Abstracts

Contributed Papers (Oral and Poster)
Colloquia
Workshops

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The Abstracts that follow are arranged by type of session (Orals first, then Posters, Workshops, Colloquia, Collegiate Branch Posters, Collegiate Branch Orals). 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.

28 ORAL SESSION 1 (Abstr. 001–005)
Breeding and Genetics–Floriculture I

001

Florida Red Ruffles and Florida Irish Lace: Two New Lance-leaf Caladium Cultivars

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Two lance-leaf caladium cultivars are to be released from the ornamental breeding program at the University of Florida. 'Red Ruffles', whose pedigree is Red Frill x ('Red Frill' x 'Candidum Jr.'), has elongated medium red leaves with ruffled green margins. Plants are upright with strong petioles, have leaf blades 25 cm long and 14 cm wide, and attain a height of 61 cm when grown in full sun in the field. Plants have more leaves and are more cold tolerant than 'Red Frill', the major red lance-leaf cultivar of commerce. Tuber yields of 'Red Ruffles' are similar to 'Red Frill' but less than 'Rosalie', with production indices of 95.0, 97.8, and 121.0, respectively. Foliage of 'Red Ruffles' is more upright and less likely to elongate under reduced light than the other cultivars. 'Irish Lace', an F_2 selection from a cross of "Candidum Jr." x "Red Frill", has elongated dark green leaves with heavily ruffled margins, which are etched with a thin red border. Leaf blades are 26 cm long and 8 cm wide and have heavy substance. Plant height is 65 cm in the field. Tuber yields of 'Irish Lace' are greater than 'White Wing', a major green/white cultivar. Use of a green caladium would be as a border or a mixture with red or white lance-leaf cultivars.

002

Breeding Aspects in *Alstroemeria* L.

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The genus *Alstroemeria* L. is endemic in South America, mainly in Chile and Brazil. Crossing barriers of mainly postfertilization origin hampered widely interspecific hybridization. Culturing the ovules 2 days after pollination in an hormone-free MS medium with 9% saccharose for 6 weeks and hereafter transfer to a MS medium with 3% saccharose gives germination of the fertilized ovules. In a diallel cross with 5 Chilean and 2 Brazilian species 39 combinations failed, whereas after early ovule culture hybrid plants were obtained in 27 of the incongruous combinations. The rate of success varied between 0.4%–22.5% depending on the species combination. The hybrids were tested in in vitro stage for their true hybridity using isozyme analysis and/or genomic in situ hybridization of chromosomes (GISH). This method can easily be applied in hybrids between Chilean and Brazilian species. Backcrosses were made using the ovule culture again and in the combination *(A. aurea* x *A. inodora)* x *A. inodora* plants were obtained although the pollen fertility was very low (1%–5%). By using species-specific repetitive probes in in situ hybridization (FISH) chromosome specific patterns were obtained enabling us characterizing the backcross hybrids for their chromosome constitution. By this method we can identify our breeding material for special traits linked with identified chromosomes.

003

Isozyme Characterization in *Alstroemeria* Species

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Isozyme analysis was used to characterize and identify 24 species, hybrids, and color variants of *Alstroemeria*, two plants of *Leontochir ovallei*, and one plant of *Bomarea*. A single technique was developed for the extraction of seven enzyme systems (PGM, PGI, 6-PGD, EST, ME, AAT, and LAP) that exhibited a high level of polymorphism. Between 11 and 18 of the species and hybrids could be identified uniquely for each of the first six enzyme systems. The final system, LAP, was tested on only 11 species and hybrids, and nine different patterns were identified. Using only three of the seven enzyme systems, it was possible to uniquely identify all of the species and hybrids investigated.

004

DNA Amplification Fingerprinting Used to Distinguish Series of Cutting, Seedling, and Ivy Leaf Geranium

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The objective was to distinguish between series of cultivars of *Pelargonium* x*hortorum* (zonal geranium), *Pelargonium* hybrids (seed geranium), and *Pelargonium peltatum* (ivy leaf geranium) using DNA amplification fingerprinting (DAF) demonstrating the utility of DAF for patent protection to prevent infringement of inventor's rights. Leaf tissue of 10 plants of each cultivar of seedling geranium was bulked for DNA extraction, and cutting and ivy geranium cultivars were bulks of five plants of each cultivar. Isolated DNA from different cultivars of a series were bulked together in their respective series. Seedling geranium series included Dynamo, Glamour, Multibloom, Orbit, Pinto, and Ringo 2000. Cutting geranium series included Designer and Showcase. Ivy geraniums were from the Guillou group. Amplification was with one of two octamer primers, followed by reamplifying with one of four different mini hairpin primers. Gels were visually scored for presence or absence of bands. The four primers generated 336 bands. The average number of bands (_1000 bp) per primer was 40. Twenty percent of bands were polymorphic and distinguished between each series of cultivars. Genetic relationships were evaluated by SAHN cluster analysis based on the distance estimator of Dice using the NTSYS-pc program (Numerical taxonomy and multivariate analysis system, version 1.8). Series were grouped according to species. Seedling geraniums were in one large group, the two cutting geraniums were grouped together and the ivy leaf geraniums were a separate branch.

005

Resistance of Pelargonium Species to the Fungal Pathogen *Botrytis cinerea*

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Botrytis cinerea is an economically important fungal pathogen of *Pelargonium* species. We are currently studying this plant–pathogen interaction to identify mechanisms of host resistance. Our ultimate objective is to develop commercial *Pelargonium* genotypes with enhanced resistance to this pathogen. Though all stages of production may be affected by this pathogen, we are investigating foliar and floral resistance of mature plants. Through simple assays, over 200 genotypes have been evaluated for foliar resistance, and more than 100 genotypes have been evaluated for floral resistance. Resistant and susceptible control genotypes have been identified for diploid and tetraploid *P.* ×*hortorum* and *P. peltatum*; these genotypes are being investigated to elucidate mechanisms of resistance. The diploid ivy accession 86-23-1 and the tetraploid zonal geranium 'Fox' have the greatest foliar resistance among the genotypes evaluated. The diploid *P.* ×*hortorum* 'Ben Franklin' has the greatest floral resistance among the evaluated genotypes. Foliar and floral resistance appear to be inherited as separate traits. Foliar resistance is manifested as a two day delay in symptom expression when compared to susceptible genotypes. Foliar resistant accession 86-23-1 has a cuticle with 150% the mass of other *Pelargonium* genotypes. This difference may be responsible for the observed resistance. Cuticle mass does not appear to be important in floral resistance.

006

Inheritance of Specific Flower Colors in *Petunia hybrida*

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The biochemistry of flowers is very complex, depending not only on the specific anthocyanin present but also on vacuolar pH, presence of metal ions, type of co-pigment present, and the molar ratio of co-pigment to anthocyanin. Because of the wide array of different flower colors, *Petunia hybrida* is an excellent model system to study the genetic interaction of all of these factors. The segregation of the different flower colors in an F_2 population from a red x violet outcross could be explained through the combined inheritance of anthocyanin pigmentation and pH. The inheritance of anthocyanin pigmentation was controlled by two independent genes (*hf* and *Mf*) that followed simple Mendelian genetics. The inheritance of pH was more complex, being controlled by two independent co-dominant genes (*Ph1* and *Ph2*). Linkage of the various pH and anthocyanin genes prevented the expression of all of the potential gene combinations.

29 ORAL SESSION 2 (Abstr. 007–014) Propagation–Cross-commodity

007

Seed Germination of Atlantic White Cedar as Influenced by Stratification, Temperature, and Light

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Cones of two provenances (Wayne Co., N.C., And Escambia Co., Ala.) of Atlantic white cedar [*Chamaecyparis thyoides* (L.) B. S. P.], were collected Fall 1994. Cones were dried for 2 months, followed by seed extraction and storage at 4°C for 6 months. Seeds were graded and stratified (moist-prechilled) for 0, 30, 60, or 90 days. Following stratification, seeds were placed at 25°C or 8/16 hour thermoperiods of 25°/15°C or 30°/20°C with daily photoperiods at each temperature of 0, 1/2, 1, 2, 4, 8, 12, or 24 h. At the conclusion of a 30-day germination period, the Alabama provenance exhibited greater germination than the North Carolina provenance for all treatments (74% vs. 46%). There were no significant differences between 25°/15°C and 30°/20°C with regard to total percent germination for both provenances. Germination was lowest at 25°C for each provenance. In some cases, however, there were no significant differences in germination of the North Carolina provenance when stratified for 60 or 90 days and germinated at 30/20°C or 25°C (61% vs. 63%). There was a highly significant quadratic response to stratification for cumulative percent germination for both

provenances. The North Carolina provenance required 90 days stratification to maximize germination (66%) in contrast to the Alabama provenance, which only needed 30 days (80%). Seeds of both provenances did not exhibit an obligate light requirement. However, photoperiods ≥1/2 h increased germination greatly over seeds in darkness (29% vs. 62%).

008

Pretransplant Temperature Regime and Container Size Alter Strawberry Plant Morphology

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Containerized strawberry transplants offer an alternative to problematic bare-root transplants, which often have variability in flowering and vegetative vigor. Containerized transplants were propagated in three different container cell sizes (75, 150, and 300 cm^3) and grown at two different temperature regimes for 2 weeks prior to planting (25/15 and 35/25°C day/night). Bare-root transplants from Massachusetts and Florida were graded into small, medium, and large plants based on crown size (8, 12, and 16 mm respectively). Plug transplants grown at 25/15°C had greater root dry weights than transplants grown at 35/25°C. Root imaging analysis (MacRHIZO) showed that the differences in dry weight were due to root area, not root tissue density. Crown dry weight increased with increasing cell size. Plug transplants grown at 25/15°C flowered earlier and had greater production than any other treatment. The 75 cm^3 cell size grown at 35/25°C produced greater December strawberry production than larger cell sizes at the same temperature regime; however, the 75 cm^3 cell size had decreased January strawberry production while the larger cell sizes had increased production. Larger plug cell sizes had significantly greater production than smaller plugs throughout the season, whereas larger bare-roots had greater production only early in the season. Containerized plug transplants therefore offers a viable alternative to problematic bare-root transplants.

009

Using a Rockwool Plug System In Vitro On *Amelanchier*, *Cercis*, Kalmia, Cherry, and Apple

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Rockwool plugs were placed in Magenta G-7 boxes (Sigma) and then autoclaved at 121°C for 20 min. Fifty milliliters of cool autoclaved liquid medium was poured into Magenta G-7 boxes in aseptic conditions before microcuttings of *Amelanchier*, *Cercis canadensis*, cherry, and apple were transferred. Murashige and Skoog medium (MS, M-5519, Sigma) containing 30 $g \cdot L^{-1}$ sucrose, and with/out 1 ppm of NAA, pH 5.5 were used in all experiments. All cultures were incubated at 23 ±1°C under a 16-hour lighting period with a light intensity of about 4000 lux of white fluorescent light. Microcuttings of *Amelanchier*, *Cercis*, Apple, and cherry rooted in rockwool plugs in 3 weeks after transfer and were ready to be out-planted in 6 weeks. Out-planted plantlets were leached with tap water and potted in 4-inch pots with Metrolite mix, then, placed in mist bench under 50% shade for 2 weeks before taking to bench with full sun light. The survival was 100%. Conditions and growth rate of rockwool-plug-rooted plantlets were much better than those plantlets rooted in agar medium. Rockwool plug plantlets had 2–3 flushes of growth before dormancy in greenhouse and were ready to be planted in the field or garden in 8 months after out-planting. Using a rockwool plug system simplifies out-planting procedure, produces better plantlets, increases out-planting survival, and greatly shorten time needed from out-planting to field-plantable size. This system is a very useful system for difficult-to-root woody ornamentals.

010

Propagation of GF_{677} Peach Rootstock by Stem Cuttings

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The rooting ability of GF_{677} peach rootstock by hardwood (H), semihardwood (SH), and softwood (S) stem cuttings collected January, February, May, and November, treated with various IBA concentrations—0, 500,1000,2000, and 3000 ppm—was studied. H cuttings collected in January and treated with 2000 ppm IBA caused significant increase in rooting (62%–5%). In addition, the SH cuttings prepared February and treated with 1000 or 2000 ppm IBA gave 42.5%. The May experiment resulted in low rooting percentage where H cuttings treated with 500 ppm IBA gave 10% rooting. In October, SH cuttings with 1000 or 3000 ppm IBA gave the highest rooting percentage (60%), while in November 90% rooting was obtained in H cuttings treated with 3000 ppm. Regardless of type of cutting, IBA at 1000, 2000, or 3000 ppm was better for rooting the GF_{677} than at 500 ppm. However, irrespective of IBA concentration, H and SH cuttings gave significantly high rooting percentages. On the other hand, best rooting was obtained when the stem cuttings of GF_{677} (regardless of wood type) were collected in November. Wounding base of the cutting of GF_{677} improved rooting ability.

011

Influence of Stock Plant Carbohydrate and Nitrogen Content on Rooting Stem Cuttings of Hedged Loblolly Pine

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Containerized, 2.5-year-old, hedged stock plants of four, full-sib families of loblolly pine (*Pinus taeda* L.) were fertilized daily with a complete nutrient solution containing 10, 25, 40, 55, or 70 ppm N, which resulted in a range of stock plant soluble carbohydrate (SCHO) and tissue N levels. SCHOs included *myo*-inositol, glucose, fructose, sucrose, and raffinose. Nitrogen concentrations and SCHO : N ratios ranged from 1.23% to 2.24% and 16:1 to 29:1, respectively. Softwood cuttings were taken in May and July 1995 and placed under intermittent mist. May cuttings rooted at significantly greater percentages than July cuttings (60% vs. 34%). Averaged over all N treatments, the best rooting family (56%) contained the highest tissue concentration of SCHOs (465 $mg \cdot g^{-1}$ dry weight) and had the highest SCHO : N ratio (26:1), whereas, the poorest rooting family (39%), exhibited the lowest level of SCHOs (357 $mg \cdot g^{-1}$ dry weight) and the lowest SCHO : N ratio (21:1). Rooting exhibited a quadratic response in regards to N fertilization levels and tissue SCHO concentrations. For both rooting trials, maximum rooting (83%) was noted for May cuttings taken from stock plants of one family fertilized with 40 ppm N, which corresponded to a tissue N concentration of 1.95% and a SCHO : N ratio of 22:1.

