat stress in apple fruit. 'Cortland' and 'Jonagold' apples were held at -8.5 °C for 0, 6, 12 or 24 h (freezing treatments), or at 46 °C for 0, 4, 8 or 12 h (heat treatments). Following treatments, fruit were stored at 0 °C and evaluated after 0, 1, 2, or 3 months. Following storage, fruit samples were kept for 12 h at 20 °C and then analyzed for ethanol production, chlorophyll fluorescence, and visible injury. Severity of flesh browning increased with increasing treatment time for both freezing and heat treatments. Freezing for 24 h and healing for 12 h caused severe flesh browning in both cultivars. Severity of heat-induced browning increased during storage. Increases in ethanol production were apparent 12 h following treatments and reflected the degree of stress-induced fruit injury. After 2 months of storage, ethanol concentrations peaked and were as much as 400-fold greater than that of controls. These stress treatments also reduced ethylene production and chlorophyll fluorescence. The degree of increase in stress-induced ethanol production and decrease in chlorophyll fluorescence correlated with stress-induced injury and could be used to predict the severity of injury that develops during storage. Other volatile production and their relationship to fruit stress will also be discussed.

118

1-MCP Controls Superficial Scald and Delays Softening in 'Cortland' Apples

Jennifer R. DeEll¹, H.P. Vasantha Rupasingh², and Dennis P. Murr²; ¹Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, Quebec J3B 3E6, Canada; ²Department of Plant Agriculture (Horticultural Science), University of Guelph, Ontario N1G 2W1, Canada

'Cortland' is an apple cultivar with inherent poor storeability because of excessive vulnerability to the development of superficial scald in long-term storage. The objectives of this investigation were to evaluate the potential of the potent ethylene action inhibitor 1-methylcyclopropene (1-MCP; EthylBloc[®]) to counteract this constraint and to develop some basic procedures for its exposure. Eight hours after harvest, fruit were exposed to 1.0 mL·L⁻¹ 1-MCP for 0, 3, 6, 9, 12, 16, 24, or 48 h at 3, 13, or 23 °C. Following exposure, fruit were placed at 0 to 1 °C in air for 120 days, after which time they were removed to 20 °C and held 7 days for post-storage assessment of ripening and to allow development of physiological disorders. In general, and within our experimental limits, the higher the temperature of 1-MCP exposure the shorter the required exposure time to obtain similar effects. The desired effectiveness of 1-MCP could be achieved by exposing fruit for at least 3 h at 23 °C, for 6 h at 13 °C, or for 9 h at 3 °C. 1-MCP-treated apples were consistently 2 kg firmer than untreated apples. Scald incidence in untreated fruit after 120 days at 0 to 1 °C and 7 days at 20 °C was 100%, whereas 1-MCP reduced scald by 95% in treatments of long enough duration at any particular temperature.

119

The Involvement of Ethylene on the Incidence of Core and Skin Browning in Stored 'Niiitaka' Pears

Y.S. Hwang, J.C. Lee*, and B.J. Lee; Division of Plant Science and Resources, Chungnam National University, Taejeon 305-764, Korea

Oriental pear, 'Niiitaka', often suffers from skin and/or core browning when storage duration is extended. Skin browning occurred in aged fruit differs from browning disorder occurred at the early stage of low temperature storage (within 1 month), which is dark in color. This disorder can be inhibited by temperature conditioning through stacking fruit under shade for 7 days. Unlike dark browning disorder, fruit affected by light browning disorder often develops core browning. Also, when the duration of temperature conditioning is extended, light browning disorder occurred more rapidly even at 0 °C. In this experiment, the effect of external application of ethylene and ethylene scrubbing in storage environment was examined. Light browning disorder increased when fruit were wrapped with polyethylene film (30 µm) and the application of ethylene scrubber effectively decreased this disorder. Skin peeling was also observed in disordered fruit. The application of ethylene resulted in the increase of light browning on skin and core browning. Thus, both disorders seemed to be involved with senescence. The involvement of ethylene on both disorders will be further discussed.

148 POSTER SESSION 17 (Abstr. 120–133)

Postharvest Physiology/Storage/Food Science

Wednesday, 26 July, 1:00–2:00 p.m.

120

Effects of Short-term Postharvest Treatments on Cilantro (*Coriandrum sativum* L.) Storage Quality

Francis X. Mangar*, Claire Kozower, and William Bramlage; Dept. Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Latinos are 6% of the population of Massachusetts and are the largest and fastest-growing ethnic minority in this state. Due to the increase in Latinos and other ethnic groups, farmers in Massachusetts are diversifying their crops to meet the demands of these new markets. Cilantro is a popular herb in Latino cuisine; however, many farmers in Massachusetts are not familiar with production and postharvest practices for this plant. A factorial experiment was initiated on a commercial farm in eastern Massachusetts to ascertain more information about short-term postharvest treatments. This experiment was performed on three dates in the

fall of 1999, which served as replications. There were three main effects: cilantro harvested the same day and stored in the sun, cilantro harvested the same day and stored in the shade, and cilantro harvested on previous day and stored in the shade. For each main effect there were six sub-effects for cilantro storage: roots intact, roots removed, roots intact and plants in sealed plastic bag, roots removed and plants in sealed plastic bag, roots intact and plants in water, roots removed and plants in water. Cilantro bunches were given a visual quality number every hour from 10:30 AM to 4:30 PM on each date. No difference in visual quality was observed between cilantro with roots intact compared to cilantro with roots removed. Cilantro stored in the direct sun had a lower visual quality index than cilantro stored in the shade. Cilantro stored in water or in a sealed plastic bag and kept in the shade showed little decrease in visual quality after 7 hours on the day of harvest. The results of these experiments will help farmers in Massachusetts to produce and market cilantro to meet the growing demands for this product.

121 Postharvest Ripening of Tomato Following Low-dose Gamma-irradiation and Water-based Chemical Treatment

G. Findley*, F.M. Woods, D.E. Conner, C. Mosjidis, S.J. Weese, C.A. Sundermann, and C.I. Wei; Auburn Univ. Agricultural Experiment Station, Auburn, AL 36849-5408

Low-dose gamma-irradiation is becoming increasingly an attractive viable technology for control of food-borne pathogens and extension of shelf life of fruits and vegetables. Typically, gamma-irradiation treatment appears to transiently stimulate ethylene synthesis in tomato, which appears to be stress associated, and dose dependent (Larrigaudie et al., 1991). We have investigated the effects of gamma-irradiation treatment at doses of 0, 0.5, 0.75, and 1.0 kGy, alone and in combination with water-based chemical treatment for improving the storage of tomato maintained at 20 °C and 95% RH for 20 days of storage. Changes in ethylene, ascorbic acid and total antioxidant content, color, total soluble solids and carbohydrate concentration were examined. Our preliminary results indicate that these treatments are effective in reducing ethylene concentration in storage while providing a means of eliminating foodborne pathogens without adversely affecting tomato quality.

122 Processing Tomato Fruit Firmness, Color Uniformity, and Peeling Response to Ethephon Sprays

Mark A. Bennett*, David M. Francis, and Elaine M. Grassbaugh; Ohio State Univ., Dept. of Horticulture and Crop Science, 2021 Coffey Road, Columbus, OH 43210

Ethephon (2-chloroethyl phosphonic acid) has been widely used under field conditions as a growth regulator to trigger the ripening of processing tomatoes prior to mechanical harvesting. Recent interest in whole-peeled and diced tomato products has raised questions about ethephon rates, and possible split applications for top quality. This 3-year field study tested two commercial cultivars of processing tomatoes ('OH8245' and 'P696') and the effect of various ethephon applications on fruit firmness, color uniformity, and peeling variables. Transplants were established in mid to late May of 1996–1998 on raised beds in single rows at the OSU/OARDC Veg. Crops Branch in Fremont, Ohio. Ethrel applications for each cultivar were: 0, 0.58, 0.58 x 2 applications, 1.17, 1.17 x 2 applications, 1.75, 2.34, 4.68, and 7.02 L·ha⁻¹. Fruit were tested for firmness, color uniformity, pH, titratable acids, and soluble solids. Samples from ethephon treatments of 0, 1.17 x 2 applications, 2.34, 4.68, and 7.02 L·ha⁻¹ were peeled and canned for color inspection and firmness after 18 months storage. Three-year data for red fruit yield showed a typical response to increasing amounts (0 to 7.0 L·ha⁻¹) of applied ethephon. While high rates (4.7 or 7.0 L·ha⁻¹) gave some of the highest red fruit yields, and the greatest percent red fruit values, high rates were also linked with among the lowest fruit solids values. Split application comparisons showed little influence on quality variables examined in this study. However, chroma values were improved (more vivid color) when 2.3 L·ha⁻¹ was applied vs. 1.17 L·ha⁻¹ applied twice. Split applications also tended to produce softer fruit. Our results suggest that single ethephon applications of 1.17 to 2.34 L·ha⁻¹ provide optimal fruit ripening and quality under midwestern U.S. conditions.

123 Quality and Shelf Life of Semi-savoy Spinach stored in Clamshell Containers

J.A. Kirkpatrick¹, T.E. Morelock¹, L.R. Howard², and F.J. Dainello³; ¹Department of Horticulture, University of Arkansas, Fayetteville, AR 72701; ²Institute of Food Science and Engineering University of Arkansas, Fayetteville, AR 72701; ³Texas Agriculture and Extension Service, Texas A&M University, College Station, TX 77843

Fresh-market spinach production has risen in the United States in the past few years as well as total value of the crop. Increased crop value may be attributed to more "value added" spinach products being produced and marketed. Public awareness of nutrition is rising due to more information being distributed concerning cancer prevention, antioxidants, and nutraceuticals. Spinach is high in the carotenoids beta-carotene and lutein, a known antioxidant for the prevention of age-related macular degeneration (AMD). It is also high in vitamins A, C, E, and folate, fiber, and the mineral iron. In this respect, spinach producers have an advantage over growers of salad vegetables such as lettuce. While this is an advantage, more innovative "value added" methods of marketing this product to the consumer are needed. A dark-green, semi-savoy spinach type developed at the Univ. of Arkansas was studied to determine shelf-life and storage capabilities of root cut plants in transparent clamshell containers. Plants were held at temperatures ranging from 1 to 6 °C. Leaf turgidity and visual characteristics were rated on a 1 to 5 scale. Acceptable characteristics and shelf-life of spinach stored in clamshell containers were seen up to 14 to 21 days when plants were stored at or near 1 °C. These results indicate that spinach packaged in transparent clamshell containers will maintain an acceptable shelf-life and could be beneficial to fresh market spinach producers.

124 Color Changes of Leaf Lettuce during Postharvest Storage

Sang Yong Nam*; Department of horticulture, Sahmyook University, 26-21 Kongreung-Dong, Nowon-Gu, Seoul 139-742, Korea

Leaf lettuce is a major and widely cultivated vegetable crop. Leaf lettuce is preferred for wrapping food, like rice or meat, and is much more popular than head lettuce in Korea. Color change and water loss condition are most important factor for buying decision as external quality. This paper studied color change during storage at 20 and 4 °C, 60% RH. The color analysis of adaxial surface of leaf lettuce during shelf-life storage condition showed that Hunter L and a value increased slightly after 5 days of harvest, while delta-Eab started increasing after 3 days of postharvest. Chlorophyll content decreased by half during the first 5 days after harvest. These color changes, however, could not explain the changes in leaf chlorophyll content while the color intensity of G (green) component in RGB analysis showed a close relationship with leaf chlorophyll content changes. Visual quality score showed that lettuce may kept its marketability up to 5 days after harvest. But, in refrigerator (4°C, 60% RH, cold chain system) storage condition. Leaf color is about three times longer than shelf-life. These results of each evaluation methods consistently demonstrated that leaf lettuce may keep its marketability up to 5 days in a distribution market without color quality damage.

125 Effect of Postharvest Curing on Respiration and Quality in Garlic Bulbs During Cold Storage

Y.J. Yang* and K.A. Lee; Div. of Horticultural Science & Environmental Architecture, Sangmyung University, Chonan, Chungnam, 330-180, Korea

Garlic (*Allium stipitum* L. cv. 'Seosan') grown in Kyungbuk, Korea were harvested on June 1999 and dried in the field for 2 to 3 days. Bulbs were selected for uniformity in size and maturity and divided into two groups. One group was further dried in the shade at 25 °C for curing before storage at 0 °C. The other group was stored at 0 °C immediately without additional drying. Respiration of garlic bulbs dried additionally for 3 months was low, ranging from 1.5 to 3.0 CO₂ mL/kg per h for 95 days in storage; ethylene was not detected until 60 days in storage. Non-curing samples showed rapid increase of carbon dioxide production after 50 days of storage, this might be related to incidence of fungal decay. Ethylene showed maximum value at 45 days in storage, thereafter remained level of 5.6-6.3 µL/kg per h. All treatments did not show sprouting during storage period, but incidence of decay was significantly reduced by additional drying. The beneficial effect of curing for 3 months at 25 °C was maintenance of low water content in garlic bulbs, which resulted in reduction of decay.

Antioxidant Responses in Detached Leaves of Two Cultivars of Spinach (*Spinacia oleracea* L.) Differing in Their Senescence Rates

D. Mark Hodges^{*1}, Wendy V. Wismer², and Charles F. Forney¹; ¹Atlantic Food and Horticulture Research Centre Agriculture and Agri-Food Canada, Kentville, NS, B4N 1J5, Canada; ²Mt. Albert Research Centre, HortResearch, New Zealand

The responses of certain antioxidants in detached leaves of two cultivars of spinach (*Spinacia oleracea* L.) differing in their senescence rates were assessed during storage in order to explore the significance of these antioxidants in senescence regulation and dynamics. To identify spinach cultivars differing in their senescence rates, 10 cultivars were grown in field plots, harvested at maturity, and their leaves detached and stored at 10 °C in the dark. At the point of harvest (d 0) and on d 5, 8, 12, and 15, samples were analyzed for lipid peroxidation (MDA), chlorophyll loss, and electrolyte leakage. The cultivars were also grown in laboratory growth chambers to corroborate field results. Two cultivars that were consistently identified as having relatively high (Spokane F1) and low (BJ 412 Sponsor) senescence rates were grown in growth chambers for 45 d, harvested at maturity, and their leaves detached and stored as above. At the point of harvest (d 0) and on d 4, 8, 12, 16, and 20, samples were analyzed for (i) activities of ascorbate peroxidase (ASPX; EC 1.11.1.11), catalase (CAT; EC 1.11.1.6), and superoxide dismutase (SOD; EC 1.15.1.1), and (ii) concentrations of MDA, total ascorbate, reduced ascorbate (AsA), oxidized ascorbate (DAsA), total glutathione, reduced glutathione (GSH) and oxidized glutathione (GSSG). Although MDA accumulated in leaves of both cultivars concomitant with time after detachment, levels became significantly higher in Spokane. Activities of ASPX declined in Spokane leaves following detachment but activities of SOD and levels of glutathione increased in this cultivar. GSH/GSSG increased in 'Sponsor', but dramatically more so in 'Spokane'. Ascorbate concentrations did not diminish in leaves of 'Spokane' to the degree that they did in 'Sponsor' tissue. DAsA/AsA values did not decrease in 'Spokane' leaves following detachment, though they did in those of 'Sponsor'. It is argued that declining activities of ASPX and levels of ascorbate and increasing activities of SOD manifested in accumulation of hydrogen peroxide in Spokane, leading to a greater potential for lipid peroxidation in this variety than for Sponsor. SOD activities and glutathione levels may have increased as a result of elevated oxidative stress in Spokane. Increased hydrogen peroxide accumulation in 'Spokane' relative to 'Sponsor' may have contributed to an increased rate of senescence in the leaves of this cultivar.

127

Ethylene Production in Tomato Fruit in Relation to Postharvest Quality Deterioration

Hakim Abdul^{*}, Pehu Eija, Voipio Irma, and Khatoon Mohfeza; ¹2312 Lawrence Ville Highway, #6, Decatur, GA 30033; ²Dept. of Plant Production, 00014 Univ. of Helsinki, Helsinki, Finland; ³Dept. of Horticulture, Bangladesh Agricultural Univ., Mymensingh, Bangladesh

Ethylene is produced by tomato fruit (*Lycopersicon esculentum*) at a rate that is dependent on fruit size, maturity stage, and adherence of calyxes. Production rate of ethylene declined with increased maturity stages. Small fruit produced higher ethylene compared to medium or large sizes. Ethylene production is positively correlated with rate of respiration, but not with visible pitting. Fruit stored with calyx produced less ethylene than those that were stored without calyxes.

128

Synergistic Effect of AVG, 1-MCP, and CA on Softening of Apples

H.P. Vasantha Rupasinghe^{*1}, Dennis P. Murr¹, Jennifer R. DeElP, and Murray D. Porteous³; ¹Department of Plant Agriculture (Horticultural Science), University of Guelph, Guelph, Ontario Canada; ²Agriculture and Agri-Food Canada, Saint-Jean-sur-Richelieu, Quebec, Canada; ³Lingwood Farms, Simcoe, Ontario, Canada

Flesh softening is a major quality parameter that can limit long-term storage of apple cultivars. This study investigated the combined effects of preharvest AVG (Retain™) application, 1-methylcyclopropene (1-MCP; EthylBloc™) exposure at harvest, and commercial controlled atmosphere (CA) storage (2.0% O₂ + 2.5% CO₂) on flesh softening of 'Empire' apple. Treatments were assigned in a split-split-plot experimental design: AVG and no AVG application as the main-plot, CA and air storage as the sub-plots, and 0, 0.1 0.5, 1.0 mL·L⁻¹ 1-MCP as the sub-sub-plots. Apples were removed from storage at 70 and 140 days after harvest and kept up to an additional 2 weeks at 20 °C for post-storage assessment of

ripening. Preharvest AVG application of 'Empire' fruit delayed maturation slightly as determined by starch index at harvest, but did not affect fruit size at harvest nor flesh softening in storage. All levels of 1-MCP were equally effective in controlling fruit softening both in air and CA, as 1-MCP-treated fruit were ≈2.5 kg firmer than untreated fruit. This firmness advantage was still evident even after 2 weeks at 20 °C, with CA-stored fruit holding their firmness the best. When all three technologies were combined, treated fruit were overall 156% firmer than control fruit (no AVG, no 1-MCP, air-stored). As well, ethylene production and emanation of aroma volatiles were reduced significantly in these fruit. Therefore, the synergism of AVG, 1-MCP and long-term CA storage could potentially hold flesh firmness and other ripening parameters of apples to values near those found at harvest.

129

Postharvest Life, Quality and Flavor Characterization of Three Strawberry Cultivars Kept in Air or CO₂-enriched Atmospheres

Clara Pelayo^{*1}, Betty Hess-Pierce¹, Susan E. Ebeler², and Adel A. Kader¹; Depts. of ¹Pomology and ²Viticulture and Enology, Univ. of California, Davis, CA 95616

Elevated CO₂ atmospheres reduce decay and extend postharvest life based on appearance of strawberries but flavor quality may be lost faster than appearance quality. California-grown 'Aromas', 'Diamante', and 'Selva' strawberries were stored at 5 °C in air or 20 kPa CO₂ + air for 15 days and evaluated for quality attributes, chemical changes, and flavor. In a "Preference Test", 'Selva' and 'Diamante' were more preferred than 'Aromas'. This may be related to their higher titratable acidity (TA), total soluble solids (TSS), the concentration of total aroma compounds, a different methyl/ethyl esters ratio, and the presence of C6 aldehydes. The postharvest life in air was 7, 9, and 9 days for 'Aromas', 'Diamante' and 'Selva', respectively and these periods were extended by 30%, 20%, and 45% in the CO₂-enriched atmosphere. There were no significant differences in TA or TSS between fruits kept in air or in air + CO₂ and panelists could not detect differences in sourness and sweetness after 9 days of storage. In contrast, there was a trend for CO₂-stored fruits of the three cultivars to be categorized as more aromatic, and for 'Aromas' and 'Selva' fruits to be described as more "strawberry like" in flavor compared to the corresponding air-stored fruits. The total aroma concentration decreased to a lesser extent in 'Aromas' and 'Selva' strawberries kept in air + CO₂ than in those stored in air. The CO₂-enriched atmosphere stimulated fermentative metabolism only in 'Aromas' and 'Selva'; the higher concentration of ethanol in these two cultivars favored the synthesis of ethyl esters. The total content of aroma compounds and the methyl/ethyl esters ratio may be two of the multiple factors determining the overall fruit flavor.

130

Response of Anaerobic Metabolism to Delaying Controlled Atmosphere Storage in Braeburn Apples

Yiping Gong^{*1}, Peter M.A. Toivonen¹, O.L. Lau², and Paul A. Wiersma¹; ¹Agriculture and Agri-Food Canada, Summerland Research Centre, Highway 97, Summerland, BC, V0H 1Z0, Canada; ²Industry Research Program, Okanagan Federated Shipper Association, c/o Agriculture and Agri-Food Canada, Summerland Research Centre, Highway 97, Summerland, BC, V0H 1Z0, Canada

Apple fruits (*Malus domestica* Borkh. cv. Braeburn) harvested from two orchards (A and B) on the same day were stored in air or pretreated in air for 0, 2 (2dCA) or 4 weeks (4dCA) before moving into controlled atmosphere (CA) storage with 1.5% O₂ + 5% CO₂. During storage at 1 °C for 9 weeks in air and/or CA, changes of pyruvate decarboxylase (PDC) activity, alcohol dehydrogenase (ADH) activity, acetaldehyde (AA) and ethanol (EtOH) concentrations in flesh tissue were assayed in addition to the incidence of Braeburn browning disorder (BBD). Immediate introduction to CA conditions induced the development of BBD with the highest incidence 62.2%, however delaying application of CA for 2 and 4 weeks reduced the incidence of BBD to 38.5% and 27.0%. The development of disorder in grower B was less than in grower A. 2dCA and 4dCA treatments did not influence PDC activity compared with treatment of CA. However, ADH activity and the accumulation of AA and EtOH in treatments of 2dCA and 4dCA were markedly lower than those in CA. The accumulation of AA in grower B was lower than grower A. The results of this study suggest that the delayed application of CA reduced BBD and this may be due to reduced anaerobic metabolism of fruits in the delayed CA.

Controlled Atmosphere Temperature Treatments for Disinfestation of 'Bing' Sweet Cherry

Krista C. Shellie*, Lisa Neven, and Steve Drake: United State Department of Agriculture, Agricultural Research Service, CQRU, 2301 S. International Blvd., Weslaco, TX 78596

Phytosanitary restrictions for insect pests can interfere with the marketing of fresh sweet cherries (*Prunus avium* L.). The objective of this research was to compare the quality of controlled atmosphere temperature treated (CAT) sweet cherries to methyl bromide fumigated cherries and non-heated, non-fumigated control fruit. Two CAT doses were evaluated: a 25-min exposure to 47 °C (117 °F) that heated the cherry center to 46 °C (115 °F), and a 40-min exposure to 45 °C (113 °F) that heated the cherries to a center temperature of 44 °C (111 °F). These heat doses approximated a heat dose that provides quarantine security against codling moth (*Cydia pomonella* Lw.) and western cherry fruit fly (*Rhagoletis cingulata* Lw.). An atmosphere of 1 kPa oxygen and 15 kPa carbon dioxide was established inside the treatment chamber for 21 min prior to heating. The influence on fruit quality of hydrocooling prior to the CAT treatment, cooling after treatment, and 2 weeks of cold storage after treatment in air or controlled atmosphere was evaluated. Each CAT dose was replicated four times using freshly harvested, 'Bing' sweet cherries acquired from similar grower lots. Quality attributes evaluated included: stem and fruit color, firmness, soluble solids concentration, titratable acidity, decay, and sensory evaluations. Hydrocooling prior to treatment, cooling method after heating and storage atmosphere had no significant influence on cherry quality after cold storage. The stem color of fumigated cherries was less green after storage than CAT treated cherries or untreated, control cherries. Cherries heated for 25 min were rated after cold storage by untrained panelists as similar to non-heated, non-fumigated control fruit. Heated cherries and methyl bromide fumigated cherries were less firm after cold storage than control fruit.

132

Semi-commercial-scale Ultra-low Oxygen Storage for Disinfestation of Mexican Fruit Fly in Grapefruit

Krista C. Shellie*¹ and Ken Rodde²; ¹United States Department of Agriculture, Agricultural Research Service 2301 S. International Boulevard Weslaco, TX 78596; ²TransFresh Corp. 40 Ragsdale Drive, Monterey, CA 93940

A treatment schedule for disinfesting grapefruit of Mexican fruit fly with refrigerated (14 °C) storage for 21 days in ultra-low oxygen (0.05 kPa) was tested using a fully loaded, 24-ft sea freight container. The objective of this research was 3-fold: 1) evaluate the ability of a free standing Electronic Oxygen Control system to maintain 500 ppm of oxygen for 21 days inside the sealed container, 2) evaluate the mortality of third instar Mexican fruit fly larvae stored for 21 days inside the sealed container, and 3) evaluate fruit market quality after 21 days inside the container. The container was loaded with 17 pallets of red-fleshed, 'Rio Star' grapefruit. Three boxes from each pallet were evaluated for fruit quality (decay (%), visible disorders (%)) after 21 days of treatment and again after 14 additional days of storage in air at 10 °C. Four cartons, each containing 24 fruit infested with third instar, Mexican fruit fly larvae, were each placed on top of a pallet in four different container locations. Upon completion of treatment, larvae were evaluated for survival. In the first replication, no fruit fly larvae survived the low oxygen treatment. In the second replication, oxygen concentration was less controlled, and 60 pupae survived the treatment. Treated and control grapefruit had similar incidence of decay when the treatment was terminated, however no sporulation was observed in fruit stored under ultra-low oxygen. Grapefruit exposed to ultra-low oxygen had a higher incidence of visible disorders, consisting of darkened, sunken areas on the fruit surface. It is unclear whether this damage is attributed to fluctuating levels of oxygen, deleterious volatiles produced during treatment, or a sensitivity of the fruit to low oxygen.