012

The Effect of Stock Plant Water Potential, Auxin Application Method, and a Polyamines on Rooting Walnut Cuttings

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Experiments with field-grown hybrid Paradox (*Juglans hindsii* x *J. Regia)* walnut trees were conducted to assess the effects of stock plant water status, auxin application method, and the addition of spermine on adventitious root formation in stem cuttings. A 2-fold increase in rooting was noted when semihardwood cuttings were collected from dry (midday Ψ_w = –1.3 MPa) stock plants compared to the same trees six days later when fully hydrated (midday Ψ_w = –0.6 MPa). Spermine, when combined with potassium indolebutyric acid (KIBA) and applied as a quick dip, enhanced the rooting percentage in hardwood cuttings (54%) compared to controls treated with KIBA alone (18%). Spermine had no effect when it was applied together with KIBA using a toothpick application, producing 65% rooting compared to controls which had 75% rooting. By itself, spermine had no effect on rooting. The toothpick method for applying rooting compounds resulted in significantly higher rooting percentages for hardwood cuttings, but not for semihardwood cuttings. Combining spermine with KIBA had no effect on rooting of semihardwood cuttings.

013

Factors Causing Losses of Rooted Cuttings of Olive Propagated under Mist and Ways of Its Prevention

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To study the reasons for the losses of rooted semihardwood cuttings of olive propagated under the mist method, a 2-year experiment was carried out at the Horticulture Dept. of Faculty of Agriculture of the Tehran Univ. In this experiment, semihardwood cuttings of olive (Zard cultivar) in four different media—heavy-(A_1), semi-heavy(A_2), medium (A_3), and light (A_4), all disinfected with two different concentrations of Captan—were used. Root growth stages with low, medium, and light densities in spring and fall were evaluated. The results indicate that there are the least losses in semi-heavy (A_2) and medium (A_3) media. This could be the result of a better ventilation conditions in these media, which activates N and Ca and finally accelerates the better growth conditions in all young rooted cuttings. On the other hand, it was clear that inadequate disinfection will result in losses of rooted cuttings, and using Captan at 2 ppm gives the best result. This

research indicate that, with the higher growth rate, the first medium will have the fewer losses. The reason is the higher density and more durability and strength of the root, which control the disease-causing factors; so far that these factors do not influence the young roots. Finally, strong and dense roots show less losses. This experiment was designed in a factorial with randomized complete block and the averages were compared in a Duncan test and the results of abnormally distributed characteristics were shown by using logarithmic and sinus method.

014

Photoperiod of Poinsettia Stock Plants Influences Adventitious Rooting of Cuttings

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The rooting efficiency of cuttings from three poinsettia cultivars were evaluated after regulating the photoperiod during the stock plant stage. 'Freedom Red', 'Monet', and 'V-17 Angelika Marble' stock plants were exposed to an extended photoperiod and to natural day length during September 1995. 'Freedom Red' cuttings rooted more quickly under an extended photoperiod compared to those under natural day length. Furthermore, root dry weight from these cuttings was greater than cuttings from stock plants grown under natural day length. 'Monet' cuttings also rooted more quickly when the stock plants were under an extended photoperiod, and showed similar differences in root weight as 'Freedom Red'. Cuttings from 'V-17 Angelika Marble' were not influenced by photoperiod. Lighting stock plants to block flower initiation produces a higher quality cutting when propagation takes place after the critical day length for flowering has passed.

75 ORAL SESSION 3 (Abstr. 015–023) Education

015

What it Means to be a Certified Professional Horticulturist

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ASHS established a Certified Professional Horticulturist program in 1992 through ARCPACS. Most plant science-related disciplines have their certification programs based in ARCPACS. Professional Certification establishes and promotes professionalism within a discipline. In an era when the general public tends to question the credibility of the scientific community, certification is a valuable tool to establish one's credentials to society. To become certified, the ASHS Certified Professional Horticulturist program required individuals to meet core educational curriculum requirements, document experience in the field, and provide professional references documenting one's professional abilities. Individuals must adhere to the professional Code of Ethics and document continuing education involvement in order to maintain their certification.

016

Expanding Horticulture Programs through Off-campus Partnerships

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Michigan State Univ. (MSU) offers 10 certificate programs through the Institute of Agricultural Technology. These programs are campus based, approximately three semesters in length, and include a professional internship. Efforts were made in horticulture to expand programs into major population centers through joint programs with community colleges. Cooperative agreements were developed with Grand Rapids Community College and with Northwestern Michigan College in Traverse City. Issues addressed in the agreements include recruiting, admissions, advising, financial aid, integration of curriculum from both institutions, distance-learning delivery through the CODEC system, instructional commitments from campus-based and adjunct faculty, procedures for transfer to bachelor's degree program at MSU, and graduation. The symbiotic relationship between the institutions has expanded curriculum opportunities in the local areas, increased accessibility to MSU Horticulture programs, and better serves the nontraditional student. Outreach efforts for academic programs complement the traditional outreach that has occurred through the Cooperative Extension Service.

017

Developing a Horticulture Transfer Program at a Two-year Technical College

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The Ohio State Univ.'s Agricultural Technical Institute is a 2-year institution within the College of Food, Agricultural and Environmental Sciences. For over 20 years the school on the Wooster campus has offered technical programs in ornamental horticulture and floriculture leading to the Associate of Applied Science degree. Enrollment in the programs of Floral Design and Marketing, Greenhouse Management, Landscape Contracting, and Construction, Nursery Management, and Turfgrass Management is near 350 students. During the past year, a new program was developed with the primary purpose of serving those students who wish to transfer into a baccalaureate program within the college. Students are granted an Associate of Science degree in Horticulture upon completion of the curriculum requirements at the technical college. Those following this track have a unique opportunity for exposure to two different learning situations. They can progress toward their goal without loss of credit. The curriculum allows students to explore several areas of horticulture before commitment to their specialty. Beginning students have the advantage of a small campus with an active learning assistance program.

018

Using Focus Groups for Landscape Horticulture Curriculum Revision

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Curriculum revision for science-oriented degrees can be based on input from research journals and discipline-oriented society meetings, but the professional nature of a landscape horticulture degree requires more detailed industry input. The curriculum revision at the Univ. of Delaware started with discussions amongst faculty who were concerned with the current plant science curriculum. A mail survey of alumni from 1984 to 1993 and employers of Univ. of Delaware Plant and Soil Sciences Dept. graduates was conducted in 1994. Survey results were evaluated and incorporated into the development of two curricula: plant biology and landscape horticulture. Focus groups were used to seek industry input for the landscape horticulture curriculum. Two focus groups—established professionals in the landscape horticulture industry and recent graduates from the Plant and Soil Sciences Dept. with landscape horticulture positions—were convened in December 1995. Focus group members received a packet of information about the department including the proposed curricula prior to the meeting. A group of faculty presented information about departmental facilities, faculty, academic opportunities and practical experiences and accomplishments. The previous survey results and proposed curricula were reviewed. A professional facilitator, using a moderator's guide prepared by faculty members, led each focus group discussion. Tapes from each discussion were transcribed and summarized. Original transcriptions and executive summaries were distributed to focus group participants and faculty. Suggestions from focus group participants were incorporated into the final curriculum. Problems associated with the focus group technique include a reluctance of faculty to accept outside opinions, a reluctance to publicly air departmental concerns, and the cost associated with a professional facilitator and rented facilities. However, the focus group technique provided significant feedback in a short period of time and helped build liaisons with industry constituents by including them in the process. Several focus group participants will be invited to join an advisory council for the department.

019

Including Stakeholders in the Curriculum Assessment Process

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Decisions regarding curricular direction are often made by departmental committees comprised of faculty who are most closely associated with the curriculum. While knowledgeable about current direction, these faculty may not be positioned to accurately forecast future shifts in industry focus. By including employers, potential employers, alumni, students, and representatives from similar programs in the process, alternative views and opinions critical to the visioning process are generated. Penn State's recent efforts in program assessment will be outlined.

020

Integrated Cropping Systems—A Multi-discipline Degree

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Washington State Univ. Tri-Cities offers a new agricultural degree program titled Integrated Cropping Systems. It is intended to provide a basic education on the fundamentals of crop production and the environmental context in which crops are grown. Courses are offered at the upper division level to interface with the lower division courses offered at local community colleges. The curriculum is composed of courses in environmental science, ecology and conservation as well as crop growth and development, crop nutrition, plant pathology integrated pest management and others. Students need to meet the same requirements as those at other Washington State Univ. campuses in regards to the general education requirements. The purpose of the Integrated Cropping Systems program is to provide an educational opportunity for agricultural professionals and others in the region who are unable to commute or move to the main campus location. The curriculum provides the background needed for such occupations as grower/producer, crop scouting, sales representative and other entry level agricultural professions. It will supply credits toward certification through the American Registry of Certified Professional Agricultural Consultants (ARCPACS). Integrated Cropping Systems is a unique agricultural curriculum designed to help agriculturists integrate their production practices into the local ecosystem in a way that the environment does not incur damage. It emphasizes the use of environmentally conscience decisionmaking processes and sound resource ethics. The program will graduate individuals who have heightened awareness of the impact agricultural practices have on the ecosystem in which they are conducted.

021

Using Decision Cases in Graduate Education: An Example

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Decision cases have been written for use in horticulture education for some time at the Univ. of Minnesota. How faculty involve graduate students in this process will be discussed using the decision case Sunny Hollow Orchard. This decision case concerns the need to make management decisions in a commercial apple orchard planted largely with Haralson, a russet-susceptible cultivar. The growers involved had to decide whether the application of GA_{4+7} for russet suppression was appropriate for their operation, given all the factors which required addressing. The case was written for use in fruit production or other intermediate-to-advanced undergraduate course. The case can be used to illustrate the decision-making processes involved in operating a commercial crop production enterprise encompassing such issues as cultural and environmental factors, financial viability and pesticide concerns. The case exposes students to a real-life situation and provides them with the opportunity to face a complex but not uncommon situation for producers in the horticultural industry. We will then focus on how this case fit into the entire PhD research program and how we hope to integrate this kind of experience into graduate education.

022

Time-lapse Video Photography: A Low-tech Way to Make Plants Dance

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The growth processes of most horticultural crops are too slow to be visually interesting to students. Time lapse photography has been used for years to speed up the action and make plants "come alive." With the advent of video technology, time lapse techniques have become convenient, easy, and affordable. The system which we have found satisfactory consists of a time lapse video cassette recorder, linked by optical fiber cable to a closed circuit color video camera in a ventilated housing. Typically, the camera has been set up in a greenhouse compartment, monitoring growth processes of vegetable crops, and linked by cable to the VCR in an office 80 m away. Equipment costs with one camera are less than $3000. Two cameras can be set up to do comparative growth studies, with two images side-by-side, using a screen splitter. Costs of the latter system is about $4500. Growth processes such as cabbage head formation, curd growth in cauliflower, and weed-crop competition of mustard and peas have been the subjects so far. The technique lends itself to increasing the visual impact of teaching, and gaining a better understanding of plant growth processes in research.

023

A Taste of the Tropics Spices Up Student Interest

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Tropical horticultural crops can be the spark that builds student interest in horticulture. They are a refreshing alternative to the temperate crops that most of our curricula are necessarily built around. Students who become familiar with production problems and opportunities between 30° north and south latitudes are better equipped to compete in the world economy. HORT 423 covers tropical ecology, soils, atmosphere, and many major crops. Beverage crops studied are cacao, coffee, and tea. Fruit and nut crops include bananas, mango, papaya, pineapple, dates, oil palm, coconut, macadamia, cashew, and Brazil nuts. Spices such as vanilla, black pepper, allspice, nutmeg, mace, cinnamon, cassia, and cloves are studied. Subsistence crops such as cassava, yam, taro, pigeon peas, chick peas, vegetable soy beans, and black beans round out an exciting semester that draws students. HORT 423 is a 3-hour-per-week lecture demonstration course supplemented with slides from the tropical countries. Many students simultaneously enroll in a 1-hour HORT 400 course that is taught during the 1-week spring break in a tropical country. Recent trips have been two each to Costa Rica and Guatemala. These study trips are gaining in popularity. For more information about HORT 423 consult the world wide web at http://http.tamu.edu:8000/~c963/a/h423main.html.