133

Watermelon Lycopene Content Varies with Cultivar and Maturity Stage

P. Perkins-Veazie*, J.K. Collins, and S. Pair: USDA-ARS, SCARL, Lane, OK 74555

The red flesh of watermelon contains the fat-soluble carotenoid pigment lycopene. A high level of lycopene in human blood serum has been correlated with a reduced incidence of several cancers. This experiment was done to determine the variation in lycopene content among watermelon cultivars and ripeness stages. Ten melons per cultivar of hybrid, open-pollinated, and triploid (seedless) types

were selected from field plantings at Lane, Okla. Additionally, 20-melon, quarterly shipments of hybrid or triploid types were used from commercial growers. Melons were cut transversely and a 100-g sample of heart tissue was removed from the center, frozen at -80 °C, extracted with a hexane-acetone-ethanol mixture and pigment quantified at 503 nm. Unripe melons (about 3 to 5 days from fully ripe) had 18% less lycopene than ripe melons. The average lycopene content of all ripe melons sampled (open-pollinated, hybrid, triploid) was 47.82 µg/g (n = 247 melons), while that of ripe hybrid and triploid melons was 54.76 µg/g (n = 209 melons). Lycopene content of ripe melons varied among cultivars, from as little as 33.96 µg/g in 'Crimson Sweet' to as much as 75.72 µg/g in 'Scarlet Trio'. These results indicate that fresh watermelon has a naturally high level of lycopene and that potential for enhanced lycopene content is already present in the germplasm of commercial cultivars.

41 POSTER SESSION 4 (Abstr. 134–158)

Crop Physiology

Monday, 24 July, 1:00–2:00 p.m.

134

Seasonal Variation in Composition and Total Load of Leaf Blade Epicuticular Waxes on Hosta

Jessie Kelth*, Carole H. Gaston, and Matthew A. Jenks: Dept. of Horticulture and Landscape Architecture, Purdue Univ., West Lafayette, IN 47907

Hosta variants for epicuticular waxes were selected based on variation in surface glaucousness, from highly glaucous to highly glossy. In an effort to determine seasonal variation in hosta waxes, gas-chromatography mass-spectrometry was used to perform detailed chemical analysis of the adaxial and abaxial leaf blade waxes four times points during the growing season, early spring, mid-spring, mid-summer, and autumn. These studies revealed that in all variants, the total wax loads increased dramatically during the period of leaf expansion in the spring, dropped roughly five fold by midsummer, and then accumulated slightly above summer levels into the fall season. The dominant wax constituent class on all hosta cultivars was primary alcohols. Changes in these alcohols were primarily responsible for seasonal changes in total wax load. In some variants, the shorter chain length alcohols were unusually high compared with alcohol distributions normally found on other plants. Besides primary alcohols, significant amounts of acids, aldehydes, and alkanes, were also found and shown to vary during the growing season. A possible association between these seasonal changes in wax profiles and hosta resistance to slugs is discussed.

135

Energy Balance and Water Loss of Two Shade Tree Species over Asphalt and Turf in Contrasting Climates

Roger Kjølgren*¹ and Janet Cole²; ¹Plants and Soils Dept., Utah State Univ., Logan, UT 84322; ²Dept. of Horticulture and Landscape Architecture, Oklahoma State Univ., Stillwater, OK 74078

We investigated water loss of shade trees over turf and asphalt in an arid and humid climate for Russian olive and silver maple. Total daily tree water loss, and dawn-to-dusk stomatal conductance (g_s) and leaf temperature (T_l), as well as air temperature, surface temperature, and vapor pressure deficit, were measured in Logan, Utah, and Stillwater, Okla., in early and mid-summer. Midday air temperatures in mid-summer were similar at both locations, 30 to 35 °C. Comparable vapor pressure deficits (VPD, kPa) were much higher in Logan, 3.5–5.0, than Stillwater, 2–2.5. Differences in humidity and air temperature between asphalt and turf were negligible at both Stillwater and Logan. Midday surface temperatures for asphalt and turf averaged 34 and 50 °C, respectively, in Logan, but were 10 °C higher for both surfaces in Oklahoma. The effect of higher longwave radiation from hotter surfaces on stomatal conductance and water loss of trees over asphalt in Stillwater was not consistently different for either species from those over turf. However, at Logan, T_l of trees over asphalt were consistently 2 to 4 °C higher and g_s was 10% to 20% lower than those over turf. Stomatal closure for trees over asphalt resulted in water loss that was the same or slightly lower as trees over turf. The effect of paved surfaces on tree water loss appears to be more pronounced in an arid than a humid climate. The combined effect of higher VPD in an arid region and greater longwave radiation from hotter paved surfaces in-

duces stomatal closure that limits water loss, and likely photosynthesis. By contrast, in humid regions, increased tree radiation interception over asphalt does not appear to trigger stomatal closure due to lower VPD.

136

Landscape Carbon Acquisition Potential of Residential Landscapes in Phoenix, Arizona

Chris A. Martin* and Linda B. Stabler; Dept. of Plant Biology, Arizona State Univ., PO Box 871601, Tempe, AZ 85287-1601

Urban sprawl of the greater Phoenix metropolitan area is rapidly replacing agricultural and non-irrigated desert vegetation with an irrigated urban forest comprised of a mixture of woody ornamental plant materials. Our objective was to estimate and compare the carbon acquisition potential (CAP) of residential landscape plants to the dominant plant species found in adjacent agricultural and desert sites. Maximum shoot and leaf gas exchange measurements were made at monthly intervals for one year (Aug. 1998 to July 1999) using a portable photosynthesis system. Concurrent diel gas exchange measurements were made seasonally. Gas exchange measurements were made on alfalfa at agricultural sites, blue palo verde, creosote bush and bur sage at desert sites, and on a mixture of 19 different woody ornamental tree, shrub and ground cover species at residential sites. A trapezoidal integration model was used to estimate daily CAP at each site based on maximum assimilation flux values and seasonally adjusted diel assimilation patterns. Annual landscape CAP was then calculated as the summation of estimates of daily CAP. Calculated annual CAP was highest at agricultural sites (159.0 mol/m² per year), lowest at desert sites (35.3 mol/m² per year), and intermediate at residential landscape sites (99.3 mol/m² per year).

137

Nitrate Assimilation and Carbon-14 Partitioning between Shoots and Roots of Tall Fescue

W. Michael Sullivan, Zhongchun Jiang*, and Richard J. Hull; Dept. of Plant Sciences, Univ. of Rhode Island, Kingston, RI 02881

Efficient use of nitrogen by turfgrasses depends on the ability of roots to absorb and assimilate nitrate. If a larger amount of nitrate is assimilated in the roots than in the shoots and organic N is transported to shoots as needed, nitrogen loss through clipping removal would be reduced. However, the ability of roots to assimilate nitrate depends on carbohydrate supply from the shoots. Our study examined the relationship between nitrate assimilation and photosynthate partitioning between shoots and roots of tall fescue grown in nutrient solution. To alter the pattern of nitrate reduction and photosynthate partitioning, we treated the plants as follows: 1) nutrient solution was aerated and nitrate was supplied to the roots, 2) nutrient solution was not aerated and nitrate was supplied to the roots, 3) nutrient solution was aerated and nitrogen was supplied to the leaves as nitrate, and 4) nutrient solution was aerated, and nitrogen was supplied to the leaves as urea. Photosynthate partitioning was assessed using carbon-14 as a tracer. Nitrate and nitrite reductase activities were determined by *in vivo* methods. Forty-eight hours after the grass leaves were exposed to carbon-14, >60% of the fixed carbon was translocated to stems and >15% to roots. Foliar application of urea resulted in less export of fixed carbon from leaves and lower leaf nitrite reductase activity than when nitrate was supplied to leaves. Less than 5% of the plant total nitrate reduction was attributed to root based activity. Root aeration decreased root nitrate reductase activity. Our results suggest that root-zone aeration and foliar N application could affect total nitrate assimilation and photosynthate partitioning to roots.

138

Nodulation Capacity of Rhizobia Isolated from Root Zones of *Maackia amurensis* in Two Chinese Forests

Mark Kroggel*, James A. Schrader, and William R. Graves; Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Maackia amurensis Rupr. & Maxim. is a leguminous tree species possessing meritorious ornamental characteristics and is confirmed to associate with rhizobia that fix nitrogen, but few attempts to isolate symbiotically superior rhizobia have been made. Our goals were to isolate rhizobia from the root zones of indigenous trees of *M. amurensis* in two ecologically distinct forests in the Heilongjiang Province of China, characterize the rhizobia, and compare their effectiveness at causing nodulation of this host plant. Rhizobia were isolated and cultured from nodules that formed on seedlings grown in soils collected in May 1998, from the Maershan (45°N, 127°E) and Liangshui (47°N, 128°E) Research Forests. In-

oculants from each of the 160 isolates were applied to seedlings. A subset of 48 isolates that evoked the most nodules was partitioned by cluster analysis into 12 similarity groups based on measures of number of nodules (17.9 ± 6.5), the ratio of growth rate on two distinct media (2.26 ± 1.8), pH reaction as measured by absorption at 614 nm of bromthymol blue (0.98 ± 0.36), and tolerance to sodium chloride at 15 g/L (23 out of 48). By using single-isolate cultures of similar cellular concentration as inoculants, one isolate from each group and USDA 4349, an isolate obtained during previous research, are being compared for their capacity to infect and nodulate seedlings.

139

Flower Senescence in *Hibiscus syriacus* L.

Hye Jin Kwon, Song Kwon, and Ki Sun Kim*; Dept. of Horticulture, Seoul National Univ., Suwon 441-744, South Korea

This experiment was undertaken to characterize the physiological changes taking place during the petal senescence of *Hibiscus syriacus*. Five distinctive developmental stages were chronologically suggested. Flower bud dry weight increased almost linearly from Stage I to Stage IV at a rate of ≈15 mg/day. Fresh weight and fresh/dry weight ratio increased much more rapidly between Stage III and Stage IV than during the early stage of development. It showed that petal expansion was partially due to an increased water uptake. The highest osmolality (411 mmol) was found in the fully open flowers. During the subsequent senescence and collapse of the flower, from Stage IV to Stage V, there were a rapid loss of fresh and dry weight and the fall of fresh/dry weight ratio, corresponding to the wilting that characterizes early senescence. A rise in cell sap osmolality coincided with the increase in soluble sugar content and fresh/dry weight ratio, and with the expansion of *Hibiscus syriacus* petal. Therefore, buds at Stage III, where they are under physiological maturity, might be appropriate to harvest. *Hibiscus syriacus* flowers showed a small but respiratory peak at Stage IV. The maximum rate of respiration was obtained with fully open flowers (Stage IV), whereas ethylene production remained extremely low until the petals started to open. Ethylene production, ACC synthase, and ACC content increased as the fresh weight of the flowers started to decline. At Stage V, there were a loss of petal fresh weight and a considerable increase in ethylene production (9 nL/g per h). The results of the present study have shown that petal tissue at Stage IV, presenescent stage, was characterized by the increase of soluble sugar and fresh weight, which might be expected to lead to petal expansion and limit turgidity. ABA and the stomata on petal might promote the disorganization.

140

Ultrastructural Changes during the Senescence of Petals in *Hibiscus syriacus* L.

Hye Jin Kwon*, Song Kwon, and Ki Sun Kim; Dept. of Horticulture, Seoul National Univ., Suwon 441-744, South Korea

Five distinctive developmental stages were chronologically suggested. Cells at Stage I and II were essentially free of cytoplasmic or vacuolar abnormalities and the cytoplasm contained numerous electron-dense mitochondria with well-developed cristae. At Stage III, there were a localized dilation of mitochondria matrix and a partial-diluted cytoplasm in mesophyll cells. At Stage IV, characterized by high levels of fresh weight and osmolality, most mesophyll cells were seen to be ruptured, resulting in a general mixing of cell contents and diluting cytoplasm. It can be explained as an irreversible senescence phenomena that tonoplast in mesophyll cell was ruptured partly, corresponding to rapid increase in petal cell size and turgidity. Petal turgidity was due to an increase of content in soluble sugar. At Stage V, there was a loss of petal fresh weight. With a loss of turgidity, most mesophyll cells have collapsed completely. There were a notable plasmolysis in vasculature. The activity of protease in petals was found to increase between Stage II and III, and then decreased rapidly at Stage IV, resulting in the decrease of total protein content before senescence. Unexpectedly, there were stomata in hibiscus petals. Ultrastructural disorganization, like as a broken tonoplast, was observed in mesophyll cells at Stage IV. ABA and the stomata on petal might promote the disorganization. The final stages of senescence involved breakdown of cellular organization leading to hydrolysis of previously separated compartments. The cellular disorganization triggered during the flowers are still in the process of opening may be one of the earliest physiological signal that senescence is under way.