31 ORAL SESSION 4 (Abstr. 024–033) Crop Production–Diseases and Insects

024

Fumigant Alternatives to Methyl Bromide for Polyethylene-mulched Tomato

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Tomato (*Lycopersicon esculentum* Mill.) was grown to evaluate various chemicals as possible alternatives to methyl bromide as a soil fumigant. Due to pest pressures from weeds, nematodes, and soil fungi, the use of a broad-spectrum fumigant is essential for economical tomato production. Methyl bromide (MBr) is the fumigant of choice for most growers using polyethylene mulch culture. In 1991, MBr was identified to be in a group of chemicals allegedly responsible for depletion of the stratospheric ozone layer. The U.S. Environmental Protection Agency (EPA) has since called for a phaseout of MBr by the year 2001. At several locations in Florida, alternative soil fumigants were evaluated including 98% MBr-2% chloropicrin (Pic) at 450 $kg \cdot ha^{-1}$, 67% MBr 33% –Pic (392 $kg \cdot ha^{-1}$), Pic (390 $kg \cdot ha^{-1}$), 1,3-dichloropropene + 17% Pic (1,3-D+C17) at 327 $L \cdot ha^{-1}$, and metham sodium (935 $L \cdot ha^{-1}$). Metham sodium was also applied by drip irrigation as well as enzone (1870 $L \cdot ha^{-1}$). Dazomet (448 $kg \cdot ha^{-1}$) was surface applied and incorporated. Pebulate (4.5 $kg \cdot ha^{-1}$) was incorporated with some treatments. Pic and 1,3-D+C17 treatments provided control of nematodes and soil fungi. With the addition of pebulate, some nutsedge control also was obtained. Tomato fruit yields with 1,3-D+C17 + pebulate and with Pic + pebulate ranged from 86% to 100% of that obtained with MBr treatments. Pest control and crop production were lower with the other treatments than with the above combinations and with MBr. These studies indicate that no one pesticide can provide the broad spectrum control provided by MBr.

025

Field Tolerance of Bell Pepper Cultivars to Bacterial Leaf Spot under Epidemic Conditions

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Bacterial leaf spot (BLS) caused by *Xanthomonas campestris* pv. *vesicatoria* is the scourge that has devastated and continues to limit expansion of both fresh-market and processing pepper production in Kentucky. Fourteen new BLS-resistant varieties and breeding lines were evaluated together with two standard (sus-

ceptible) varieties in 1995 at two locations. Twenty advanced lines and commercial varieties were tested at the same locations in 1996. All entries were exposed to an induced BLS epidemic at one location, but were kept disease-free at the second location. Epidemic development was slow and field resistance to four races of BLS was high for all but one of the lines tested, which claimed resistance to races 1, 2, and 3 in 1995. Six entries performed well both under BLS epidemic conditions and in the disease-free environment in 1995. Cultivars with resistance to only race 2 or races 1 and 2 of the pathogen were no different from susceptible checks in terms of yields and disease resistance and were not tested in 1996; combined results form 1995 and 1996 are discussed.

026

Influence of Nitrogen Fertilization and Plastic Mulches on Insect Populations and Disease Incidence on Bell Peppers (*Capsicum annuum*)

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Production of red bell peppers (*Capsicum annuum* L. cv. King Arthur) is relatively new to Quebec, and management techniques need to be further developed in terms of insect and disease control as well as fertigation techniques. The purpose of the experiment was to compare the fertigation of peppers using either the conventional method (weekly fertigation) or fertigation based on the readings of the SPAD 502 chlorophyll meter. The experiment compared the effects of these fertigation treatments, with respect to insects and diseases, on either a silver or black mulch. The study done in 1995, demonstrated that using the chlorophyll meter saved 28 kg N/ha compared to the weekly fertigated plants. However, this decrease did not affect the population of insects or the disease incidence on the plants. The main differences occurred between the black and silver mulch treatments for aphid populations. Plants on silver mulch had significantly lower numbers of aphids than the other treatments. Plants on black mulch also had low aphid population compared to plants grown on bare soil. The relationship between silver mulch and viruses or tarnished plant bug were not as apparent. However, the viral infections and tarnished plant bug populations on the plants tended to be lower than those on most of the black mulch treatments. Sunscald was not influenced by mulch or fertigation treatments. This may be partly attributed to the amount of leaf area. The number of fruit invaded by European corn borer was too low to draw any conclusions. Blossom end rot, sclerotinia, and bacterial spot were not present in the field in the 1995 season. The results from the 1996 season should further elucidate these results.

027

Benefit of Chemical and Cultural Control in Managing Pumpkin Viruses and Vectors

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Pumpkins rank third in acreage among Ohio's fresh market vegetables. Recently, increasing incidence of insect-vectored viruses have threatened the economic potential of this crop. Studies were initiated in 1992 to obtain information on abundance of insect pests, to evaluate the effect of insecticides, reflective mulch and row covers on pest density and yield of marketable fruit. In 1994 and 1995, statewide virus surveys were conducted to determine virus types infecting the pumpkin crop. In 1992 the greatest insect injury of concern was cucumber beetle feeding on fruit rinds, Insecticides lowered pest density, but there was no effect on marketable yield. In 1993, yield of virus-infected fruit was lower were reflective mulch was used than where rowcovers or foliar insecticides were used. Marketable yield and virus incidence in 1994 were not affected by reflective mulch, rowcovers or stylet oil due to the late arrival of the virus. In 1995, aphid infestations at three locations were significantly lower on plants on reflective mulch than on plants on bare ground. Results of the 1994 virus survey showed that watermelon mosaic virus (WMV) was the most common virus in Ohio pumpkins. The watermelon mosaic developed late in the season and fruit deformity was not severe enough to affect marketable yield. There was some incidence of cucumber mosaic and squash mosaic virus but zucchini yellow mosaic virus was not detected in 1994. Results of ELISA testing of samples collected in August/September 1995 at 27 farms were 18 farms positive for watermelon mosaic virus, 5 sites positive for squash mosaic, 4 sites positive for papaya ringspot and 1 site positive for zucchini yellow mosaic.

028

Efficacy of Endogenous Satellite Expression to Confer Resistance to CMV in Satellite Transgenic Tomato under Field Conditions

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Viral satellite RNA associated with cucumber mosaic virus (CMV) is know to modulate CMV symptomology. Virulent CMV associated RNA 5 (CARNA 5) satellites may intensify crop disease. Naturally occurring variants of these satellites, however, attenuate CMV symptoms. Satellite transgenic tomato plants expressing the S-CARNA 5 or 1-CARNA 5 ameliorating forms of the satellite were evaluated under simulated CMV epidemic conditions in USDA–APHIS approved field trials. Trials conducted at Beltsville, Md., in 1994 and 1995 demonstrated that CMV can be effectively controlled under field conditions in satellite transgenic plants. Yields of transgenic lines infected with CMV were 50%–65% greater than that of non-transgenic infected controls. Yields of noninfected transgenic lines ranged from 5% greater than, to 33% less than, noninfected nontransgenic controls. Expression of CARNA 5 in inoculated transgenic plants greatly reduced CMV foliar symptoms and virus titers when compared to inoculated control plants. Levels of CARNA 5 were detected at varying levels in infected transgenic plants throughout the growing season. Virus or satellite was not detected in samples collected from tomato border plants and weeds growing inside and outside a nonhost crop border surrounding the test plot. Field tests conducted in 1996 will evaluate transgenic tomato plants with a double construct coding for the CMV coat protein gene and 1-CARNA 5 satellite.

029

Activation of Systemic Acquired Disease Resistance in Cucumber Seed during Germination

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Systemic acquired disease resistance (SAR) involves the activation of the natural physiological defense mechanisms against pathogen infection in a systemic manner within plants. A series of experiments were conducted in which 'Beit Alpha' cucumber seed were treated with 2,6-dichloro-isonicotinic acid (INA) during osmotic conditioning or imbibition in water. Following germination and emergence, seedlings were challenge inoculated at the two-leaf stage with *Colletotrichum lagenarium* and incubated as a bioassay for expression of SAR. INA (289 μM) treatment of imbibed seeds reduced the number of anthracnose lesions per leaf by >90% as compared to untreated controls. Interactions were observed between INA treatment and the solute used for osmotic conditioning. Priming in 0.5 M KH_2PO_4 or 0.49 M sorbitol in combination with INA resulted in rapid seedling emergence and a 65% to 80% reduction in disease lesion incidence relative to primed controls. Increases in solute concentration, so as to lower the osmotic potential of the priming solution and thus extend the period of exposure to INA, did not result in enhanced SAR expression. Maximum SAR induction occurred when imbibed seeds were exposed to INA at the onset of expansive radicle growth. This study demonstrates that SAR can be abiotically induced in cucumbers during seed germination.

030

Two-year Grower Survey of Western Flower Thrips and Tospovirus Incidence and Management in Maine Greenhouses

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A mail survey of greenhouse growers was conducted in 1994 and 1995 to determine the presence and importance of western flower thrips (WFT), *Frankliniella occidentalis* Pergande, in Maine greenhouses in growing years 1993 and 1994. Respondents were licensed growers with at least 1000 ft^2 (93 m^2) of greenhouse growing area. The survey objectives were to develop a grower demographic profile; determine the incidence of WFT and two WFT-vectored plant viruses, tomato spotted wilt (TSWV) and impatiens necrotic spot (INSV); and identify current WFT management strategies. The survey shows that Maine greenhouse growers are seasonal, experienced and retail oriented. Their growing area averages less than 10,000 ft^2 (929 m^2) and they produce a diverse crop mix and choose to import production stock as much as propagate it themselves. Both WFT and TSWV/INSV have increased in severity in Maine greenhouses over the past 10 years. Larger, year-round greenhouses are more likely to experience in-

festations of WFT and higher virus incidence. An integrated pest management (IPM) strategy is employed by the majority of growers surveyed. Insecticide application is the primary tactic used to control WFT. Fewer than 4% of the growers use natural enemies to control thrips. However, 63% responded that future research in pest management should focus on biological control.

031

Effect of UV-reflective Mulches on Tomato Yields and on the Silverleaf Whitefly, *Bemisia argentifolii* (Bellows & Perring)

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Field studies were conducted for three seasons, Fall 1994, Spring 1995, and Fall 1995 on the effect of UV-reflective films (mulches) on fruit yields and on the silverleaf whitefly [*Bemisia argentifolii* (Bellows and Perring)] of staked, fresh-market tomatoes (*Lycopersicon esculentum* Mill). The UV-reflective mulches were metallized aluminum (ALU) and painted aluminum (PAL) on either black or white plastic film. The AL and SL mulches were evaluated with and without a white (fall) or black (spring) 25-cm-wide painted band in the bed center. Controls were the conventional white (fall) or black (spring) polyethylene mulches. Highest reflected energy ($\mu mol \cdot m^{-2} \cdot s^{-1}$) to the plants at 25 cm from the mulch surface was measured on the ALU without white painted band or on PAL on white or black mulch with white painted band. Lowest energy was reflected from the white or black controls. Whitefly populations in the fall were lower on the ALU than on the PAL mulches. In the spring, when whitefly populations were low, number of whiteflies on tomato leaves were similar with all treatments. The proportion of plants with symptoms of the silverleaf whitefly transmitted tomato mottle virus (TMoV) were highest on controls. Yields in the fall were similar with UV-reflective or with white mulch. In the spring, fruit size and marketable yields were greater ($P < 0.05$) on plants with PAL on white plastic film without black band than on black control.

032

Repellency of n-Alkanes and Relationship of Structure and Repellency of Trichome Secretions from *Lycopersicon hirsutum*

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Many accessions of *Lycopersicon hirsutum* are highly resistant to insects. Trichomes and their secretions have been extensively indicated as factors of resistance. One mechanism of resistance mediated by secretions is repellency, a mechanism that is consistent with the observation that few insects visit plants of *L. hirsutum*. Trichome secretions from certain accessions of *L. hirsutum* f. *typicum* are repellent to spider mites. However, the composition of secretions from different accessions of f. *typicum* are chemically diverse. Sesquiterpene hydrocarbons are prevalent in secretions, but are structurally diverse. How structure may relate to repellency is of interest but difficult to address because isolation of pure sesquiterpene hydrocarbons from hydrocarbon mixtures is difficult. To begin examining relationships between structure and activity we determined how chain length of n-alkanes related to repellency of spider mites. n-Alkanes having chain lengths from 8 to 22 carbon atoms were assayed for repellency. The C16-C18 alkanes were most repellent. Smaller and larger hydrocarbons were less repellent. The EC_{50} for n-hexadecane was equal to that of the most repellent natural products we have isolated from trichome secretions of *L. hirsutum*.

033

Susceptibility of Seven Tomato Varieties to *Spodoptera littoralis* (*Lepidoptera: Noctuidae*) and Colorado Potato Beetle (*Coleoptera: Chrysomelidae*) Leaf Infestation

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The development and deployment of crop varieties that resist or tolerate insect attack is one tactic of pest management that can eliminate one or more spray applications per season, a significant savings to the grower. Seven tomato, *Lycopersicon esculentum* Mill. cultivars (Marmand, Edkawy, VF-145, GS-27, Pakmore-B, Flordade, and UCX) were evaluated under greenhouse conditions for differences in mortality and feeding behavior (leaf-area ingested) of the 4th instar larvae of *Spodoptera littoralis* (Boisd) and the Colorado potato beetle, *Leptinotarsa decemlineata* (Say). The most resistant cultivars to *S. littoralis* during two summer seasons, 1990 and 1991, were Edkawy and UCX (37% mortality) and VF-145 (33% mortality). Mortality was least (20%) on the F_1 hybrid GS-27, indicating that GS-27 was the most favorable cultivar for *S. littoralis*. *L. decemlineata* larvae reared on excised tomato leaflets of the same varieties indicated similar trends. Factors responsible for greater resistance of Edkawy and UCX to *S. littoralis* and *L. decemlineata* are under investigation.