Salinity Tolerance of Four Turfgrasses

Saad Alshammary*, Y.L. Qian, and S.J. Wallner; Dept. of Horticulture and Landscape Architecture, Colorado State Univ., Fort Collins, CO 80523

The need for salinity-tolerant turfgrasses is increasing because of increased use of effluent water for turfgrass irrigation. Greenhouse studies were conducted to determine the relative salt tolerance and salt tolerance mechanisms of 'Challenger' Kentucky bluegrass (*Poa pratensis*), 'Arid' tall fescue (*Festuca arundinacea*), 'Fults' alkaligrass (*Puccinellia distans*), and a saltgrass (*Distichlis spicata*) collection. Kentucky bluegrass and tall fescue were irrigated with saline solutions at 0.2, 1.7, 4.8, or 9.9 dS/m, whereas alkaligrass and saltgrass were irrigated with saline solutions at 0.2, 28.1, 32.8, or 37.5 dS/m prepared using a mixture of NaCl and CaCl₂. The salinity levels that caused 50% shoot growth reduction were 9.0, 10.4, 20.0, and 28.5 dS/m for Kentucky bluegrass, tall fescue, saltgrass, and alkaligrass, respectively. Concentrations of proline, a proposed cytoplasmic compatible solute, were 25.8, 30.4, 68.1, and 17.7 μmol/g shoot fw in Kentucky bluegrass, tall fescue, alkaligrass, and saltgrass, respectively, at the highest salinity level imposed. Bicellular, salt-secreting glands were only observed by scanning electron microscopy on leaves of saltgrass, indicating salt secretion is one of the important salt tolerance mechanisms adopted by saltgrass. Ion contents (Na, Cl, and Ca) in both shoots and roots of all grasses increased with increasing salinity levels. However, alkaligrass maintained a much lower Na, Ca, and Cl contents in roots and shoots than other grasses, suggesting that ion exclusion is one of the major salt tolerance mechanisms in alkaligrass. Tall fescue did not appear to restrict the uptake and translocation of salt in shoot tissues, but maintained a higher K/Na ratio than all other grasses under saline conditions.

142

Root Mortality and Nutrient Uptake of Creeping Bentgrass in Response to Differential Root and Shoot Temperatures

Bingru Huang* and Qingzhang Xu; Department of Horticulture, Kansas State University, Manhattan, KS 66506

This study was designed to compare and determine root growth and nutritional responses of creeping bentgrass cultivars that differ in heat tolerance to deferential, supraoptimal shoot and root temperatures. Shoots and roots of 'Penncross' (heat sensitive) and 'L-93' (heat tolerant) were exposed to four differential air/soil temperature regimes (20/20-control, 20/35, 35/20, and 35/35 °C) in water baths and growth chambers. Exposing roots to supraoptimal root temperature (35 °C) while maintaining shoots at normal temperature (20 °C), or at 35 °C in particular, reduced root fresh weight, root number, the content of N, P, and K in shoots and roots, and accelerated root death for both cultivars. High root temperature had a greater detrimental effects on root growth and nutrient accumulation than high shoot temperature for both cultivars. Reducing root temperature at supraoptimal shoot temperature improved root growth, reduced root mortality, and increased N, P, and K content in shoots and roots. Among the three nutrient elements, K was the most sensitive to changes in root temperature. L-93 generally maintained higher root fresh weight and number, and N, P, K content in shoots and roots, particularly K in roots, under high root (20/35 °C) or shoot/root (35/35 °C) temperatures. The results indicated that root growth and nutrient accumulation, particularly K, played an important role in creeping bentgrass tolerance to heat stress imposed to shoots by high air temperature or to roots by high soil temperatures. Reducing root temperature under supraoptimal ambient temperatures enhanced root growth and nutrient relations, and thus could lead to the improved shoot growth in cool-season grasses as reported previously.

143

Gas Exchange, Water Relations, and Growth of Seaside Alder Exposed to Drought and Flooding

William R. Graves and Sarah J. Gardner*; Department of Horticulture, Iowa State University, Ames, IA 50011-1100

Alnus maritima [Marsh.] Nutt. (seaside alder) is a rare species that occurs naturally only on soils that are frequently or constantly saturated with fresh water. The objective of our first experiment was to determine effects of drought and flooding treatments of differing severity on foliar gas exchange, water relations, and development of plants grown in containers in a greenhouse. In a second experiment we examined how the rate of water loss from soil during drought episodes affected the gas exchange and survival of leaves. In the first experiment, changes in soil moisture content, which ranged from saturation to 10% or less by volume across treatments, were associated with altered stem water potential and

net photosynthesis. Analysis of the osmolarity of liquid extracted from leaves indicated that osmotic adjustment did not occur in response to drought. Shoot dry weight per plant ranged from over 7 g (only the lower portion of the soil profile kept saturated) to less than 3 g (entire soil profile constantly saturated). Episodes of drought of different severity led to plants with shoots that weighed between these two extremes, and exposure to soils with 10% water or less by volume did not elicit leaf desiccation or abscission. Results of the second experiment suggest that leaf desiccation can result from exposing plants to 10% water or less by volume if the drought develops rapidly in a small volume of soil. We conclude that, despite the niche it occupies in nature, seaside alder may have the potential to be used in managed landscapes with soils that vary in moisture content.

144

The Effect of Water Stress on Growth of Several Warm-season Turfgrass Species

Edward W. Bush*, James N. McCrimmon, and Allen D. Owings; Louisiana State University Agricultural Center, Department of Horticulture, 137 J. C. Miller Hall, Baton Rouge, LA 70803

Four warm-season grass species [common carpetgrass (*Axonopus affinis* Chase), common bermudagrass (*Cynodon dactylon* [L.] Pers.), St. Augustinegrass (*Stenophrum secundatum* Walt. Kuntze.), and zoysiagrass (*Zoysia japonica* Steud.)] were established in containers filled with an Olivia silt loam soil for 12 weeks. Grasses were maintained weekly at 5 cm prior to the start of the experiment. Water stress treatments consisted of a control (field capacity), waterlogged, and flooded treatments. Waterlogging and flood treatments were imposed for a period of 90 days. The effects of water stress was dependent on grass species. Bermudagrass vegetative growth and turf quality were significantly reduced when flooded. Carpetgrass, St. Augustingrass, and zoysiagrass quality and vegetative growth were also reduced by flooding. St. Augustinegrass and zoysiagrass root dry weight was significantly decreased. Zoysiagrass plants did not survive 90 days of flooding. Leaf tissue analysis for common carpetgrass, common bermudagrass, St. Augustinegrass, and zoysiagrass indicated that plants subjected to waterlogging and flooding had significantly elevated Zn concentrations.

145

Water Deficit Stress Responses of Seven Tree Species Used in Urban Landscapes

Coye A. Balok and Rolston St. Hilaire*; Department of Agronomy and Horticulture, New Mexico State University, Box 30003, MSC 3Q, Las Cruces, NM 88003

Plant development, leaf morphology, leaf cuticular wax content, and leaf water relations were determined for seven tree species exposed to consecutive cycles of drought. The objective of the experiment was to identify plant taxa suitable for landscapes prone to drought. On the day drought treatments began, plant development traits and leaf morphology varied among species. Leaf cuticular wax content was different among species and ranged from 0.053 mg·cm⁻² in California white oak (*Quercus lobata* Née), to 0.200 mg·cm⁻² in Texas red oak (*Quercus buckleyi* Buckl.). Wax content in Bur oak (*Quercus macrocarpa* Michx.) and Shumard oak (*Quercus shumardii* Buckl.) averaged 0.105 and 0.11 mg·cm⁻², respectively. At harvest, Texas red oak plants treated with drought had the highest root-to-shoot dry weight ratio which averaged 3.1. In contrast, plants of Arizona ash (*Fraxinus velutina* Torr.) and California white oak that were frequently irrigated had the lowest root-to-shoot dry weight ratio. Drought did not affect stem elongation, total lamina area, leaf dry weight, and specific leaf weight. Abaxial leaf surfaces of Arizona ash were the most pubescent and averaged 1836 trichomes/cm². Drought-stressed plants of golden rain tree (*Koelreuteria paniculata* Laxm.) had the most negative midday leaf water potential, which averaged -2.5 MPa. Plants of Chinkapin oak (*Quercus muehlenbergii* Engelm.) that were irrigated frequently had the least negative predawn leaf water potentials. Predawn leaf water potentials tended to be more negative for Arizona ash and golden rain tree than for the oak species. These results suggest that some species of oak might perform well in landscapes prone to drought.

146

Cold Hardiness Evaluation of Deer-resistant *Thuja plicata* for Northern Latitudes

A.M. Shirazi*, T.M. Boland, and K.R. Bachtell; The Morton Arboretum, 4100 Illinois Route 53, Lisle, IL 60532

The expansion of urban communities to rural areas is leading to an increase of the problem of deer damage. White-tailed deer (*Odocoileus virginianus*) dam-

age to landscape plants in commercial nurseries, residential and public areas is very widespread. *Thuja occidentalis* (Arborvitae) is one of the most common landscape plants. It is widely produced by nurseries and used by homeowners in the landscape. However, it is also highly favored by deer for browsing. *Thuja plicata* (Arborvitae) the Western Cedars is a highly deer-resistant arborvitae. One of the principal limiting factors for new arborvitae for its success in nursery production and its use in the landscape is cold hardiness (in northern climates). However, the cold hardiness of different *Thuja plicata* is not known. Deer-resistant *Thuja plicata* cultivars: 'Atrovirens', 'Cancan', 'Elegantissima', 'Excelsa', 'Gelderland', 'George Washington', 'Hillier', 'Sunshine', and 'Virescens' planted in Spring 1998 at The Morton Arboretum research plot in Lisle, Ill. Branch cold hardiness was tested by artificial freezing in Jan. 1999 and 2000. Ice-nucleated samples were placed in an ultra-low temperature and kept at 2 °C overnight, and the temperature then lowered at 5 °C/h to -40 °C, at which time samples were taken out at each test temperature (at 4 °C intervals). After the freezing test, the samples were thawed at 4 °C for 24 h, then planted in a peat and perlite media and kept at 100% humidity in a greenhouse. Samples were evaluated after 2 weeks for visual browning and lowest survival temperature. There were significant differences in coldhardiness between the nine cultivars tested in Jan. 1999. 'Elegantissima', 'Excelsa' and 'Cancan' were the most hardy (-34 to 40 °C), followed by 'Virescens', 'Sunshine', and 'Gelderland' (-27 to 32 °C), 'Hillier' and 'Atrovirens' (-24 to 25 °C). 'George Washington' was the least hardy (-20 °C) cultivar.

147

A 27-kDa Rhododendron Deacclimation Protein is Related to ABA Stress Ripening/Water Deficit Stress Inducible Family of Proteins

Rajeev Arora* and Chon-Chong Lim; Division of Plant & Soil Sciences, P.O. Box 6108, West Virginia University, Morgantown, WV 26506

Many reports have shown the accumulation of specific proteins associated with cold acclimation in plants. However, there is a scarcity of data on the physiological and/or biochemical changes associated with deacclimation process. This study was initiated to determine protein changes specifically associated with deacclimation in Rhododendron. Current-year leaves were collected from three Rhododendron cultivars ('Chionoides', 'Grumpy Yellow', and 'Vulcanis Flame'; ≈4-year-old rooted cuttings) during natural non-acclimated (June), cold-acclimated (January), and deacclimated (May) state. Leaf freezing tolerance was evaluated using controlled freezing protocol (Lim et al. 1998, J. Amer. Soc. Hort. Sci. 123:246-252). Seasonal SDS-PAGE profiles exhibited a distinct accumulation of 27 kDa protein in deacclimated and nonacclimated tissues, but this protein was essentially undetectable in cold acclimated tissues of all three cultivars. Further characterization of this polypeptide, labeled as RhDAP27 (for rhododendron deacclimation protein), revealed that it has an iso-electric point of 6.5, has a compositional bias for Glu/Gln (13.9%), His (11.4%), Gly (11%), Ala (10%), Lys (8.3%), and Asp/Asn (8.1%)—hydrophilic amino acids constituted about 54% of the total amino acids while 40% were nonpolar, aliphatic amino acids (Gly, Ala, Val, Leu, Ile, Pro) and only 6% were aromatic amino acids (Phe and Tyr). Micro-sequencing of the four peptides produced by partial cleavage of RhDAP27 revealed a striking homology of RhDAP27 with two proteins (from Mesembryanthemum crystallinum and *Pinus taeda*) that belong to the family of ABA stress ripening/water deficit stress inducible proteins.