38 ORAL SESSION 5 (Abstr. 034–038) Breeding and Genetics–Floriculture II

034

Postharvest Longevity of *Antirrhinum majus* L. Cut Flowers as Influenced by Backcrosses to a Short-lived Recurrent Parent and Harvest Time

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An inbred backcrossing approach was taken to transfer long postharvest keeping time of cut flowers from a white inbred line of *Antirrhinum majus* L. into a yellow short-lived inbred line. Three backcrosses to the short-lived recurrent parent were done followed by three generations of selfing by single-seed descent. Plants from 56 accessions of BC1S3 through BC3S3 were grown twice (June and August 1995) in a greenhouse and flower stems harvested for postharvest longevity evaluation. Postharvest evaluation was done in deionized water under continuous fluorescent light. Longevity was determined as the number of days from cutting to discard when 50% of the open florets on a flower stem wilted or turned brown. One yellow accession was retrieved that was not significantly different in postharvest longevity from the white long-lived parent. Environment substantially influenced postharvest longevity over harvest dates. Possible causes for variation of postharvest keeping time will be presented.

035

Floral Initiation in *Pelargonium* ×*domesticum* is Affected by Total Cumulative Irradiance

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Floral initiation signals the commencement of sexual reproduction in angiosperms. In many plant species this developmental phase is controlled by photoperiod. However, it may be regulated by other factors, such as plant age or specific temperature or irradiance requirements. Floral initiation occurs in *Pelargonium* ×*domesticum* (regal Pelargoniums) in response to exposure to cool (7–12°C) temperatures for about 4–6 weeks, or to cumulative irradiance at 18–23°C. Broad genetic variability exists so that floral initiation in some cultivars is almost completely controlled by temperature, while in others it is almost completely controlled by cumulative irradiance. Among the latter group of genotypes, genetic variability exists for the amount of irradiance required. The purpose of this study was to determine the precise irradiance requirements for nine commercially important cultivars. The cultivars varied significantly in their response to irradiance with respect to floral initiation. Low irradiance requiring genotypes developed visible (5 mm) buds with as little as 250 mol of total cumulative irradiance; floral initiation in these cultivars occurred with only 50 mol of irradiance. High irradiance requiring genotypes still had vegetative meristems after 300 mol of total cumulative irradiance. Further studies were conducted on 'Majestic', chosen for its high irradiance requirement. The objective of this study was to determine whether cool temperatures (7–12°C) or heat stress (23–28°C) could replace the irradiance effect. The results indicated that neither of these environmental conditions could replace the effects of moderate temperature (18–23°C) and high cumulative irradiance in this cultivar.

036

Effects of Heat Stress on Floral and Vegetative Development in New Guinea Impatiens

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Fifty-three commercial New Guinea Impatiens cultivars (*Impatiens hawkeri* Bull.) from six different breeding series were tested for level of heat tolerance.

Five floral (flower number, flower length, flower width, floral dry weight, and flower bud number) and five vegetative characteristics (leaf dry weight, stem dry weight, total dry weight, number of nodes, and number of branches) were evaluated with emphasis placed on continued flowering under long term heat stress. Significant differences among cultivars were found in each data category ($P \leq .0001$). Flower number varied from 0 to 6, flower length varied from 10 to 51 mm, flower width varied from 10 to 47 mm, floral dry weight varied from 0 to 0.5 g, and flower bud number varied from 0 to 14. Four heat tolerant (Celebration Cherry Red, Celebration Rose, Lasting Impressions Shadow, and Paradise Moorea) and three nonheat-tolerant (Lasting Impressions Twilight, Danziger Blues, and Pure Beauty Prepona) cultivars were identified using a Weighted Base Selection Index. These cultivars were used as parents in a full diallel crossing block with reciprocals and selfs. One hundred seedlings from each of 49 crosses were evaluated for heat tolerance. General and specific combining abilities of the parents were evaluated as was heritability. It was found that the four heat tolerant cultivars had higher general combining abilities. Heat tolerance has low heritability and is controlled by many genes. Superior genotypes were identified (selection intensity of 0.05) and retained for further evaluation and breeding efforts.

037

Inheritance of Characters Important to Drought Tolerance in New Guinea Impatiens (*Impatiens hawkeri)*

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The study was designed to provide information on the inheritance of certain characters important to drought tolerance in New Guinea impatiens. Seven genotypes, three were drought tolerant and four drought susceptible, were crossed in a full diallel with selfs. Drought tolerance of parents was estimated using stomatal conductance. At least 55 seedlings per cross were grown in the greenhouse for 2 months and evaluated for drought tolerance. Leaf fresh weight (LFW) leaf area (LA), leaf length (LL), leaf width (LW), and leaf thickness (LT) were measured using 10 leaves from each plant (parents plus progeny). From these measurements, we calculated LFW/LA and LL/LW. Stomatal conductance was measured on parents plus progeny of three crosses (drought tolerant x drought tolerant, drought tolerant x drought susceptible and drought susceptible x drought susceptible). Heritabilities and nonadditive and additive genetic variance for each trait were determined. All characters were significantly different between families. LFW/ LA and LT was positively correlated with drought tolerance. The heritabilities for these traits were high, indicating that these characters can be used for selecting for drought tolerance in New Guinea impatiens and that rapid progress can be and was made in improving drought tolerance in New Guinea impatiens.

038

Physiological Differences between Zinc-efficient and Zinc-inefficient Genotypes of Interspecific *Exacum*

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Research in Penn State's *Exacum* breeding program has revealed genotypic variation for the development of zinc deficiency, which may indicate the presence of zinc efficiency factors. Through preliminary experiments, we have identified both genetic families and individual genotypes that can be classified as either zinc-efficient or zinc-inefficient. Chi-square contingency analyses indicate significant differences ($P < 0.001$) in segregation patterns for zinc deficiency among hybrid families. Segregation patterns within families ranged from 100% of the progeny developing zinc deficiency to 100% of the progeny remaining healthy. Two genotypes contrasting in zinc efficiency have been identified and used in experiments designed to investigate physiological factors related to zinc efficiency. The zinc-efficient genotype has a significantly higher ability to decrease solution pH ($P < 0.01$), significantly higher root cation exchange capacity ($P < 0.007$), significantly lower root/shoot ratio ($P < 0.001$), significantly lower water loss/cm^2 leaf ($P < 0.03$), and significantly higher fresh weight/dry weight ratio ($P < 0.001$). Research on zinc uptake rates is currently being conducted utilizing the efficient and inefficient genotypes. Based on all of our research, we conclude that 1) a strong genetic effect is involved in the zinc nutritional status of interspecific *Exacum* hybrids and 2) a number of physiological traits differ between zinc-efficient and zinc-inefficient genotypes.

45 ORAL SESSION 6 (Abstr. 039–045) Biotechnology–Transgenics

039

Reduction of 1-Aminocyclopropane-1-carboxylic Acid (ACC) in Pollen by Expression of ACC Deaminase in Transgenic Petunias

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Petunia hybrida pollen accumulates significant levels of the ethylene precursor 1-aminocyclopropane-1-carboxylic acid (ACC) late in development. This pollen ACC is thought to play a role in the rapid burst of ethylene produced by pollinated pistils. To investigate this further, we have expressed the ACC deaminase gene product from Pseudomonas in transgenic petunias under the control of three different promoters including CaMV-35S, LAT52, and TA29 directing construction expression, pollen-specific expression and tapetum-specific expression, respectively. Several transgenic plants expressing the LAT52-ACC deaminase gene exhibited significant reduction of ACC in pollen. Two independent transformants contained only trace amounts of ACC in pollen. In contrast, the other promoters did not lead to reduced ACC in pollen. Pollination of wild-type pistils with pollen from LAT52-ACC deaminase plants elicited increased ethylene similar to wild-type pollen. Fecundity was unaffected by the reduction in pollen ACC content. Taken together, we conclude pollen-borne ACC is not the elicitor of pollination-induced ethylene production by pistils.

040

Postharvest Behavior of Transgenic Cantaloupe Melons with Suppressed ACC Oxidase Activity

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We have generated transgenic Cantaloupe Charentais melons expressing an ACC oxidase antisense gene in which ethylene production was reduced to less than 1% as compared to control untransformed fruits. As a consequence, some aspects of the ripening process were strongly inhibited (aroma volatiles production, chlorophyll and cell wall degradation, pigmentation of the rind, activation of peduncular abscission zone) while others remained unchanged (coloration of the flesh), allowing us to distinguish between ethylene-dependent and ethylene-independent pathways. Some postharvest characteristics of the transgenic fruit are described in terms of expression of ripening-related genes, respiratory behavior, and biochemical composition. Data also are presented showing that exogenous ethylene treatments could reverse the antisense phenotype.

041

Expression of the *RolC* Gene in Transgenic Plants of *Salpiglossis sinuata* L.

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The phenotypic expression and inheritance of the *rolC* gene in the transgenic plants of *Salpiglossis sinuata* L. were investigated. The chasmogamous salpiglossis plants with solid yellow flower color (*ccrrDD*) were transformed with *Agrobacterium tumefaciens* strains LBA4404 and EHA101 carrying *rolC*, *GUS*, and *NPTII* genes via a leaf disc co-cultivation system. The transgenic plants were shorter in plant height, produced more branches with a compact growth habit, and developed smaller flowers and narrower leaves as compared to the control plant. While the transgenic plants showed the same corolla color and color shades as the parental line, they became male sterile. A backcross between a male-sterile transgenic plant (*ccrrDD* plus *rolC*) and a nontransformed red-flowering line (*ccRRDD*) produced a progeny with red flower color and the same altered growth habit as the transgenic female parent. Only 4 out of 32 plants in this progeny population showed the negative GUS staining as well as the non transgenic phenotype. These results suggest that at least two copies of the *rolC* gene were integrated into one homologous chromosome pair during transformation and that a cross-over event may have occurred during meiosis.

042

Engineering Transgenic Eggplant (*Solanum melongena* L.) Resistant to the Colorado Potato Beetle (*Leptinotarsa decemlineata* Say)

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A chimeric construct, containing the synthetic *cryIIIA* (*Btt*) gene, the NPTII selectable marker and the *uidA* reporter gene, was incorporated via *Agrobacterium tumefaciens* into eggplant, variety Hibush. The synthetic *cryIIIA* gene, altered at the nucleotide level without changing the amino acids of the toxic protein by J. Kemp of New Mexico State Univ., Las Cruces, is adapted for high expression in plant cells. To verify the transgenic status, GUS assays were performed on over 300 plants, from which 185 were confirmed to be transgenic. Physical incorporation of the chimeric construct was further confirmed by Southern analysis of about 30 transgenic plants; both single and multiple site incorporation of the *Btt* gene were found. Resistance to Colorado potato beetle (CPB) was assessed by: a) placing egg masses of CPB on leaves of plants grown in the growth chamber; b) placing first-instar larvae on detached leaves; c) observing 173 transgenic plants under field conditions. About 60% of the transgenic plants displayed a very high level of resistance to CPB. No larvae survived on the resistant plants longer than 50–60 hours after hatching. Upon selfing, the transgenic plants with a single construct segregate in the S_1 generation in a Mendelian fashion.

043

Optimization of Microprojectile Bombardment-mediated Gene Delivery into Bisected Axillary Buds of Grape Hybrid Cultivars

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Direct DNA delivery via microprojectile bombardment has been successfully used to transform a wide range of species. Transformation using this system is dependent on the optimization of several parameters. These parameters involve the explant, the gene construct, and parameters in the bombardment system. DNA was delivered into bisected axillary buds of grape hybrids 'Chancellor' and 'Valiant'. Target tissues were bombarded with gold microprojectiles coated with GUS::NPTII fusion gene construct(pBI426). Several experiments with varying parameters were conducted in order to increase the frequency of DNA delivery. Data were analyzed as a completely random design with 6 single petri dish as a replication and 50-60 bisected axillary buds per replication in each treatment. The treatment design was the single-factor method.Higher frequencies of transient transformation were obtained using microprojectiles of 1.6 μm diameter, adding 0.15 M mannitol and 0.15 M sorbitol, under a pressure of 68.6 cm Hg and a target distance of 6 cm. After 40 days on the selection medium containing 50 mg kanamycin/L regenerated plantlets were obtained and 40% of them expressed the *GUS* gene. The biolistic approach using bisected axillary buds as target tissue could be a method to achieve stable transformation and transgenic grape plants.

044

Plant Regeneration of Hot Pepper (*Capsicum annuum* L.) and Expression of Mouse Adenosine Deaminase (ADA) Gene via *Agrobacterium*-mediated Transformation

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Since in vitro regeneration and transformation systems in hot pepper (*Capsicum annuum* L.) have not been available, the application of new genetic manipulations has been limited. Here we report an efficient procedure to regenerate whole pepper plants and to generate transgenic plants expressing a foreign gene was established. High frequency of plant regeneration was observed when hypocotyl and cotyledon explants were cultured on MS/B_5 medium supplemented with NAA 0.05 mg·L^{-1} plus zeatin 2.0 mg·L^{-1}, NAA 0.05 mg·L^{-1} plus zeatin 2.0 mg·L^{-1}, IBA 10.0 mg·L^{-1} plus BA 1.0 mg·L^{-1}, IAA 0.02 mg·L^{-1} plus zeatin 3.0 mg·L^{-1}. An addition of $AgNO_3$ 5–10 μm to these media improved the regeneration rate by about 10%. For plant transformation, hypocotyl and cotyledon explants of pepper were preconditioned on kanamycin-free shoot induction medium for 48 hours. Then, co-cultivation with *Agrobacterium tumeaacience* was done on the co-culture medium for 2 days. The explants were then blotted in sterile filter paper and placed on shoot induction and selection medium containing kanamycin sulfate (100 mg·L^{-1}) and carbenicillin (500 mg·L^{-1}). PCR showed that the introduced ADA gene was integrated and stably expressed in the regenerated plants. ADA enzyme activities were checked by spectrophotometric analysis.

045

Establishment of a Plant Regeneration and Genetic Transformation System of *Panax ginseng* C.A. Meyer

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Plant regeneration of ginseng has been known to be difficult, and there are a few reports on plant regeneration of ginseng via somatic embryogenesis. In vitro flowering has, however, been one of the major drawbacks in these regeneration systems in which BA and GA_3 were included in germination and shoot multiplication media. Multiplication of adventitious shoots from a single somatic embryo, abnormal morphology, and vitrified shoots were also observed. All these facts have made successful acclimatization of ginseng plantlets difficult. The purposes of this study were 1) to establish the plant regeneration system via organogenesis, 2) to improve normal plant regeneration via somatic embryogenesis, 3) to improve the efficiency of plant regeneration from protoplast culture, 4) to understand the acclimatization process, 5) to develop effective genetic transformation protocol. Data in relation with all these studies are presented in detail.

46 ORAL SESSION 7 (Abstr. 046–052) Culture and Management–Vegetables

046

Interaction of In-row Spacing and Degree of Pruning on Yield of 'Agriset 761' Tomato

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Three in-row spacings of 46, 61, and 76 cm were combined with three pruning methods [none, light (half the suckers removed from the ground to the fork), and heavy (all suckers removed from the ground to the fork] in a complete factorial design. Three harvests were made and responses differed among harvests. At first harvest yields decreased as in-row spacing increased and yields increased as degree of pruning increased. No interactions occurred. At second harvest yields again decreased as in-row spacing increased but only heavy pruning decreased yields. A interaction occurred where the closest in-row spacing pruned lightly did not follow the same pattern as the other two row spacings pruned the same. At third harvest yields increased as in-row spacing increased but pruning method had little effect. With seasonal total yield, in-row spacing had little effect but heavy pruning reduced seasonal total yield over none or light pruning.

047

Adaptation of the CROPGRO Model to Simulate Yield of Fresh-market Tomato

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Modeling the growth of field-grown tomato (*Lycopersicon esculentum* Mill.) should assist researchers and commercial growers to outline optimal crop management strategies for specific locations and production systems. A generic crop-growth model (CROPGRO) was previously adapted to simulate the growth of fresh-market tomato under field conditions. Plant growth and development of field-grown tomato, and fruit yields, will be outlined and compared to model predictions for a number of locations in Florida, nitrogen fertilizer rates, and irrigation management practices. Possible application of the model to quantify effects of crop management on crop production will be discussed using simulated yield values for a wide range of environmental conditions.

048

Effects of Irrigation and Nitrogen Fertilizer Rate on the Annual Culture of Globe Artichoke in Quebec

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This research is focused on developing production techniques for globe artichoke (*Cynara scolymus* L.) production in Quebec, Canada. It is a herbaceous perennial grown for its immature flower bud. The globe artichoke is usually propagated vegetatively because plants grown from seed lack uniformity. Furthermore, only a small percentage of plants grown from seed flower due to insufficient cold treatment for vernalization. Artichokes cannot be grown as perennials where winter temperatures are below –10°C. The objectives are to determine the optimum nitrogen fertilizer requirements, and irrigation levels, and to evaluate two widely grown cultivars. Globe artichoke was grown in the greenhouse from seed in March 1995. Seedlings were naturally vernalized and transplanted to the field in mid May on silver plastic mulch. A split-split-plot design was used with three replications. At the rate of 2.5 cm per week water was applied via drip irrigation to one half of the field and the other half received irrigation based on tensiometer readings. The nitrogen treatments were 100, 200, and 300 kg/ha of N of which two-thirds was incorporated preplant. The remainder was applied as a sidedress a month later. In this study, 'Imperial Star' (IS) produced uniform plants from seed and a higher percentage of plants produced flower heads (bolted) than 'Green Globe Improved' (GG Imp). The harvest period began on 1 Aug. for IS and 9 Aug. for GG (Imp). It ended on 18 Sept. for both cultivars. Eighty-six percent of the IS plants produced buds compared to thirty-nine percent for GG (Imp). Both cultivars produced a high percentage of small buds. Yield from plants that received 2.5 cm of water weekly was greater than the irrigation treatment based on tensiometer readings. Data on nitrogen treatments, days to flowering and harvest, flower bud quality, weight and size of terminal buds, and total yield are being statistically analyzed using SAS.

049

Spatial Arrangement for Daikon Seed Production

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Seed production systems for daikon or Chinese winter radish (*Raphanus sativus* L., Longipinnatus Group) were investigated in the Winter Garden of southwest Texas in 1992 and 1993. Planting dates ranged from October through March. Bed configurations (number of rows x bed spacings) were 2 x 0.96 m, 2 x 1.93 m, 3 x 1.93 m, and 4 x 1.93 m. Within-row spacings were 5, 10, and 15 cm. Crops were grown using minimum fungicide and insecticide amounts, while no attempt was made to control weeds chemically. Seed was harvested between May and June. Seed yields ($kg \cdot ha^{-1}$) increased for planting dates of October to November. Lower seed yields from the January or later plantings appear to be related to increased disease and insect pressures. Total and medium class size (≥3 and ≤4 mm in diameter) seed yields were highest at 40 rows x 1.93 m bed spacings and 10 cm within-row plant spacings. Germination and percent coatless seeds were unaffected by bed configuration and within-row plant spacings. The closest within-row spacings (5 cm) increased the risk of plant lodging and delayed plant maturity.

050

Adjustments of Irrigation Scheduling Model for Bell Pepper

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An irrigation scheduling model represented by 12.7 DAT * 0.5 * ASW = D(DAT – 1) + [Ep(DAT) * CF(DAT) – R – I] was tested in central Alabama for Spring-grown bell pepper (*Capsicum annuum* L.). In the model, DAT (days after transplanting) is crop age; effective root depth is 12.7 DAT with a maximum of 250 mm; usable water ($mm^3 \cdot mm^{-3}$) is 0.5 ASW; deficit on the previous day is D(DAT–1); evapotranspiration is pan evaporation [Ep(DAT)] times a crop factor value [CF(DAT) = 0.15 + 0.018 DAT – 0.0001 DAT * DAT]; rainfall (R) and irrigation (I) are in mm. The model called for 13 irrigations between 17 and 85 DAT. Under the current N recommendation rate for bell pepper (112 kg/ha), marketable yield increased quadratically from 36% to 148% of the model rate. Highest marketable yields occurred near the model rate. Under a N rate of 170 kg/ha, yields increased linearly. These results suggests that the model provided adequate moisture to maximize bell pepper marketable yields under the recommended N rate.

051

Fifty-year History of Harvesting Pickling Cucumbers Mechanically

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For 50 years, engineers, producers, processors, and manufacturers have been working on new and improved ways for mechanization of the harvest of pickling cucumbers, *Cucumis sativus* L. In 1957, processors investigated multiple-pick concepts. Multiple-pick harvesters were commercially manufactured in the early 1960s (Chisholm–Ryder). In the late 1950s, Stout and Ries evaluated the known multiple-pick harvesting concepts. In the early 1960s, once-over harvesting concepts were considered and evaluated by Ries and Stout. By significantly increasing the plant population and other horticultural practice and variety improvements, once-over harvest became the main thrust of mechanization from 1965 on. By 1970, at least major five commercial manufacturers sold harvesters (Blackwelder, FMC Corp., Hart Carter [later sold out to Cuke, Inc.], Porter-Way, and Wilde). In 1996 there are four commercial manufacturers (Cuke, FMC Corp., Jerry's Welding, and Pik Rite). Limited multiple-pick research and manufacturers persisted (Aero-Glide, Mac-Weld, and Powell). By 1975 over 85% of Michigan's pickling cucumbers were mechanically harvested, leading all other states. Today, about 60% of Michigan's production is harvested with machines. The information presented will be informative and an historical aid for engineers, manufacturers, horticulturists, processors, and historians, etc. to ensure that the worldwide research is known by scientists endeavoring to accomplish harvest mechanization.

052

Wind Protection and Planting Date Affect Snapbean Growth and Yield

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The effects of windbreak shelter on growth, total, and marketable yield of snapbeans were evaluated during 1994 and 1995. Plantings of 'Strike' and 'Rushmore' were made at roughly 2-week intervals in exposed plots and plots protected by tree windbreaks. Air and soil temperature, relative humidity, wind speed and direction were monitored continuously and averaged hourly. Wind speed in shelter was 36% and 43% that of open field wind speed in 1994 and 1995 respectively. Air and soil temperatures were higher in sheltered areas. Sheltered plants had significantly higher total dry weight and leaf area index, and significantly greater total internode lengths than exposed plants. For each year, sheltered plant means for both total and marketable seasonal yields were significantly higher compared to exposed plants. Mean pod yields were significantly affected by planting date and cultivar. 'Rushmore' produced significantly higher total and marketable yields than 'Strike'. The two cultivars responded similarly to sheltered and exposed production environments. Shelterbelts can increase total and marketable yields, with greatest increases early and late in the growing season, an additional advantage since market prices tend to be higher at these times.

58 ORAL SESSION 8 (Abstr. 053–058) Seedling Stand Establishment

053

Plant Population and Spacing Effects on Processing Tomato Growth and Yield

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Processing tomato (*Lycopersicon esculentum* Mill.) producers in the Great Lakes region have expressed interest in cutting crop establishment costs and improving profitability by reducing plant populations. This study compared plant development, fruit set, fruit size and yields using a range of single and twin-row plant populations (14,800 to 44,500 plants/ha) and four commercially important processing tomato cultivars ('OH8245', 'H9036', 'PS696', and 'H7135') with differing vine types and maturities. The 3-year study was conducted at Fremont, Ohio, on a Colwood fine sandy loam, using raised beds and other standard cultural practices. Six- to seven-week-old transplants (288 cell size) were mechani-

cally planted in middle to late May. Once-over harvest was timed to achieve 80%–90% red fruit, using a Johnson tomato harvester. Plant population had a significant effect on 1995 fruit yields for all cultivars tested. Optimum red fruit yields were observed at 37,100 plants/ha in twin-rows for 'OH8245', which was similar to 1994 results. Optimum fruit yields for 'PS696' were obtained at twin-row populations of 29,600-44,500 plants/ha in 1995. Three year results for 'OH8245' (medium-sized vine) indicate no significant differences due to plant population or arrangement. Mean red fruit yields varied considerably by year in this field research (62.7, 95.2, and 44.8 MT/ha in 1993, 1994, 1995 respectively), but twin-row spacing of 'OH8245' provided significant yield gains in 2 of 3 years for populations of 29,600 plants/ha or greater.

054

Effects of Irrigation System on Pepper Transplant Production

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A study was conducted in Fall 1995 at the Horticultural Greenhouse, North Carolina State University, to examine growth of banana ('Banana Supreme'), bell ('Camelot'), and jalapeno ('Mitla') pepper under overhead (OI), ebb and flood (EF), and float (F) irrigation systems. Plant emergence was fastest in the float system, but slowest in the OI system. Irrigation treatment was highly significant for all weekly sampling dates for root and shoot fresh weight, root and shoot dry weight, root length, stem diameter, height, and leaf area. Stem diameter of F plants was greater than both EF and OI. However, EF and OI plants had similar diameter regardless of sampling date. Root fresh weight did not differ among pepper cultivars. By 39 days after planting (DAP), F plants had 33% greater root fresh weight, by 46 DAP they were almost double, and at 53 DAP they were 44% larger compared to the EF treatment. Float plants had greatest root length, but EF and OI plants had denser root mass (visual observation) in the transplant container cell. At 46 and 53 DAP, EF plants were generally taller than OI plants, and by 60 DAP this difference was almost 30%. Float plants were about double the height of the EF and OI plants and this difference continued until the experiment terminated. Bell pepper had the greatest shoot fresh weight at all sampling dates after 25 DAP, while jalapeno was greater than banana only up to 39 DAP. Beyond 39 DAP, banana pepper fresh weight surpassed jalapeno pepper. By 53 DAP, shoot fresh weight of float transplants were almost 3 times greater than EF or OI plants. Float plants reached a satisfactory size (137 mm height) for transplanting by 8 weeks. Height of EF and OI plants at this time was 68 and 48 mm, respectively. This experiment is being repeated in Spring 1996.

055

Seed Leakage Does Not Contribute to Thermoinhibition in Jalapeno and Cayenne Cultivars

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Chile (*Capsicum annuum* L.) seeds sown in July for fall transplants in the greenhouse often yield poor stands due to thermoinhibition. To determine cultivar response to high temperature, five jalapeno cultivars and one cayenne cultivar used commercially in Florida and New Mexico were tested. Two seedlots of 'Cayenne, Large Red Thick', 'Ole', 'Jalapeno M', 'Mitla', and 'Tam Veracruz', and one seedlot of 'Ebano' were evaluated on a thermogradient table at a temperature range of 20, 25, 30, 35, and 40°C. Percent germination, mean daily germination, and germination performance index were calculated. Additional seeds were soaked for 24 hours at 25, 30, 35, and 40°C. The exudate was then measured for electrical conductivity and glucose equivalents as an indication of seed leakage. All cultivars exhibited thermoinhibition, but the critical temperature of onset varied among cultivars. 'Ebano' had the highest germination performance index across all temperatures among the six cultivars. At 40°C, however, no cultivar exceeded 4.0% germination. There was significant variation in germination performance between seedlots of some cultivars. The electrical conductivity and the number of glucose equivalents leached from the seed varied among cultivars, but did not correlate with decreased germination. Thermoinhibition in chile is probably due to factors other than those associated with membrane leakage.