148

Seasonal Cold Hardiness Estimations of Male and Female Specimens of Two Holly Species

Orville M. Lindstrom¹, Malgorzata A. Florkowska*¹, John Ruter², and Pamela Lewis³; ¹Department of Horticulture, University of Georgia, Griffin Campus, 1109 Experiment Street, Griffin, GA 30223-1797 ²Department of Horticulture, University of Georgia, Coastal Plain Station, Tifton, GA 31793 ³Bamboo Farm and Coastal Gardens, 2 Cranebrake Road, Savannah, GA 31419

Seasonal, stem and leaf cold hardiness levels of male and female plants of *Ilex purpurea* Hassk. and *Ilex rotunda* var. *microcarpa* (Lindl. ex Paxton) were determined over two winter seasons. The samples for the cold hardiness studies were taken from established plants growing at the Univ. of Georgia Bamboo Farm and Coastal Gardens in Savannah. Each month, 40 stem cuttings (4 to 5 inches long) were sent by overnight mail for evaluation. The plants were prepared for laboratory freezing exposure tests within 2 h of receiving. The samples were visually evaluated after freezing exposure to estimate their cold hardiness. In general, *Ilex purpurea* was more cold-hardy than *I. rotunda* var. *microcarpa* over

both seasons tested, except in midwinter (Jan. 1998 and Feb. 1999) where *I. rotunda* var. *microcarpa* was more cold-hardy than *I. purpurea*. *Ilex purpurea* attained cold hardiness earlier in the fall and lost its hardiness later in the spring. In general, few consistent differences were observed between the cold hardiness of male and female plants within species.

149

Effects of Plant Growth Retardants on the Growth of *Aerides japonicum* Cultured in Vitro

J.D. Chung*¹, Y.K. Park¹, S.O. Jee², H.Y. Kim³ and M.S. Cho⁴; ¹Dept. of Horticulture, Kyungpook National Univ., Taegu 702-701, Korea; ²Dept. of Horticulture, Joongbu Univ., Kumsan 312-940, Korea; ³Dept. of Life Resources, Catholic Univ., of Taegu-Hyosung, Kyungsan 712-702, Korea; ⁴Dept. of Horticulture, Taegu Univ., Kyungsan 712-714, Korea

This experiment was conducted to identify the effect of various growth retardants on the growth of *Aerides japonicum* in vitro. Paclobutrazol was found the most effective retardant for reducing the leaf growth of seedling. Ancymidol and uniconazole also showed retarding effects on leaf growth of one, whereas Daminozide didn't. When growth retardants were added to culture medium, leaf length of seedlings was gradually shortened and leaf width became wider than that of control. However, root length was shorter and number of roots and root diameter were greatly increased. On the contrary, at 0.05 and 0.1 ppm uniconazole, growth of leaf and root were enhanced. It was showed that the possibility of using as an additive for good growth of *Aerides japonicum* seedling in vitro. The activity of GA-like substances was higher in the portion in which growth of seedlings were promoted. It was identified by anatomical observations that the number of stomata and thickness of cell layer in leaf were increased by treatment of retardants.

150

Color Fading of Rose Petals Due to a Transient High Temperature Stress

M. Oren-Shamir* and Dela Gal; Institute of Horticulture, A.R.O., The Volcani Center, Bet-Dagan 50250, Israel

Changes in temperature during rose flower development, often cause a significant fading of flower color, decreasing its market value. We are studying the effect of transient high temperature stress on red roses (*Rosa xhybrida*, 'Jaguar'). We have found that a transient temperature stress of 39/18 °C day/night respectively for 3 days, in comparison to the growth temperature of 26/18 °C, caused a significant fading to flower color at a mature bud stage. The plant organ responsible for color fading is the flower bud only. When the stress was applied to the whole plant, not including the flower buds, there was no change on the mature bud color. We have also shown that there are specific flower developmental stages sensitive to the transient increase in temperature. Flower buds at the critical stage of development, that have been exposed to temperature increase have a faded pink-red color when matured. Total anthocyanin levels of faded flowers, due to temperature stress, decreased to ≈50%. In addition, the ratio between the two anthocyanidins composing the red color, cyanidin and pelargonidin, changed dramatically due to the temperature stress: flowers on plants that have not overcome a temperature stress had a ration of 1:1, while those that have faded due to the temperature stress have a ration of 2:1 of pelargonidin to cyanidin, respectively. These findings hint to specific stages of anthocyanin synthesis, that are hypersensitive to increased temperature. We are now in the process of identifying and characterizing these stages.

151

The Effect of Supro-optimal Temperature on Photosynthesis, Carbohydrate Allocation, Flowering, and Growth of *Coreopsis grandiflora* 'Sunray' AND *Gaillardia x grandiflora* 'Goblin'

Melyssa K. Davis* and Jeff S. Kuehny; Department of Horticulture, 137 Julian C. Miller Hall, Louisiana State University, Baton Rouge, LA 70803-2120

Coreopsis and *Gaillardia* were exposed to supra-optimal temperatures of 35 °C for a 6-week period beginning at flower initiation. Photosynthesis measurements were recorded at 1100 HR, 1300 HR, and 1500 HR for 3 days each week and carbohydrate partitioning was determined once per week. Results indicate that the time of day the measurements were taken made little difference on rate of photosynthesis and that there was a similar trend in photosynthetic rate over the 6-week period. Photosynthesis decreased as the plants began to flower and then increased until the onset of flower senescence. The patterns of carbohydrate par-

tititioning were similar to those observed for photosynthesis. The plants grown at supra-optimal and optimal conditions had a similar trend and rate of photosynthesis throughout the 6-week period. Plant growth and total carbohydrates significantly decreased as the duration of high temperature increased for both species, however *Gaillardia* was more heat tolerant than *Coreopsis*.

152

Environmental Factors Affect the Growth and Transpiration Rate of Potted Oriental Cymbidium (*Cymbidium goeringii*)

Keun Ho Cho¹, Beyoung Hwa Kwack², Moo Ryong Huh³, and Chiwon W. Lee¹; ¹Dept. of Plant Sciences, North Dakota State Univ., Fargo ND 58102; ²Dept. of Horticultural Science, Korea Univ., Seoul, 136-701, South Korea; ³Dept. of Horticulture, Gyeongsang National Univ., Chinju 660-701, South Korea

The biomass yield, transpiration rate, and chlorophyll contents in *Cymbidium goeringii* plants grown under various light, temperature, and humidity conditions were investigated. Two-year-old plants potted in pine-bark medium were grown for 12 weeks during the summer months in polyethylene film-covered mini-greenhouses having four different environmental conditions: a) closed house (CH) with high humidity (95.1% RH), high light (800 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and high temperature (37.5 °C), b) ventilated house (VH) with low humidity (41.4% RH), high light (800 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$), and medium temperature (31.5 °C), c) shaded closed house (SCH) with high humidity (91.0% RH), low light (110 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and medium temperature (33.3 °C), and d) shaded ventilated house (SVH) with medium humidity (61.5% RH), low light (110 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) and low temperature (30.5 °C). Plants grown in CH produced leaf chlorosis with 50% shorter leaves and 40% lower relative growth rate (7.9 mg/g fresh weight per day) compared to plants grown in SVH. *Cymbidium* plants grown in SCH or SVH showed higher leaf and root dry weights as compared to those grown in CH or VH. Leaf chlorophyll-a and -b contents as well as carbohydrate levels were the highest in plants grown in SVH, indicating the benefits of shading and ventilation. The rate of transpiration showed a quadratic response to increasing levels of leaf temperature ($r^2 = 0.81$), wind velocity ($r^2 = 0.82$), and vapor pressure deficit (VPD, $r^2 = 0.91$). Regression analysis revealed that the maximum transpiration rate occurred at 25.4 °C leaf temperature, 2.1 m/s wind velocity, and 2.3 kPa VPD in this experiment.

153

Garden Performance of New Guinea Impatiens in Sun and Shade

R.D. Berghage¹, E.J. Holcomb¹, and A.H. Michae²; ¹Department of Horticulture, Pennsylvania State University, University Park, PA 16802-4200; ²Dauphin County Cooperative Extension

The New Guinea Impatiens (*I. hawkeri* Bull.) has become one of the most important spring crops for many growers. Rapid and continuous development of new and improved cultivars have lead to tremendous diversity in flower color, leaf color, plant size, and growth rate. Penn State has conducted large-scale garden evaluations of New Guinea Impatiens since the mid-1990s. Each cultivar is evaluated in both the sun and shade for uniformity, flowering, foliage, and overall growth and form. Ratings use a 1 to 5 scale with 1 being unacceptable, 2 = poor, 3 = fair, 4 = good, and 5 = excellent. Height, width, and flower size are measured in August. One hundred fourteen cultivars in 15 commercial series have been in the trials for two or more seasons. There are significant differences in the performance of cultivars and series in the trials. 'Celebrette', 'Paradise', 'Pure Beauty', 'Celebration', and 'Riviera' were the top-performing series. Within each series there were outstanding cultivars and others that did not perform as well. Plants performed better in the shade than in the sun. The average rating for plants grown in the sun was 3.3 while the rating for shade grown plants was 3.8. New Guinea impatiens were shorter (11 vs. 12.3 cm), spread less (18.9 vs. 22.1 cm), and had smaller flowers (4.8 vs. 5.3 cm wide) in the sun than in the shade, respectively. There were no significant interactions between sun vs. shade, and cultivar or series.

154

Suppressing Purple Passion (*Gynura aurantiaca*) Flowering Using Selected Plant Growth Regulators

Jianjun Chen*, Russell D. Caldwell, and Cynthia A. Robinson; University of Florida, Mid-Florida Research and Education Center, 2725 Binion Road, Apopka, FL 32703

Gynura aurantiaca is a colorful foliage plant with creeping stems and velvety purple hairs that cover the green leaves. It grows rapidly, but is cultivated prima-

rily for those attractive purple leaves. Annually during the spring, this plant produces prominent flowers both in appearance and smell, gaudy and malodorous. Flowering coupled with acquiring an over-grown leggy appearance have been key limitations in its production and use in interiorscaping. This study was undertaken to determine if an available commercial plant growth regulator could inhibit flowering. A-Rest (ancymidol), B-Nine (daminozide), Bonzi (paclobutrazol), cycocel (chlormequat chloride) and florel (ethephon) each diluted to three different concentrations were sprayed in two applications in early spring at 2-week intervals. Flowering and bud numbers and plant growth (number of lateral shoots, vine lengths and internode lengths) were recorded. Results indicated that applications of A-Rest, B-Nine, Bonzi and Cycocel, regardless of treatment concentrations, were ineffective in suppressing the flowering of this plant; whereas, florel completely suppressed flowering at the three concentrations used. The florel-treated plants also grew more lateral shoots, which produced a compact and dense bush-look, indicating that appropriate concentrations of florel application not only will stop flowering of purple passion but can also improve and prolong its aesthetic value as a potted or hanging-basket interior plant.

155

Fertilizer Concentration Affects Whole Plant CO₂ Exchange and Growth of Subirrigated Pansies

Marc van Ierse¹ and Jong-Goo Kang²; ¹Dept. of Horticulture, Univ. of Georgia, Griffin, GA 30223-1797; ²Dept. of Horticulture, Suncheon National Univ., South Korea

Subirrigation is an economically attractive irrigation method for producing bedding plants. Because excess fertilizer salts are not leached from the growing medium, salts can accumulate in the growing medium. Fertilizer guidelines developed for overhead irrigation may not be appropriate for subirrigation systems. Our objective was to quantify the effect of the fertilizer concentration (N at 0, 135, 285, and 440 mg·L⁻¹) on whole-plant CO₂ exchange and growth of subirrigated pansies. Whole plant CO₂ exchange rate (net photosynthesis and dark respiration) was measured once every 10 min for 31 days. Whole-plant photosynthesis, dark respiration, and carbon use efficiency increased during the experiment. Fertilizer concentration started to affect the growth rate of the plants after approximately 7 days. Maximum photosynthesis and growth were achieved with N at about 280 mg·L⁻¹ in the fertilizer solution [electrical conductivity = 2 dS·m⁻¹]. Growth was reduced by ≈10% when the plants were fertilized with N at 135 and 440 mg·L⁻¹ compared to 280 mg·L⁻¹. Growth of plants watered without any fertilizer was greatly reduced, and plants showed symptoms of N and K deficiency. The size of the root system decreased and the shoot : root ratio increased with increasing fertilizer concentration, but the size of the root system was adequate in all treatments. These results indicate that subirrigated pansies can tolerate a wide range of fertilizer concentrations with relatively little effect on plant growth.