056

Factors Affecting the Loss of Viability when Maize Grains are Imbibed and then Redried

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Seed hydration and dehydration affects many physiological reactions, including priming, accelerated aging, and desiccation intolerance. Maize grains were repeatedly imbibed and desiccated, or imbibed and held for periods of time to identify the role of each of these factors. Grains were equilibrated to 12% moisture content (mc) and subjected to cycles (up to 14) of hydration (2 hours) and immediate dryback, or one hydration of 2 to 12 hours and dryback. Germination and vigor (root length and leachate conductivity) were determined after each cycle. Grains adjusted to three levels of hydration (27%, 34%, and 40%) were held for up to 10 days in a sealed desiccator. Each day samples were taken and either dried to the original mc prior to evaluation, or evaluated immediately as above. With each cycle of 2 hours of imbibition, seed mc increased (22% to 39%). Root lengths increased (priming effect) during the early cycles of imbibition and dryback. Decline in germination after eight cycles was a result of either accelerated aging or desiccation intolerance. Based on the results of the holding study, both factors contributed to deterioration, but desiccation intolerance was only observed when mc was above 27%. Conductivity of grain leachates was not correlated with loss of germination or vigor in whole grains, but appeared to reflect deterioration in isolated embryos.

057

Varietal Identification of Cyclamen and Petunia Seeds Using RAPDs

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Varietal identification of cyclamen and petunia is important for flower seed production because these crops are marketed as hybrids and genetic purity determinations assure the purity of the seed lot and the success of hybridization. Random amplified polymorphic DNA (RAPD) banding patterns have been shown to be useful in identifying genotypes of various crops. This molecular biology technique was applied to five commercial cyclamen and six petunia hybrids. Using bulk seed/seedling samples, the varieties could be differentiated. However, when individual seeds of the cyclamen hybrid were tested, differing polymorphisms were observed. These variations were attributed to genetic variability in the inbred parents. We conclude that the genetic purity of cyclamen seeds can be improved and that the use of RAPDs can assist breeders of hybrid flowering crops in better monitoring seed quality.

058

Modifying Relative Humidity during Accelerated Aging For Impatiens Seeds

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The accelerated aging vigor test subjects seeds to high temperatures (41°C) and relative humidity (about 100%) for short durations (usually 72 hours). These recommendations, however, have been developed for large-seeded agronomic crops and may be too severe for small-seeded flower crops that deteriorate rapidly during storage such as impatiens. We examined the effect of aging regime duration (48, 72, and 96 hours) and temperature (38 and 41°C) as well as relative humidity using three saturated salt solutions (KCl–87% RH, NaCl–76% RH, and NaBr–55% RH) on two commercial impatiens seed lots differing in seed vigor but not percentage germination. The greatest differences in percentage germination after 4 days were found among the treatments of 48 hours for KCl, 72 hours for NaCl, and 96 hours for NaBr. While any of these saturated salt solutions may be used in a commercial situation to determine impatiens seed vigor, we suggest that a total 7-day test period consisting of 72 hours aging at 41°C using saturated NaCl with germination being determined 4 days after aging is most convenient.

59 ORAL SESSION 9 (Abstr. 059–063) Culture and Management–Small Fruits/ Viticulture

059

Influence of Crop Load and Cluster Microclimate on Yield and Fruit Quality in 'Seyval Blanc'

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A 2-year field study was initiated in 1994 to examine the interactions between crop load and cluster exposure and their influences on the yield and fruit quality of mature, own-rooted 'Seyval blanc' grapevines. Light, moderate, and heavy crop loads were established near bloom by cluster-thinning vines planted at 2.6 x 3.0-m spacing to around 20, 40, and 80 clusters per vine, respectively. At veraison, three clusters per vine were given one of three natural shaded treatments: fully exposed, partially shaded, and densely shaded. Vines with the heavy crop load produced higher yields per vine and lower cluster and berry weights. Heavy vine clusters tended to be more green in 1994 and possessed lower pH and soluble solid concentrations in both years compared to other crop loads. Compared to densely shaded clusters, fully exposed clusters had smaller average cluster and berry weights, lower titratable acidity, higher pH and soluble solid concentrations, and more yellow coloration. In 1994, no significant interactions were found for any fruit quality or yield characteristics. In 1995, significant interactions were found for soluble solids and hue angle, but not for yield, pH, or titratable acidity. These results suggest that the crop load of the vine and microclimate around the cluster, in addition to their individual effects, sometimes interact to affect fruit quality in 'Seyval blanc' wine grapes.

060

Surfactants Improve the Efficacy of Hydrogen Cyanamide Applied to Grapevines

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Field experiments conducted in 1994 (low-chill winter) and 1995 (high-chill winter) examined the effects of surfactants on the efficacy of hydrogen cyanamide (H_2CN_2) applied to 'Perlette' grapevines (*Vitis vinifera* L.) in the Coachella Valley of California. In 1994, when surfactants were not used, vines treated with 1% and 2% H_2CN_2 exhibited similar rates of budbreak and grew more rapidly than vines treated with 0.5% H_2CN_2. When 1% or more of the surfactant Armobreak was used, budbreak was generally similar among all H_2CN_2 concentrations. The number of days after treatment required for 70% budbreak declined as H_2CN_2 and Armobreak concentrations were increased. Results were similar in 1995, however, budbreak was inhibited when vines were treated with 2% H_2CN_2 + 2% Armobreak. A separate experiment conducted in 1995 revealed that two other surfactants, Activator 90 and Agridex, had similar effects on the efficacy of H_2CN_2 as Armobreak. The results indicate that, when 2% surfactant is used, the standard commercial H_2CN_2 concentration used in California may be reduced 75% while maintaining treatment efficacy. Chemical names used: hydroxypolyoxyethylene polyoxypropylene ethyl alkylamine (Armobreak); alkyl polyoxyetheylene ether (Activator 90); paraffin petroleum oil (Agridex).

061

Evaluation of Composted Municipal Sludge and Composted Yard Waste on Strawberries

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Compost increases nutrient availability, cation exchange capacity, and micronutrients in the soil. In urban areas, yard waste consisting of grass clippings, leaves, and woody materials can be composted. The purpose of this study was to compare the effects of soil-composted municipal sludge and soil-composted yard waste mixtures on strawberry plants grown in the greenhouse. Earliglow strawberry plants were planted in pots containing a soil mix of 0%, 10%, 20%, or 40% by volume of composted municipal sludge or composted yard waste. Plants were grown in the greenhouse with supplemental lighting. Soil-compost mixes having greater the 90 mhos of soluble salts were detrimental to the plants; plant survival was reduced by 80% in the 40% composted sludge–soil mix within 2 weeks after transplanting. Plants survived and grew in all other treatments. Composted yard waste at 20% to 40% by volume increased leaf K and B, but decreased P, Ca, and Mg.

062

Salvaging a Rabbiteye Blueberry Crop with GA_3 following Subfreezing Temperatures

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Recent research in Georgia indicated gibberellic acid (GA_3) could possibly be used to induce fruit set of freeze damaged rabbiteye blueberry (*Vaccinium ashei*) blooms. This research was conducted to determine the subfreezing temperature limit at which GA_3 could be expected to be of use in salvaging a crop with freeze-damaged flowers. Rabbiteye blueberries with flower buds at stages 5 to 6 of development (fully elongated corollas and open blooms) were exposed to temperatures of 0, –1, –3, and –4.5°C in growth chambers to simulate overnight freezing events. After cold exposure, plants were placed in a greenhouse with a hive of bumblebees. Half of the plants were treated with GA_3 and half were not. The number of flowers and subsequent fruit were recorded in order to calculate fruit set. Temperatures of –1°C and below caused fruit set resulting from pollination by bees to decline compared to control plants; whereas, flowers treated with GA_3 had fruit set comparable to control plants down to –3°C. Plants exposed to –3°C had 50% to 80% fruit set when treated with GA_3 compared to 5% to 19% fruit set for untreated plants. Temperatures of –4.5°C caused severe flower damage, and fruit set by pollination or GA_3 was very poor (<2%). These results indicate that GA_3 should be useful in salvaging a blueberry crop exposed to temperatures of –1 to –3.5°C during bloom.

063

The Effect of Wind on the Vegetative and Reproductive Growth of Four Primocane-fruiting Red Raspberries (*Rubus idaeus* L.) in the Establishment Year

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Four primocane fruiting (PP) red raspberry cultivars, 'Bogong', 'Cascade', 'Heritage', and 'Dinkum', were grown in exposed or sheltered (50% permeable artificial windbreak) sites fully exposed to prevailing westerly winds. The cultivars were evaluated to determine the effects of wind stress on vegetative and reproductive development and leaf gas exchange during the establishment year. The artificial windbreak resulted in an overall 35% reduction in wind velocity, increased the number of calm days (<5.4 $km \cdot h^{-1}$) and decreased the incidence of strong breezes (>36 $km \cdot h^{-1}$). Concurrently, the artificial windbreak did not have much of an effect on altering relative humidity, air or soil temperature. All cultivars responded similarly to wind exposure Plants in exposed sites had reduced leaf areas, internode lengths, leaf, cane, and total above ground dry weights. Leaf gas exchange parameters (P_n, g_s and C_i) expressed per unit leaf area did nor differ between treatments for most of the season but the sheltered plants as a whole supported a greater total leaf area and must have fixed a greater amount of carbon than the exposed plants. These larger sheltered plants produced a more extensive fruiting framework and resulted in a 2-fold yield increase. For these reasons, it is highly recommended to shelter raspberry plants from wind in the establishment year.

60 ORAL SESSION 10 (Abstr. 064–071) Water Stress/Water Utilization–Woody Plants

064

Root-zone Stress Effects on Water Relations and Growth of Silver, Red, and Freeman Maples

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Freeman maples (*Acer*×*freemanii* E. Murray) are suspected to be more resistant to environmental stress than red maples (*A. rubrum* L.) because the lineage of Freeman maple includes silver maple (*A. saccharinum* L.). Little is known, however, about stress resistance of silver maple, and few data from direct comparisons of red and Freeman maples are available. Our objectives were to determine effects of root-zone heat on silver maples from northern and southern provenances, and to compare red and Freeman maple cultivars for resistance to root-zone heat stress and drought. There were no provenance-by-temperature interactions when silver maples from 33.3°N (Mississippi) and 44.4°N (Minnesota) latitude were grown with root zones at 29 and 35°C. Plants from 44.4°N latitude had 36% higher fresh mass, 43% more leaf surface area, and 35% and 59% higher, respectively, root and shoot dry masses than plants from 33.3°N latitude. Midday xylem water potential was 68% more negative for plants at 35°C than for plants at 29°C, and transpiration rate was 129% less for plants with root zones at 35°C than for those with root zones at 29°C. During preliminary work with Autumn Flame and Franksred red maple and Indian Summer and Jeffersred Freeman maples, rooted cuttings were grown in 25 and 37°C root zones under both drought and nondrought conditions. Reductions in growth at 37°C were similar for all cultivars. Results of this work could influence development, marketing, and use of Freeman maples.

065

Water Use by Three Landscape Trees under Limiting Conditions

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Evergreen elm (*Ulmus parvifolia*), southern live oak (*Quercus virginiana*), and South American mesquite (*Prosopis alba*) were irrigated at 75%, 50%, and 33% of reference evapotranspiration for 2 years in Phoenix, Arizona. Each tree was irrigated with twenty-nine 3.8-L·h^{-1} drip emitters to a depth of 90 cm. Initial trunk diameters were about 4 cm. Water use was monitored by heat balance sap flow gauges and related to canopy volume, projected canopy area, and total leaf area. Oak used more water than elm, and elm more than mesquite under all irrigation regimes. Irrigation regimes had a greater effect on oak and elm water use than on mesquite, but all trees maintained an acceptable canopy regardless of treatment.

066

Water Use and Crop Coefficients of Woody Ornamentals in Containers

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Twelve species of woody ornamental plants were grown for 2 years in containers at Riverside and Davis, Calif., to determine plant water use (WU) and compare crop coefficients (Kcs). WU was determined gravimetrically in 1993 and 1994, five times each year in Riverside and four times each year in Davis. WU and Kc were affected by significant interactions among species, location, and time of year. WU was primarily influenced by the month, while Kc was most affected by location. *Rhaphiolepis* and *Pittosporum*, followed by *Juniperus* and *Photinia*, respectively, were the highest water users in Riverside when averaged over the 2 years. *Arctostaphylos* was the highest water user in Davis, followed by *Juniperus*, *Cercis*, and *Pittosporum*, respectively. *Rhamnus*, *Prunus*, and *Cercocarpus* were among the lowest water users in both locations. *Heteromeles*, *Buxus*, and *Ceanothus* were intermediate water users. The largest difference in species WU between the two locations was found for *Arctostaphylos* and *Cercis*, both high water users in Davis, but moderate or low water users in Riverside. The other species ranked similarly in both locations. Kcs of the 12 species, when averaged over the 2-year sampling period, ranked similar to water use. Kcs tended to be artificially high in the winter months and were not correlated to the low WU during that time.

067

The Effects of an Experimental Antitranspirant on Whole-plant Transpiration of Ornamental Landscape Shrubs

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Survivability of ornamental landscape plants during transport and the early stages of transplanting is a concern of the nursery and landscape industries. An effective antitranspirant may help avoid unnecessary plant losses during these periods of plant stress. The objective of this study was to evaluate the effects of a new experimental antitranspirant on whole-plant transpiration of two ornamental landscape shrubs. Plants of *Hibiscus rosa-sinensis* and *Photinia* ×*fraseri* were treated with the experimental antitranspirant N2001. Treatment rates included: 0% (as a control), 10%, 12.5%, or 15%. All treatments were mixed as a percentage of N2001 in a given volume of reverse osmosis water and applied to the roots as a drench. Whole-plant transpiration was determined gravimetrically by weighing the plants daily. Stem-flow gauges further monitored daily water use on an hourly basis. At the termination of the experiment, leaf areas and leaf dry weights were determined. Application of the antitranspirant reduced whole-plant transpiration immediately for all treated plants compared to that of control plants. On day 1, the 10%, 12.5%, and 15% treatments significantly reduced whole-plant transpiration levels by 41%, 50%, and 62%, respectively, compared to untreated plants. On day 3 and 4, the antitranspirant was still effective, reducing whole-plant transpiration by 47% and 24% on average, respectively, compared to untreated plants. By day five there were no significant differences in whole-plant transpiration between any treatment. Differences in whole plant transpiration can be attributed to antitranspirant application due to lack of differences in leaf area, dry weight or leaf area ratio between any treatment.