156

Effects of the Inductive Period, Shoot Density, and Leaf Removal on the Flowering of *Heliconia rostrata* Ruiz & Pavon

Norberto Maciel* and Richard A. Criley; Dept. of Horticulture, Univ. of Hawaii, Honolulu, HI 96822

Heliconia rostrata is a herbaceous-musoid sympodial rhizomatous plant that grows as clump. After three leaves are produced, each shoot of the clump may bear an inflorescence if it is induced by short days (SD). However, the relationship between shoot density and flowering has not been quantified. To evaluate the effects of the inductive period, number of shoots, and leaf removal on flowering, rhizomes were planted in 120 pots (8 L). One-third of the pots were planted with two rhizomes, while the remainder was planted with one. One-half of the pots with one rhizome were allowed to develop all their shoots for three generations, while in the remaining pots only one shoot per generation was allowed to grow. In addition, one-half of the plants in all the treatments were subjected to selective leaf removal. The plants were grown under long days (LD) >13 h in a glasshouse until four leaves were produced. Inductive SD was supplied to all the plants from 5:00 PM to 8:00 AM. After 8 weeks of SD, one-half of the plants were given LD, while the other half continued under SD (conSD) until flowering. The highest percentage of flowering shoots (39% to 35%) was observed in plants under conSD; plants under SD-LD were 10% to 9%. The second generation of shoots showed the highest flowering (74% conSD and 21% SD-LD), followed by the first (62% conSD and 18% SD-LD), and third (31% conSD and 0% SD-LD) generations. Non-flowering shoots of the first generation were aborted or dead.

Shoots of the third were still vegetative, since they had few leaves to be induced. Fewer flowers occurred in clumps allowed to develop all their shoots. Intact plants from rhizomes with one shoot per generation flowered more than the partially defoliated ones under conSD.

157

Susceptibility of Poinsettia Cultivars to Whiteflies

Robert P. Rice Jr.^{*1} and Michael Crane²; ¹Cal Poly, San Luis Obispo, CA 93407; ²Western Farm Service, Oxnard, Calif.

Twenty-four poinsettia cultivars (*Euphorbia pulcherrima*) were exposed to a population of greenhouse whitefly (*Trialeurodes vaporariorum*) and silverleaf whitefly (*Bemisia argentifolii*) for 6 weeks. Evaluation was based on the number of immature whitefly present on each of the marked leaves. The poinsettias that produce white bracts were more heavily infested with immature stages of whitefly than those cultivars that produce red bracts, while those that produce pink bracts were intermediate. There was a wide range in degree of whitefly infestation among poinsettia cultivars. Leaf trichome density also explained a portion of the variance in whitefly oviposition rates among several of the cultivars. Cultivars with high trichome densities sustained less whitefly oviposition than did cultivars with low trichome densities. Certain cultivars tested showed an appreciable natural resistance to whitefly ('Freedom Red', 'Freedom Bright Red', 'Red Velvet', 'Cranberry Punch', 'Pepride').

158

Dormancy of *Ornithogalum* Evaluated by Nuclear Magnetic Resonance Imaging

M.S. Roh^{*1}, M. Line², Y.H. Joun¹, and P. Brannigan¹; U.S. Department of Agriculture, Agricultural Research Service, ¹Floral and Nursery Plants Research Unit and ²Environmental Chemistry Laboratory, Beltsville, MD 20705

Ornithogalum hybrid bulbs (selection 327-2) were stored dry at 10, 16, 22, 28, and 35 °C for 6 weeks upon harvest. After storage, bulbs were subjected to a nuclear magnetic resonance (NMR) imaging to obtain the longitudinal spin-lattice relaxation time (T1) profile across the cross section of intact bulbs and to a scanning electron microscopy (SEM) to observe an inflorescence development. Bulbs were forced in a greenhouse maintained at 21/19 °C. When bulbs were stored at 10, T1 was shorter through the cross section of bulbs and the shoot apex was under a vegetative stage. This suggests that dormancy was not broken during the storage, leaf emergence was delayed, and plants failed to flower. Bulbs stored at 22 and 28 °C formed the primary scape and inflorescence with several florets. At the base of the primary scape of bulbs stored at 22 °C, a vegetative apex was observed by both MR imaging (MRI) and SEM. In the center of bulbs where leaves and floral organs were present, T1 was longer as compared to the scales. This suggests that dormancy in the scales was broken and the leaves and scape were ready to emerge. Leaf emergence and flowering was the fastest when bulbs were stored at 22 °C and at 16 or 22 °C, respectively. Due to its nondestructive nature, MRI can be used to study the state of bulb dormancy and also the progress of inflorescence development during bulb storage prior to planting.

93 POSTER SESSION 11 (Abstr. 159–188)

Crop Physiology

Tuesday, 25 July, 1:00–2:00 p.m.

159

The Relationship between Actual Photosystem II Efficiency and Quantum Yield for CO₂ Assimilation is Not Affected by Nitrogen Content in Apple Leaves

Lailiang Cheng^{*1}, Leslie H. Fuchigam², and Patrick J. Breen²; ¹Dept. of Fruit & Vegetable Science, Cornell University, Ithaca, NY 14853; ²Dept. of Horticulture, ALS 4017, Oregon State University, Corvallis, OR 97331

Bench-grafted Fuji/M26 apple (*Malus domestica* Borkh) trees were fertigated with different concentrations of nitrogen by using a modified Hoagland's solution for 45 days. CO₂ assimilation and actual photosystem II (PSII) efficiency in response to incident photon flux density (PFD) were measured simultaneously in recent fully expanded leaves under low O₂ (2%) and saturated CO₂ (1300 ppm) conditions. A single curvilinear relationship was found between true quantum

yield for CO₂ assimilation and actual PSII efficiency for leaves with a wide range of leaf N content. The relationship was linear up to a quantum yield of approximately 0.05 mol CO₂/mol quanta, then became curvilinear with a further rise in quantum yield in response to decreasing PFD. This relationship was subsequently used as a calibration curve to assess the rate of linear electron transport associated with rubisco and partitioning of electron flow between CO₂ assimilation and photorespiration in different N leaves in response to intercellular CO₂ concentration (C_i) under normal O₂ conditions. Both the rate of linear electron flow, and the rate to CO₂ or O₂ increased with increasing leaf N at any given C_i, but the percentage of linear electron flow to CO₂ assimilation remained the same regardless of leaf N content. As C_i increased, the percentage of linear electron flow to CO₂ assimilation increased. In conclusion, the relationship between actual PSII efficiency and quantum yield for CO₂ assimilation and the partitioning of electron flow between CO₂ assimilation and photorespiration are not affected by N content in apple leaves.

160

Light Conversion Efficiency in Peach Training Systems

Luca Corelli-Grappadelli^{*}, Gianfranco Ravaglia, and Eugenio Magnanini; Dipartimento Colture Arboree, Universita' di Bologna, V. F. Re 6, 40126 Bologna, Italy

Training system efficiency may be defined as the ratio of fruit produced to the amount of light intercepted by the canopy. In apple, a positive, linear relationship between yield and light intercepted is generally found, but in peach similar data are hard to come by. This paper reports data from an ongoing training systems trial now in the 7th year, with trees trained as Y, palmette, and delayed vase. During the life of the orchard, light interception has been measured for the different tree shapes, the yields have been recorded, and, in some years, whole-canopy gas exchanges of cropping trees have been measured. In general, the trees have been intercepting light in amounts proportional to canopy shape and tree density, with the Y (planted at higher density) intercepting more light than the other two systems, which appear more comparable to each other, despite the fact that they intercept light during the day in different ways, with the delayed vase exposing more or less the same leaves to incoming light during most of the day. Cropping has followed the amounts of light intercepted, with higher yields for the Y, without appreciable differences in fruit quality traits. The data accumulated so far indicate furthermore that the palmette and the delayed vase, despite slightly different light interception potentials (lower for the palmette), have similar yields. This might depend in part on the fact that these two systems intercept light according to different patterns during the day, with the palmette—which distributes the light intercepted in a more even fashion between the two sides—perhaps at an advantage over the vase in terms of managing the stress of excessive light (heat) loads during the central hours of the day. Whole canopy Carbon exchange data have been found to be in agreement with the patterns of light interception.

161

Effects of Light Intensity on Leaf Anatomy of Some Tropical Fruit (Rambutan, Durian, Mangosteen, and Longkong)

Montree Issarakraisila^{*1} and Ravie Sethpakdee²; ¹Institute of Agricultural Technology, Walailak Univ., Nakhon Sri Thammarat, Thailand; ²Dept. of Horticulture, Faculty of Agriculture, Kasetsart Univ., Thailand

Leaf anatomy of young rambutan (*Nephelium lappaceum* Linn.), durian (*Durio zibethinus* Murray), mangosteen (*Garcinia mangostana* Linn.), and longkong (*Aglaia dookoo* Griff.) potted plants grown under different light intensity (100%, 55%, 40%, or 25% of full sun) were observed. The thickness of both palisade and spongy parenchyma decreased as the light intensity decreased. This resulted in a decrease of lamina thickness when the light was lower. An exception occurred in mangosteen when the thickness of both palisade and spongy parenchyma in leaf grown under full sunlight were lower than in leaves grown under 55% or 40% full sun. The thickness ratio of palisade and spongy tissue in rambutan and durian decreased as light intensity decreased. While the ratios in mangosteen and longkong leaves grown under full sunlight were lower than the ratios of leaves grown under 55% or 40% of full sun. The frequency of stomata also decreased as the light intensity decreased. The thickness of palisade tissue of leaves grown under 55% of full sun in rambutan, durian, mangosteen, and longkong were 70, 110, 110, and 55 μm, respectively. The thickness of spongy tissue of leaves grown under 55% of full sun in rambutan, durian, mangosteen, and longkong were 60, 30, 410, and 145 μm, respectively. The thickness of leaves grown under 55% of full sun in rambutan, durian, mangosteen, and longkong were 186, 230, 565, and 233 μm, respectively. The number of stomata per square

millimeter of leaves grown under 55% of full sun in rambutan, durian, mangos-teen, and longkong were 437, 221, 133, and 301, respectively. Photosynthesis efficiency and light adaptation were discussed.

162

The Influence of Root Restriction on Flowering, Fruiting, Tree Growth, Yields, and Fruit Quality of Apple Trees

R.E. Byers*, D.H. Carbaugh, and L.D. Combs; Virginia Polytechnic Inst. and State Univ., Alton H. Smith, Jr. Agricultural Research and Extension Center, 595 Laurel Grove Road, Winchester, VA 22602

'Fuji'/MM.111, 'Pink Lady'/M.7A, and 'Summerfield'/M.7A apple trees were planted in several types of individual root restrictive bags in the field in 1995. Bags were made of Knit and Woven fabrics, Galvanize hardware cloth (6.4 cm) with various holes sizes and of different bag volumes. The bags confined the development of large roots to within the bag. Roots that penetrated the bag resulted in root branching and large root inhibition. As the roots enlarged, roots penetrating the bags were restricted in diameter by the fabric hole size. Roots enlarged to some degree on both sides of the fabric holes but were not killed by girdling within the first few years. Root restriction bags decreased trunk caliper, shoot growth, pruning weights, number of cuts per tree, increased flowering, fruit numbers, and weight per tree. Fruit firmness, soluble solids and color was increased and starch was lower than the nonbagged controls. In cage and tank trials pine and/or meadow voles easily penetrated all of the fabric and polypropylene bags within 24 h, except for the galvanized hardware cloth (6.4 cm). Susceptibility of each material to vole damage was tested by placement of an apple inside a small bag of each. Root restriction bags seemed to be a viable alternative to dwarfing rootstocks for control of tree size, early flowering, and early fruiting.

163

The Influence of Apogee and Its Combination with Ethephon, Chemical Thinners, Cations, and/or Adjuvants for Apple Tree Growth Control and Return Bloom

R.E. Byers*, D.H. Carbaugh, and L.D. Combs; Virginia Polytechnic Inst. and State Univ., Alton H. Smith, Jr. Agricultural Research and Extension Center, 595 Laurel Grove Road, Winchester, VA 22602

Prohexadione calcium applied as a series of three applications starting soon after petal fall to 'Fuji'/M.9 apple trees reduced the number of pruning cuts, pruning time, pruning weight per tree, current season's shoot length, individual shoot weights, and increased number of nodes on the lower 40 cm of shoots. Fruit diameter, soluble solids, starch, or individual fruit weights were not affected by Apogee sprays. Fruit color and firmness were slightly increased in only one experiment. Growth suppression appeared to be greater on trees cropping more heavily. When trees were more heavily thinned, less shoot growth control was achieved. Apogee applied at 250 mg/L in three applications caused a significant increase in fruit set when compared to the control. Alone Vydate, Carbaryl+Oil, or Carbaryl+Accel+Oil caused fruit thinning, but neither ethephon nor shading 3 days caused significant thinning. Apogee did not influence results of chemical thinners when applied between the first and second Apogee applications. The 10% and the 27.5% Apogee formulations gave similar shoot growth inhibition when applied with Regulaid or Oil+Silwet L-77. When using hard water (well water), the 27.5% Apogee formulation was not as effective as the 10% formulation. The 10% Apogee formulation has more NH_4SO_4 than the 27.5% formulation w/w; NH_4SO_4 is used to prevent inactivation of Apogee by calcium and other cations when hard water is used for spraying. The addition of CaCl (frequently used to reduce bitter pit and corkspot disorders) to the 27.5% Apogee formulation caused poorer growth control than with hard water alone. When Apogee was used at 125 mg/L, the addition of NH_4SO_4 restored the effectiveness of the hard water+CaCl mixture. Alone the additives NH_4SO_4 , Ca Cl, Regulaid, and/or Oil plus L-77, had no effect on tree growth. Apogee plus L-77+Oil provided additional growth suppression when compared to Apogee+Regulaid. In 1998, three applications of Apogee (63 mg/L) or ethephon (135 mg/L) did not affect shoot growth of 'Fuji'/M.9 trees at these low rates. Combinations of Apogee and ethephon gave good control of tree growth. Flowering and fruit set were not promoted by any of these applications.

164

Combinations of Chemical Thinners for Bloom and Post-bloom Apple Thinning

R.E. Byers*, D.H. Carbaugh, and L.D. Combs; Virginia Polytechnic Inst. and State Univ., Alton H. Smith, Jr. Agricultural Research and Extension Center, 595 Laurel Grove Road, Winchester, VA 22602

Effectiveness of pollination/fertilization inhibitors for flower thinning depends highly on the precise timing of sprays within 24 to 36 h after flower opening. In 1999, cool weather delayed the application of hormone-type thinners, which were intended for at bloom comparison with pollination/fertilization. Pollination inhibitors applied in bloom and hormone thinners applied at petal fall or 8 mm fruit diameter caused good fruit thinning. Ethephon applied in bloom did not cause thinning of 'Empire' fruit, but Sevin + Accel + Oil caused good fruit thinning when applied in bloom. Sevin + Accel + Oil increase fruit diameter and did not affect fruit russet. Ethephon applied at 22 mm fruit diameter at water rates of 935 L/ha or 3741 L/ha and chemical rates of 21.5 L/ha or 42.9 L/ha did not cause significant fruit thinning. In 1998, pollination inhibitors and hormone-type growth regulators caused flower and fruit thinning of 'Starkrimson'/MM111/106 trees. Good thinning occurred with both pollination inhibitors and ethephon treatments; but Sevin + Accel + oil was not as effective. Thinex caused the most side russet. Treatments that thinned generally caused increased fruit diameter. In 1999, return bloom was promoted by early thinning, but ethephon did not appear to promote return bloom beyond the thinning effect. In 1998, endothall caused good thinning of 'York'/MM.111 with a minimum of foliage injury. Fruit diameter was increased. Thinning with endothall in 1998 greatly increased return bloom in 1999, but trees were slightly over thinned. Fruit injury caused by carbaryl was almost non-existent in 1999 in two tests having over 25 carbaryl treatments that compared different formulations and adjuvants for thinning and injury. Some very slight, non-significant injury, may have occurred with three of nine formulations tested when trees were shaded. Shading trees for 1 day in conjunction with carbaryl sprays also did not promote injury. In a previous year, shading trees promoted carbaryl injury. A tank mix of Oil with either 50WP, 80WP, XLR, or 4L formulations caused 3 to 8% of the fruit to show injury at a very low intensity. However, in an adjoining block, Sevin + Accel + Regulaid caused injury to >50% of the fruit when applied the same day as the other experiments. Further investigations on this problem are in progress.

165

Ethephon, Foliar Nutrient, and Gibberellin Sprays on Subsequent Season(s) Return Bloom and Fruit Set

R.E. Byers*, D.H. Carbaugh, and L.D. Combs; Virginia Polytechnic Inst. and State Univ., Alton H. Smith, Jr. Agricultural Research and Extension Center, 595 Laurel Grove Road, Winchester, VA 22602

Heavily cropping 'York'/M.27 trees sprayed with seven multiple low doses of ethephon (135 mg/L each) did not cause greater return bloom in 1999 unless foliar fertilizers (either 18-18-18 or Ca NO_3) were added to the ethephon sprays. Foliar fertilizer sprays alone did not promote return bloom. 'York'/M.7 trees selected for very little bloom in 1997 ("off year" of the biennial bearing cycle) and sprayed with 160 mg/L GA_3 or 320 mg/L GA_3 had significantly less return bloom in the 1998 ("on year") (61% and 46% spurs flowering, respectively, compared to control trees that had 99% of spurs flowering). Trees sprayed in 1997 ("off year") with GA_3 return bloom and cropped in 1999; but trees in the "off year" in 1997 that were not sprayed with GA_3 did not crop in 1999. Sprays of GA_3 provided some control of alternate bearing of 'York'/M.7 trees when applied in the "off year" of the biennial bearing cycle. Leaves taken from 'Braeburn'/M.27 trees in 70 °F rooms evolved ethylene through out the 12 days of the test. A moderate ethylene peak occurred on about days 5 and 6. Leaves from trees in the 40 °F room did not evolve detectable ethylene levels until trees were put in another 70 °F room on day 6. Ethylene levels were about the same from day 6 through day 12 for all treated trees at 70 °F. Nontreated control trees in rooms at 40 or 70 °F did not produce detectable ethylene levels during the experiment (except for a very small amount detected only on day 2 from leaves seal for 24 h at 70 °F).

166

Influence of Crop Level on Growth and Quality of 'Braeburn' Apple Fruit

P.I. Garriz*, G.M. Colavita, and H.L. Alvarez; Facultad de Ciencias Agrarias, Comahue National Univ., c.c.85, 8303 Cinco Saltos, R.N., Argentina

Crop load and the genetic biological carrying capacity (source-sink relation-

ships) determine the potential for fruit size development on apple; however, the environment within which the fruit grows attenuates this potential. The effects of different crop loads on the growth pattern and the progress of maturity in apples were evaluated at the Comahue National Univ., Argentina (lat. 38 56'S long 67 59'W), during the 1998–99 growing season. Our experiment was conducted on 6-year-old 'Braeburn'/Malling Merton 111 apple (*Malus domestica* Borkh.) trees spaced 4.0 x 2.3 m and trained to palmette leader. Treatments were 1) light crop load (LC), 2.5 fruit/cm² trunk cross-sectional area (TCSA), 2) moderate crop load (MC), 6.5 fruit/cm² TCSA (standard commercial crop load) and 3) high crop load (HC), minimum 8 fruit/cm² TCSA, no fruit removed from tree. Whole trees were hand-thinned 19 days after full bloom (DAFB). Fruit diameter (FD) was taken at two weekly intervals (n = 24 per date and treatment) and maturity indexes were determined at harvest. Analysis of variance was used and mean separations were computed with Student's *t*-test. From 38 DAFB until harvest, fruit size was significantly reduced ($P < 0.01$) in the HC trees, indicating that they were source-limited during growth. At 166 DAFB, FD was 7.48, 7.14, and 6.89 cm for the LC, MC and HC treatments, respectively. Adequate carbon was apparently available to support a commercial crop load since no differences were found between LC and MC trees. Crop level influenced flesh firmness; at 173 DAFB, it was significantly lower in HC trees than MC and LC trees (84.33, 92.51, and 91.57 N, respectively). These results suggest some goals of thinning for ensuring sizable 'Braeburn' fruit.

167

Nutrient Uptake and Growth Performance of OH87 and OH97 Pear Rootstocks

Shufu Dong*, Lailiang Cheng, Pinghai Ding, Guihong Bi, and Leslie H. Fuchigami, Department of Horticulture, Oregon State University, Corvallis, OR 97331

One-year-old (Old Home) OH87 and OH97 pear rootstocks were grown in 2-gallon containers under natural conditions at Corvallis, Ore., in 1999. Uniform plants were harvested during August and September, and total leaf area, new shoot number and length, and root growth were measured. The kinetics of NH₄⁺ and NO₃⁻ uptake by new roots of both rootstocks were determined with the ion-depletion technique. OH87 had larger total leaf area, and more and longer shoots than OH97. Total root biomass was similar between the two rootstocks, but OH87 had a larger proportion of new roots and more extension roots than OH97. Both rootstocks had lower Km values for NH₄⁺ absorption than for NO₃⁻ and therefore both had greater absorptive power for NH₄⁺ than for NO₃⁻ at the low nutrient concentrations. The maximum uptake rates (V_{max}) of OH97 were similar for both NH₄⁺ and NO₃⁻ absorption, but OH87 had a much higher maximum uptake rate for NO₃⁻ than for NH₄⁺.

168

Weed Suppression and N and P Mineralization in an Orchard Mulched with Composted Poultry Litter

P.L. Preusch¹ and T.J. Tworokski*²; ¹Hood College, Frederick, MD, 21701; ²USDA-ARS, Kearneysville, WV 25430

Improper management of poultry manure and bedding (litter) can cause hypoxia in aquatic communities, but poultry waste can be converted to a stable organic fertilizer by composting. Peach trees (*Prunus persica* L. 'Sunhigh') received the following treatments in May 1998: commercial fertilizer (15 g N/m²), low-rate composted poultry litter (15 g N/m² as 2.9 kg composted litter/m²), high-rate composted poultry litter (62 g N/m² as 11.6 kg composted litter/m²), and no treatment control. Weeds were completely controlled during 1998, but, by Sept. 1999, the high-rate poultry litter had only 27% weed cover compared with 86% for the commercial fertilizer-treated plots. Soil N was highest in plots treated with commercial fertilizer (16.4 mg N-NH₄ and 18.6 mg N-NO₃ per kg soil, 6 weeks after treatment) and did not differ among the remaining treatments (in the high rate of poultry litter—3.2 mg N-NH₄ and 0.7 mg N-NO₃ per kg soil, 6 weeks after treatment). Water soluble P in the soil did not differ among treatments at 6 weeks after treatment (≈12 mg P per kg soil for all treatments) but, at 47 weeks after treatment, plots with the high rate of poultry litter had 30 mg P per kg soil compared with 14 mg P per kg soil in plots treated with commercial fertilizer. In general, Mehlich 1 acid-soluble P did not differ among the litter- and fertilizer-treated plots (averaging 45 mg P per kg soil). Acid-soluble P was lowest in control plots (averaging 21 mg P per kg soil). Results indicate that poultry litter could be used as a weed suppressant without adversely affecting nitrogen release to the environment. However, P mineralization may be problematic and requires further investigation.

169

Root Characteristics of Peach Trees with Different Shoot Growth Habits

T.J. Tworokski* and R. Scorza; USDA-ARS, Kearneysville, WV 25430

Peach trees (*Prunus persica* L.) with diverse shoot growth habits have been developed, but little is known about their root systems. Characterizing shoot and root systems can improve basic understanding of peach tree growth and be important in the development of rootstocks and own-rooted trees. This research determined shoot and root characteristics of four peach tree growth habits (compact, dwarf, pillar, and standard). Seed from four peach growth habits were planted in 128-L containers, grown outside during the 1998 growing season, and then harvested. Compact tree leaf number (1350/tree) was twice, but leaf area (6 cm²/leaf) was half, that of pillar and standard trees. The number of lateral branches in compact trees (34) was nearly three-times more than in pillar and standard trees. The leaf area index (LAI) of pillar trees was greater than compact and standard trees (13 compared with 4 and 3, respectively) due to a narrower crown diameter. Dwarf tree shoots were distinct with few leaves (134 per tree) and a large LAI of 76. Compact trees grew more higher-order lateral roots than pillar and standard trees. More second-order lateral (SOL) roots were produced by compact than standard trees (1.2 vs. 0.8 SOL roots/cm first-order lateral root). Pillar trees had higher shoot-to-root dry weight ratios (2.4) than compact and standard trees (1.7 for both) due to smaller root dry weights. The results indicate fundamental differences in root characteristics among the peach tree growth habits. Compact trees had more higher order lateral roots in roots originating near the root collar (i.e., more fibrous roots), and this correlated with more lateral branches in the canopy. Shoot weights were the same among pillar, compact, and standard trees but root weights were less in pillar trees, resulting in greater shoot-to-root dry weight ratios. These results indicate significant differences in root as well as shoot architecture among growth habits that can affect their use as scion or rootstock varieties.