068

Water Loss, Embolism, and Post-transplant Growth of *Acer rubrum* and *Crataegus phaenopyrum* as Influenced by Length of Storage

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Year-old seedlings of *Acer rubrum* L. and *Crataegus phaenopyrum* (L.f.) Medic. were grown for 1 year in a Groseclose silty clay loam. Seventy-two plant per species were harvested on 15 Dec. 1995 and weighed. Plants were stored at 4°C for 0, 1, 3, 5, 10, or 15 weeks. At the end of each storage period, 12 plants were weighed to determine water loss. Six plants were then sacrificed to determine percent embolism, and six plants were planted in a pine bark media and grown in a glasshouse for 15 weeks to determine the influence of storage on post-transplant growth and embolism recovery. Length of storage had no influence on embolism of *Crataegus*. Embolism of *Acer* increased linearly with increasing length of storage. Embolism was greater for *Crataegus* compared to *Acer* at each harvest. Water loss for both species increased linearly as time of storage increased.

069

Morpho-physiological Responses of *Pinus halepensis* Mill. Seedlings to Drought Stress

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Aleppo Pine (*Pinus halepensis* Mill.) is known to be the most drought-resistant Mediterranean Pine. This species is widely distributed throughout the Mediterranean region and displays a high intraspecific variability, with respect to its physiological and morphological response to environmental conditions. In this experiment we evaluated the response of *Pinus halepensis* seedlings to drought. Sixty germinated seeds (accession A6, Shaharia, Israel) were grown in soil for 8 weeks and then transferred to black plexiglass tanks containing half-strength air-sparged Hoagland solution. After 6 weeks of acclimation to hydroponics, the osmotic potential of the solution was lowered by adding polyethylene-glycol (PEG) 8000. Water potential was lowered in 0.2 MPa increments every 4 days, until a final value of –0.8 was reached. The seedlings were then maintained at –0.8 MPa

for a further 8 days. Ultrasonic acoustic emissions, pressure–volume (P–V) curves, shoot and root growth, leaf area, xylem diameter, root apex mitotic index and cell length were measured on control and stressed seedlings. Seedlings were then transferred to normal Hoagland solution for 24 hours to simulate rewatering, and P–V curves and ultrasonic emissions measurements were repeated. Results showed that the final root growth is maintained in the stressed seedlings at the same rate as controls, whereas shoot growth was significantly reduced. The leaf area was reduced by stress to 36%, but the xylem diameter only to 10%, leading to a lower leaf area:xylem section ratio in the stressed plants. Ultrasonic emissions in the stressed plants were 365% of the control, and 182%, after rewatering. Specific details of the growth and physiology data are presented.

070

Responses of the Fine Roots of *Citrus* to Dry Surface Soil

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Despite the frequent occurrence of hot, dry surface soil, little is known about the fate of roots in this soil layer during and following periods of surface drought. Phosphorus uptake kinetics were examined in surface roots of citrus seedlings exposed to different periods of drought. Exposure to dry soil for up to 43 days had no effect on phosphate uptake of excised roots measured at solution concentrations of 50, 750, and 1500 μM phosphate. Effects of surface drought on fine root behavior of seedlings and bearing trees were examined in the field using a split-pot arrangement. At the end of 5 weeks of drought, only about 1% of the roots in the top pot of either the seedling or tree had died. By 8 to 9 weeks of drought, about 26% of the fine laterals of the adult citrus had died, but only 6% had died in the seedling. After 15 weeks of drought, 33% of the mature tree fine roots had died but only 8% had died in the seedling. Root-soil respiration per gram root at this time was at least twice as high in the seedling as in the mature tree. Fine roots of citrus are remarkably tolerant to dry surface soils of about 5 weeks duration, both in terms of root survival and resumption of physiological activity after rewetting.

071

Effects of Irrigation Rate and Frequency on Young *Citrus* Tree Performance and Root Distribution

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Hamlin orange trees on Swingle rootstock planted in 1991 were subjected to six different rates of irrigation with approximately the same amounts of water applied either daily (1-day), every other day (2-day), or every 4th day (4-day). Rates provided from 0.43 to 1.95 of historical daily evapotranspiration (ET) applied to the wetted area. Irrigation was delayed following rainfall. The effects of irrigation rate and frequency on trunk and canopy growth, yield, soil water content, root distribution, and total water use were studied. There was little effect of irrigation rate or frequency during the first 2 years after planting. However, tree growth improved with increasing irrigation rate during the 3rd and 4th years, and growth in these years was greater when irrigation was scheduled daily. Effects of rate and frequency on growth were not as great as expected. Yield increased as irrigation increased in 1994. Leaf nitrogen was generally higher at the lower irrigation rate. Soil water content varied with depth. Extraction of soil water was more rapid in the top 45 cm of soil. Roots after 4 years did not extend below 45 cm with 60% of the roots in the top 15 cm and 90% in the top 30 cm. Roots were concentrated closer to the trunk for trees at the lower irrigation rates.

97A ORAL SESSION 11 (Abstr. 072–077) Weed Control

072

Nonchemical Weed Control in Cabbage

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Early weed infestation in vegetable crops reduces both early and total marketable yield and quality. Even if escape weeds (12 inches tall or larger) are later killed by a postemergence herbicide application, their skeletons can cause yield loss due to competition for light, temperature modification within the plant canopy, and interference with fungicide and insecticide applications. In addition, weeds can also serve as a reservoir for insect and disease organisms, especially viruses. Experiments in nonchemical weed control in cabbage were conducted at the Horticulture Research Farm, Russell E. Larson Research Center, Rock Springs, Pa., from 1993 to 1995. In addition to weedy and hoed check plots, flaming weeds at 2- to 4-leaf stage of growth with propane gas burners and planting annual ryegrass (*Lolium multiflorum*) between the rows of cabbage, living mulch, were evaluated during 3 years. The cabbage cultivar Rio Verde was transplanted generally between 15 June and July during each year. Both flaming and living mulch treatments produced yield and head quality similar to the hoed check. Management and timing of ryegrass planting in relation to cabbage establishment is very critical for success with living mulch. Flaming requires straight rows of cabbage or other crop, tractor with driver that can maintain a straight line, and burners that are aligned to burn weeds and not the crop. Results will be discussed.

073

Herbicide Tolerance Mechanisms in Eastern Black Nightshade (*Solanum ptycanthum*)

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Eastern black nightshade is one of the problematic weeds in vegetables and soybeans in the Midwest. It is representative of a rapidly growing complex of broadleaf weeds where herbicide resistance would be expected to occur. Eastern black nightshade calli lines that are resistant and susceptible to acifluorfen were maintained on the medium without the herbicide. After two years, these lines were tested for tolerance to acifluorfen and paraquat. Tolerance to acifluorfen was maintained in the previously selected lines. The lines were also cross tolerant to paraquat. Plants were regenerated from these calli lines and grown in the greenhouse. ^{14}C-acifluorfen and ^{14}C- paraquat uptake, translocation, and metabolism were studied.

074

Municipal Solid Waste (MSW) Compost Maturity Influence on Weed Seed Germination

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The influence of compost (derived from MSW and biosolids) maturity on seed germination of several weed species was evaluated. A bioassay was developed by extracting 20 g of compost of different maturities with various volumes of water, then measuring germination percentage of ivyleaf morninggloy (*Ipomoea hederacea*) seeds placed on extract-saturated filter paper in a petri dish. A 20 g (dry weight) compost: 50 mL of water generated an extract that produced the widest percentage seed germination variation in response to composts of different maturity. Ivyleaf morninggloy, barnyardgrass (*Echinochloa crus-galli* L.), purslane (*Potulaca oleracea* L.), and corn (*Zea mays* L) were selected as plant indicators to determine the compost maturity stage with maximum germination inhibition. Compost 8-week-old decreased percent germination, root growth, and germination index (combines germination rate and root growth), and increased mean days to germination (MDG) of each plant indicator. Immature 8 week-old compost extract effect on MDG and germination percent of 15 weed species was evaluated. Extract from 8-week-old compost inhibited germination in most weed species, except yellow nutsedge (*Cyperus esculentus*). Compost extracts derided from immature (3-day, 4-, and 8-week-old) compost resulted in delayed and reduced germination percent of important economic weed species.

075

Preemergent Herbicide Evaluation in Processing Pumpkin and Squash

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Two experiments were conducted to evaluate processing pumpkin and processing squash tolerance to preemergence herbicides. The experiments were randomized complete block designs with three or four replications. The herbicides were applied after seeding the crop using a CO_2-pressurized sprayer delivering 233 L/ha. We evaluated clomazone alone, and in combination with either halosulfuron or sulfentrazone. The first experiment was conducted in Morton, Ill.,

using 'Libby's Select' processing pumpkin (*Cucurbita moschata*). None of the treatments caused any significant pumpkin phytotoxicity. On 7 July all treatments reduced the number of grass weeds compared to the untreated control. There were no differences in grass control between the herbicide treatments. Broadleaf control was best in sulfentrazone at 0.56 kg/ha or clomazone + halosulfuron at 0.56 + 0.13 kg/ha and worst in the untreated control. Weed control decreased by the 29 July rating; grass and broadleaf weed control was unacceptable in all treatments due to infestation with perennial weeds. Sulfentrazone alone or with clomazone was safe for use on pumpkins in heavier soils. The second experiment, conducted in Champaign, Ill., used 'NK530' processing squash (*Cucurbita maxima*). None of the treatments caused any squash phytotoxicity. The best control on 14 July was with combinations of clomazone and sulfentrazone. On 10 Aug., all herbicide treatments were similar in their control of broadleaf weeds. Sulfentrazone and halosulfuron do not injure processing pumpkin or squash when applied either alone or in combination with clomazone.

076

Rorippa sylvestris, Creeping Fieldcress: A Threat to Production Ornamentals and Its Control

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The perennial Brassicaceae specie *Rorippa sylvestris* has been described as a weed in Scandinavian forest nurseries and in Irish, Canadian, and American nurseries. It was first introduced into Philadelphia, Pennsylvania in about 1818 and has been reintroduced repeated since. It produces little seed unless there are two different introductions together because they are self incompatible. Propagation is principally by rhizome segments from soil or ornamental propagation material. Greenhouse studies to evaluate the depth of emergence of rhizome pieces indicated that 3-cm segments would routinely emerge from depths of at least 24 cm. Allocation to shoot, roots, stems or shoots form rhizomes varied greatly by depth. The greatest shoot weight was from shallow depths with increasing new shoots from rhizomes and stem weights from deeper depths. Preemergence control was excellent with dichlobenil granules at 3 or 6 lb/A, isozaben at 1 or 2 lb/A and the geotextile/herbicide (Biobarrier). The geotextile (Typar) fitted as collars alone were not effective. Trifluralin incorporated into the surface 2 inches at 2 lb/A was effective but did allow some emergence. Trifluralin plus isoxaben or oryzalin plus isoxaben were also effective at rates of 2 plus 0.5, 4 plus 1, or 6 plus 1.5 lb/A, or 3 plus 1, 4.5 plus 1.5, or 6 plus 2 lb/A, respectively, of the two herbicide combinations. Metolachlor at 3, 4.5, or 6 lb/A was ineffective for preemergence control of 3 cm rhizome pieces. Post emergence control was not commercial with 2,4-D, triclopyr, clopyralid or a combination of the latter two, when treated in the 6 to 8 leaf stage with 0.25% or 0.5% solutions. Once creeping field cress is established in ornamentals it is very difficult to control.

077

A Comparison of Four Orchard Floor Management Strategies for Lemons in Southwestern Arizona

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Four orchard floor management strategies—disking, mowing, chemical mow, and clean culture using herbicides—were evaluated in a 'Limoneira 8A Lisbon' lemon orchard in Southern Arizona, starting in the fall of 1993. Disking was the cultural practice used to manage the orchard floor before the start of the experiment. Although disking the orchard floor may have injured shallow tree roots, it provided satisfactory weed control except underneath the tree canopies where bermudagrass, purple nutsedge, and other weed species survived. Chemical mowing with Roundup at 1.168 L/ha did not provide satisfactory control of many weed species and required too many applications to be commercially feasible. This treatment was converted to a combination clean culture and disk treatment (clean and disk) in Summer 1995. Mowing the orchard suppressed broadleaf weed species, allowing the spread and establishment of grasses, primarily bermudagrass, and to a lesser extent, southern sandburr. A fall application of Solicam and Surflan followed by a summer spot treatment application of Roundup was used to control the weed flora in the clean culture treatment. Spot treatment applications of sethoxydim (Poast and Torpedo) were also made to control bermudagrass growing under the tree canopies in the clean culture treatment. Total 1995 yield of the mow, clean & disk, disk, and clean culture treatments were 4867, 5112, 5216, and 6042 kg of fruit, respectively. For the first harvest of 1995, the trees under clean culture also had significantly greater numbers of large fruit than did the trees under the other treatments.