170

The Effect of Ca: NH₄ Ratio on the Growth of Sour Orange Seedlings

Dariusz Swietlik*; USDA-ARS Appalachian Fruit Research Station, Kearneysville, WV 25430

The purpose of this study was to determine the effect of Ca: NH₄ ratio in the rhizosphere of hydroponically grown sour orange seedlings (SO) (*Citrus aurantium* L.) on the plants' vegetative growth and N uptake. The experiment was prompted by our observation that application of N in the form of NH₄ in conjunction with CaCl₂ was more efficient in eliminating N deficiency in field-grown grapefruit trees than the same rates of N applied in the form of NH₄NO₃ without CaCl₂. About 40-cm-tall SO were pruned back to the 4th leaf and grown for 6 weeks in nutrient solutions containing 5 mM NH₄⁺ at CaCl₂: NH₄⁺ molar ratios of 1.0, 1.3, 1.6, 1.9, 2.2, or 2.5. In an additional treatment, NO₃⁻ was used as the sole source of N at CaCl₂: NO₃⁻ ratio of 1:1. The level of Ca:NH₄ ratio had no effect on new leaves number, shoot growth, total and average leaf area, specific leaf weight, as well as leaf, stem, and tap root dry weight. However, lateral root dry weight decreased at Ca: NH₄ ratio of 2.5. No growth differences were found when the plants were supplied with NH₄⁺ vs. NO₃⁻ at Ca:N molar ratio of 1:1.

171

Changes of Carbohydrate Metabolism in Apple Leaves in Response to Sink-source Manipulation

Rui Zhou and Bruno Quebedeaux*; Department of Natural Resources Sciences and Landscape Architecture, Univ. of Maryland, College Park, MD 20742

In order to determine whether the changes in the demand for the transported carbohydrates in apple source leaves are associated with specific carbohydrate enzyme changes, we made source-sink manipulation by girdling or defoliation. The girdle was applied to side branches with several fully expanded leaves, and the defoliation was conducted by removing about 90% of source leaves in apple seedlings. 3-year-old apple (*Malus domestica* Borkh. cv. Gala) seedlings were grown in a 15/9-h light (≈700 μmol photons/m² per s, 22 °C)/dark (18 °C) in the growth chamber. When the demand for transported carbohydrates from a particular source leaf is limited by girdling, carbohydrates including starch, sorbitol and sucrose accumulated in the source leaves, meanwhile girdling reduced net photosynthetic rates (Pn) dramatically from 12.8 initially to 4.6 μmol CO₂/m² per s over a 7-day period. When the demand for transported carbohydrate in the remaining source leaves was increased by defoliation, all carbohydrate levels decreased while Pn of individual leaves increased from 13.6 initially to a maximum

of 19.8 $\mu\text{mol CO}_2/\text{m}^2$ per s after 7 days. These Pn changes in the carbohydrate depleted and accumulated leaves were due mainly to changes in the photosynthetic capacity as indicated by Pn-Ci curve measurements. The carbohydrate enzyme activities were also dramatically changed during the 7-day experimental period. The activity of aldose-6-phosphate reductase (E.C. 1.1.1.200), an important enzyme in sorbitol biosynthesis, increased significantly from 27.5 to 39.2 $\mu\text{mol/h}$ per g FW in the carbohydrate depleted leaves while it remained unchanged in the girdled leaves, the activity of sucrose-6-phosphate synthase (SPS, E.C. 2.4.1.14), a key enzyme for sucrose biosynthesis, increased from 15.4 to 23.0 $\mu\text{mol/h}$ per g FW in the depleted leaves and declined from 17.4 to 8.2 $\mu\text{mol/h}$ per g FW in the girdled leaves, the activity of fructose 1,6 bisphosphatase (E.C. 3.1.3.11), another key enzyme for sucrose biosynthesis in non-Rosaceae species showed a similar pattern as SPS, ADPglucose-pyrophosphorylase (E.C. 2.7.7.27), a key enzyme for starch biosynthesis, decreased a small amount in the girdled leaves but increased markedly from 42.9 to 56.0 $\mu\text{mol/h}$ per g FW in the depleted leaves. These results indicated the specific roles of the enzymes in the partitioning of carbon between sorbitol, sucrose and starch in apple source leaves.

172

Calorimetric Evaluation of Apple Seed Dormancy

E. Carvajal-Millan¹, A.A. Gardea¹, V. Guerrero-P¹, F. Goycoolea², and C. Rivera¹; ¹Centro de Investigación en Alimentación y Desarrollo, Unidad Cuauhtemoc, Apdo. Postal 781, Cuauhtemoc, Chih, Mexico; ²Centro de Investigación en Alimentación y Desarrollo, Unidad Hermosillo, Apdo Postal 1735, Son., Mexico

Apple embryos from moist seeds kept at 4 °C were used for a calorimetric characterization of Red and Golden Delicious apple seed dormancy. Seeds were sampled at 100-h intervals during 1200 h. The metabolic response of such samples was compared to that from chilled Golden Delicious seeds (>1200 h) stored under controlled atmosphere (CA). Isothermal calorimetry at 25 °C, evaluated metabolic activity (q), respiration rate (RCO₂), metabolic 65 °C estimated activation energy (E_a) in a 10 to 20 °C range, and respiration coefficients (Q₁₀) from 10 to 50 °C at 10 °C intervals. Data showed a direct relationship between chilling exposure and embryo metabolic responses from both cultivars. Once chilling requirement was satisfied, Red and Golden Delicious seeds presented a significant increase ($P \leq 0.05$) in q, 0.94 and 0.98 $\mu\text{W}/\text{mg}$ dry weight (dw); RCO₂, 9.9 and 7.6 mmol CO₂/mg dw; and R_{SG}· Δ _{HB}, 3.6 and 2.5 $\mu\text{W}/\text{mg}$ dw, respectively. On the other hand, q/RCO₂ did not follow a definite pattern, neither in Red nor Golden Delicious cultivars. E_a decreased 19.2 and 23.4 J/mol per °K per mg dw in Red and Golden Delicious, respectively, as a function of seed chilling. Q₁₀ showed a significant response to temperature, but not to chilling exposure. Golden Delicious seeds from CA showed a significant reduction on q, RCO₂, and R_{SG}· Δ _{HB} of 0.28 $\mu\text{W}/\text{mg}$ dw, 2.47 mmol CO₂/mg dw, and 14 $\mu\text{W}/\text{mg}$ dw, respectively. Results show that calorimetry is a sufficiently sensitive, fast, and precise tool to quantify metabolic responses during seed chilling, as evolving energy.

173

Calorimetric Evaluation of Metabolic Intensity of Apple Lateral Buds and Roots during the Transition from Para- to Endodormancy

J. Llamas¹, A.A. Gardea, J.J. Martinez-Tellez, V. Guerrero-P, E. Carvajal-Millan, J.A. Orozco, and A. Rascon-Chur; Centro de Investigación en Alimentación y Desarrollo, Unidad Cuauhtemoc, Apdo. Postal 781, Cuauhtemoc, Chih, Mexico

Potted 1-year-old 'Starking Spur' and 'Golden Delicious' trees on MM.106 were used to characterize the metabolic changes in lateral buds and roots during their transition from para- to endodormancy. Sampling period was from 4 Sept. to 25 Nov. 1999 at 10-day intervals. Well-formed lateral buds were collected from the apical section of current growth; while root samples were white rootlets. Isothermal calorimetry at 25 °C was used to evaluate metabolic activity (q), respiration rate (RCO₂), metabolic efficiency (q/RCO₂), and growth rate (R_{SG}· Δ _{HB}). In both cultivars, q from buds showed significant differences ($P \leq 0.05$) among sampling dates; 'Starking' rose from 1.8 to 3.7 $\mu\text{W}/\text{mg}$ dry weight (dw), while in 'Golden' change was from 2.1 to 3.3 $\mu\text{W}/\text{mg}$ dw. RCO₂, q/RCO₂, and R_{SG}· Δ _{HB} showed a pattern similar to q. On each sampling date, cuttings were also forced to break and, in all dates, buds broke after 21 days, demonstrating a paradormant condition. MM.106 root tips q behave differently depending on the variety they were grafted on to. When grafted with 'Starking', root tips produced a small, but significant, increase in q (from 9.1 to 15.7 $\mu\text{W}/\text{mg}$ dw) as the season progressed. RCO₂ and R_{SG}· Δ _{HB} behaved similarly, increasing from 27.6 to 57.6 mmol CO₂/mg dw and 3.4 to 8.3 $\mu\text{W}/\text{mg}$ dw, respectively. These conditions agreed with a

dynamic root growth. A small decrease in q/RCO₂ was observed. However, when grafted with 'Golden' root tips metabolic responses did not increase; furthermore, q decreased while RCO₂, q/RCO₂, and R_{SG}· Δ _{HB} did not show a defined pattern. Four complete 2-year-old trees of each variety, kept in 1-m³ containers, were sampled. The relation of root/wood dry matter was estimated, with difference found between varieties.

174

Muskmelon Fruit Soluble Acid Invertase and Sucrose Phosphate Synthase Activity and Polypeptide Profiles during Growth and Maturation

Gene Lester¹, Luis Saucedo Arias², and Miguel Gomez-Lim²; ¹USDA, ARS, Kika de la Garza SARC, 2301 South International Blvd., Weslaco, TX 78596; ²Dept. de Biotecnología y Bioquímica, Unidad Irapuato, Centro de Investigación y de Estudios Avanzados del IPN, Apartado Postal 629, Irapuato, Gto. 3650, Mexico

Muskmelon [*Cucumis melo* L. (Reticulatus Group)] fruit sugar content is the single most important consumer preference attribute. During fruit ripening, sucrose accumulates when soluble acid invertase (AI) activity is less than sucrose phosphate synthase (SPS) activity. To genetically heighten fruit sugar content, knowledge of sugar accumulation during fruit development in conjunction with AI and SPS enzyme activities and their peptide immunodetection profiles is needed. Two netted muskmelon cultivars ['Valley Gold' (VG), a high sugar accumulator, and 'North Star' (NS), a low sugar accumulator] with similar maturity indices were assayed for fruit sugars, AI, and SPS activity and immunodetection of AI and SPS polypeptides following 2, 5, 10, 15, 20, 25, 30, 35, and 40 (abscission) days after anthesis (DAA). Both cultivars, grown in spring and fall, showed similar total sugar accumulation profiles. Total sugars increased 1.5 fold, from 2 through 5 DAA and then remained unchanged until 30 DAA. From 30 DAA until abscission, total sugar content increased, with VG accumulating significantly more sugar than NS. In both cultivars, during both seasons, sucrose was detected at 2 DAA, which coincided with higher SPS activity than AI activity. At 5 through 25 DAA, SPS activity was less than AI activity resulting in little or no sucrose detection. It was not until 30 DAA that SPS activity was greater than AI activity resulting in increased sucrose accumulation. VG at abscission had higher total sugar content and SPS activity and lower AI activity than NS. Total polypeptides from both cultivars 2 through 40 DAA, were immunodetected with antibodies: anti-AI and anti-SPS. NS had AI isoforms bands at 75, 52, 38, and 25 kDa that generally decreased with DAA. One isoform at 52 kDa remained detectable up to anthesis (40 DAA) VG had the same four AI isoforms, all decreased with DAA and became undetectable by 20 DAA. It is unclear if one or all AI isoforms correspond with detected enzyme activity. VG and NS had one SPS band at 58 kDa that increased with DAA and concomitantly with SPS activity. VG had a more intense SPS polypeptide band at abscission than did NS. Thus, netted muskmelon sugar accumulation may be increased by selecting for cultivars with a specific number of AI isoforms, which are down-regulated, and with high SPS activity during fruit ripening.

175

Comparison of Suitability of Nonmelting and Melting Flesh Peach Cultivars for Fresh-cut

J.K. Brecht¹, K. Cordasco, and W.B. Sherman; Horticultural Sciences Department, University of Florida, Gainesville, FL 32611

Two nonmelting flesh ('GUFprince' and 'UF2000') and two melting flesh ('Tropic Beauty' and 'Rayon') peach cultivars were segregated into ripeness categories at harvest according to initial flesh firmness and prepared as fresh-cut slices as described in Gorny et al. (HortScience 33:110-113), except that there were no "overripe" (0-13 N flesh firmness) stage nonmelting flesh fruit. Slices were stored at 1, 5, or 10 °C for 8 days and were evaluated for visual and taste quality, flesh firmness and color, and respiration and ethylene production rates every other day during storage. The optimal ripeness for preparing fresh-cut slices from the melting flesh cultivars was the "ripe" (13-27 N flesh firmness) stage; less-ripe melting flesh slices did not ripen at 1 or 5 °C and riper melting flesh slices and those held at 10 °C softened excessively, became discolored, and decayed. The optimal ripeness stage for the nonmelting flesh cultivars was 40-53 N flesh firmness, which corresponded to physiologically ripe (climacteric rise) for nonmelting flesh fruit, but melting flesh fruit at that firmness were physiologically only mature-green (preclimacteric). Storage of nonmelting flesh slices was limited by surface desiccation at 1 °C, and by flesh discoloration at 5 and 10 °C, which was more severe in riper slices. The best storage temperature for both fruit genotypes