76 ORAL SESSION 12 (Abstr. 078–083) Photosynthesis

078

The Relationship between Leaf Nitrogen Content and Photosynthesis in Apple Leaves

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Fertigation of young Fuji/M26 apple trees (*Malus domestica* Borkh.) with different nitrogen concentrations by using a modified Hoagland solution for 6 weeks resulted in a wide range of leaf nitrogen content in recently expanded leaves (from 0.9 to 4.4 $g \cdot m^{-2}$). Net photosynthesis at ambient CO_2, carboxylation efficiency, and CO_2-saturated photosynthesis of recently expanded leaves were closely related to leaf N content expressed on both leaf area and dry weight basis. They all increased almost linearly with increase in leaf N content when leaf N < 2.4 $g \cdot m^{-2}$, leveled off when leaf N increased further. The relationship between stomatal conductance and leaf N content was similar to that of net photosynthesis with leaf N content, but leaf intercellular CO_2 concentration tended to decrease with increase in leaf N content, indicating non-stomatal limitation in leaves with low N content. Photosynthetic nitrogen use efficiency was high when leaf N < 2.4 $g \cdot m^{-2}$, but decreased with further increase in leaf N content. Due to the correlation between leaf nitrogen and phosphorus content, photosynthesis was also associated with leaf P content, but to a lesser extent.

079

The Effect of Light Intensity before Harvest on Phenethyl Isothiocyanate Concentration in Watercress (*Nasturtium officinale* R.Br.) Depends on Photoperiod

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Watercress plants were grown in growth chambers at 15°C or 25°C and either an 8- or 12-hour photoperiod (PP). The photosynthetic photon flux (PPF) was 265 $\mu mol \cdot m^{-2} \cdot s^{-1}$ in all chambers, but beginning 1 week before harvest, half of the plants in each chamber were subjected to a higher PPF (434 $\mu mol \cdot m^{-2} \cdot s^{-1}$). At harvest, watercress leaves and stems were analyzed for phenethyl isothiocyanate (PEITC) content. Watercress grown at 25°C, the 12-hour PP, and 1 week of high PPF produced the highest PEITC concentration in leaves and stems, and plants grown at 15°C, the 8-hour PP, and the low PPF until harvest produced the lowest PEITC concentration. Plants grown at the 8-hour PP, then exposed to 1 week of high PPF, produced 57.3% and 45.9% greater PEITC at 25 and 15°C, respectively, then plants exposed to the low PPF until harvest. However, plants grown at the 12-hour PP and subjected to 1 week of high PPF produced PEITC levels similar to plants grown under the low PPF at 25 and 15°C. At 25°C, plants grown under the low PPF and the 12-hour PP produced 62% greater dry mass than plants exposed to 1 week of high PPF and the 8-hour PP, but did not differ in PEITC content. Thus, the effect of 1 week of high PPF on PEITC concentration depended on photoperiod.

080

Using Video Thermal Image Analysis to Monitor Stomatal Opening in Fruit Crops

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This study demonstrates that thermal image analysis can be used to localize stomatal opening and closing on leaves of apple, and cherry. An attached leaf was placed in an environmental chamber used for gas exchange and leaf temperature was monitored with cromel-constantan thermocouples, (0.08 mm) pressed against the underside of the leaf, or with an Inframetrics 600 thermal image analyzer that was focused on the upper side of the leaf. Radiation was monitored in the 8–12 μm range and the image was recorded on video tape. A two-degree temperature difference due to stomatal opening was detected. Stomatal opening as monitored by gas exchange was correlated significantly with leaf temperature. Under steady state conditions, stomata from cherry oscillated at 20-minute intervals. Stomata opened and closed uniformly. Factors investigated were light, carbon dioxide, ABA, and water stress. In all cases changes in tem-

perature correlated with stomatal opening and closing. Response time to a change in environment was less than 10 minutes. The practical implications of this study are discussed.

081

Comparison of Single Leaf and Whole Canopy Gas Exchange Rates of Tomato and Soybean throughout Stand Development

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The relationship between whole canopy and single leaf measurements of gas exchange has not been well documented. Two experiments were conducted in the Biomass Production Chamber at Kennedy Space Center (20-m^2 growing area) to compare whole canopy versus single leaf net carbon assimilation rate (A_{net}) measurement of a stand of tomato (*Lycopersicon esculentum* Mill. cv. Reimann Philipp) and soybean [*Glycine max* (L.) Merr. cv. Hoyt]. Both crops were grown under a 12/12 hour photoperiod under HPS lamps at PPF of 800 ($mol \cdot m^{-2} \cdot s^{-1}$, at 26/22°C (light/dark), and constant 65% RH for 90 days. CO_2 concentration was controlled to 1200 ($mol \cdot mol^{-1}$ during the light cycle. Midday measurements of A_{net} of single leaves were obtained weekly from upper canopy leaves using a portable photosynthesis system. Whole canopy measurements of A_{net} were calculated daily from CO_2 addition data obtained at 5-minute intervals by the BPC monitoring and control system. Single leaf rates exceeded whole canopy rates prior to full canopy coverage then averaged 0.63 of whole canopy for both species during the period of full canopy coverage. Results suggest that reliable estimates of canopy gas exchange can be obtained from single leaf measurements under relatively constant environment conditions.

082

Dynamic Optimization of Photosynthetic Photon Flux for Efficient Photosynthesis and Growth of Leaf Lettuce Canopies

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'Waldmann's Green' leaf lettuce (*Lactuca sativa* L.) is being used as a model leafy vegetable crop to develop a protocol for variable control of photosynthetic photon flux (PPF) during crop production. Feedback from real-time photosynthetic gas exchange rates by lettuce canopies is used to modulate electronic dimming ballasts of lamp banks. Algorithms within process-control software are being fine tuned to maximize increments of photosynthetic output relative to increments of photon input. Dynamic optimization of PPF was 21% more efficient than constant high PPF saturating photosynthesis with respect to biomass accumulated per photons absorbed. Dynamic optimization also is being combined with principles of phasic control, in which environmental resources such as photosynthetically active radiation (PAR) and carbon dioxide (CO_2) are deliberatively limited in input during specific phases of crop development when plants are less sensitive to inputs (e.g., lag, plateau, and senescence phases) but optimized for the responsive exponential phase. Preliminary results indicate that leaf lettuce growth benefits from optimizing environments for no more than 4 or 5 days during a 20-day production cycle. Dynamic optimization of CO_2 level is achieved by controlling the injection of CO_2 into the inlet air stream of Minitron II crop canopy cuvette/growth chambers. Algorithms are being modified to simultaneously vary PPF and CO_2 for optimum photosynthesis.

083

Effects of Fluorescent Intracanopy Lighting on Cowpea Canopy Productivity and Yield

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The planophile (horizontal) leaf presentation of closed cowpea (*Vigna unguiculata* Walp.) leaf canopies limits PAR absorption from overhead lamps to the top layer of overlapping leaves, resulting in suboptimal canopy photosynthesis and premature senescence and abscission of lower, shaded leaves. Very low crop yield rates have been obtained in growth chamber studies using dense cowpea stands compared to greenhouse and field studies using more widely spaced plants. Nine separate growth compartments were constructed in each of two growth rooms. Eight or sixteen 15-W fluorescent lamps were mounted horizontally or vertically in tiers within each compartment, remote from their ballasts, and which can be switched on or off separately according to different lighting strategies. Mylar sleeves around each tube prevents contacting leaves from overheating. Intracanopy lighting arrangements draw from 0.27 to 0.54 kW of power/m^3 of growth volume, compared to 1.18 $kW \cdot m^{-3}$ for traditional overhead lighting. PPF within compartments varies from 80 to 280 $mmol \cdot m^{-2} \cdot s^{-1}$, depending on sensor location, lamp arrangement, and lamp number. Each compartment is equipped with a recirculating hydroponic system. One room is operated with overhead plus intracanopy lighting, whereas the other utilizes intracanopy lighting only. Cowpea canopies are being grown under different lighting strategies and compared for growth, yield, productivity, leaf orientation, and individual leaf gas-exchange rates. Electrical power draw and total electrical energy consumption are being compared among treatments.

78 ORAL SESSION 13 (Abstr. 084–091) Stress–Cold Temperatures

084

Seasonal Change in Cold Hardiness of Field-grown Ash Trees

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Cold hardiness of *Fraxinus americana* 'Autumn Purple', *Fraxinus oxycarpa* 'Raywood' and *Fraxinus pennsylvanica* 'Summit' was measured in laboratory tests. Current season stem growth was collected from trees in Willamette Valley nurseries at 3 to 6 week intervals from November 1994 to February 1995 and from October 1995 to March 1996. Replicated 9-cm stem samples with two buds each were placed in tubes and immersed in an ethylene glycol bath. Samples were nucleated with crushed ice, held overnight at –2°C and then frozen at 3°C/hour. After freezing, samples were thawed overnight, incubated at room temperature and 100% relative humidity for 10 to 14 days, then sample viability was determined by visual browning. A Tk_{50}, the temperature at which 50% tissue injury occurred, was calculated for buds and stems. Buds were generally less hardy than stems. 'Raywood' was slower to cold acclimate in the fall and did not become as cold hardy in midwinter as 'Summit' and 'Autumn Purple'. Cold acclimation and midwinter hardiness of 'Summit' and 'Autumn Purple' was similar; however, 'Summit' deacclimated more rapidly. Between the 11 Dec. 1995 and 9 Jan. 1996 freeze tests, 'Summit' stems lost about 9 °C of freeze tolerance. In both the 1995 and 1996 February freeze tests, 'Summit' stems were less hardy than 'Raywood' stems.

085

Lowest Survival Temperature (LST) Estimations in 33 Varieties of *Viburnum* by Controlled Freezing

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Stems of 33 varieties of *Viburnum* were screened for low temperature tolerance on five dates. Terminal stem cuttings were shipped overnight to Orono, Maine, from Oregon, Michigan, and Minnesota. Following a controlled freezing regime, stems were incubated for 7–14 days and evaluated for injury by visual observation. Lowest survival temperatures (LST) were estimated as the lowest temperature at which 100% of stems were uninjured. Varieties of *V. dentatum*, *V. lantana*, *V. opulus*, and *V. trilobum* were rated as consistently very cold tolerant. *Viburnum* ×*pragense*, *V. dilatatum*, and *V. rufidulum* were rated as consistently moderately cold tolerant. All *V. tomentosum* varieties showed inconsistent LST estimates. Varieties from the Oregon source were rated as cold intolerant. Direct comparisons by variety and source will be discussed with emphasis on consistent LST estimates. Rates of deacclimation as they occurred over the five testing dates will also be discussed.

086

Variability in the Speed of Cold Deacclimation among Tuber-bearing Wild Potato Species

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Frost injury limits the cultivation of potatoes in many regions around the world. We are currently studying the factors that contribute to frost survival in potato in an attempt to improve its frost tolerance. Wild potato species have been distinguished for their high degree of non-acclimated frost tolerance (growing

under normal conditions) and their high cold acclimation capacity (able to increase frost tolerance upon exposure to cold). Cold acclimation can be reversed upon exposure to warm temperatures (deacclimation). The ability to gain freezing tolerance rapidly in response to low temperatures as well as not being able to deacclimate rapidly in response to warm daytime temperatures would be advantageous for a plant against spring or fall freezes. Last year we presented evidence for the variability in the speed of cold acclimation among 7 wild tuber-bearing potato species (*S. acaule, S. commersonii, S. megistacrolobum, S. multidissectum, S. polytrichon, S. sanctae-rosae and S. toralapanum*). The same set of species was used for the present study to find out if there is also variability for the speed of deacclimation. Relative freezing tolerance of these species was measured before and after cold acclimation as well as after one day of deacclimation (exposure to warm temperatures). Our results suggest that there are differences in the speed of deacclimation among these species. We found that while some species lost near a half of their hardiness, others lost only a third or less of their hardiness after one day of deacclimation.

087

Changes in Freezing Tolerance, Water Potential, and Gene Expression of *Poncirus trifoliata* 'Rubidoux' Seedlings Exposed to Acclimating Low Temperatures and Long Days

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Poncirus trifoliata is a comparatively hardy, cross compatible, and graft compliant relative of *Citrus*. The citrus industry in Florida has suffered immense economic losses due to freezes. Although much research has been done in citrus freeze hardiness, little work has been on the early induction of freeze tolerance by low temperature. *Poncirus trifoliata* 'Rubidoux' seedlings were germinated in perlite under intermittent mist at about 25°C and natural daylight conditions in a greenhouse and grown 2 weeks. See dlings were then transferred into a growth chamber at 25°C and 16 hour daylength for 1 week. Temperature was lowered to 10°C and tissue samples were collected at 0, 6, 24, and 168 hours. Freezing tolerance, at –6.7°C as determined by electrolyte leakage, and stem (leaves attached) water potential, measured using a pressure bomb, were also recorded for a subset of seedlings for the above intervals. After exposure to low temperature for 48 hours a red coloration became visible at the petiole leaflet junction an d at the buds, with subsequent exposure to low temperature the coloration spread to the leaves. Clones for phenylalanine ammonia lyase (PAL), 4-coumarate:CoA ligase (4CL), and chlorophyll ab binding protein (CAB), and chalcone synthase (CHS) were used to probe RNA isolated from *P. trifoliata*. PAL and 4CL transcripts increased in response to the low temperature. Significant increases in freeze hardiness occurred within 6 hours in the leaves, and increases continued for up to one week. Water potential increased from –0.6 to –2.0 MPa after 6 hours, then returned to –0.6 MPa after 1 week. These data indicate that increases in freezing tolerance and changes in water potential and gene expression can be detected shortly after low temperature treatments are imposed on *P. trifoliata* seedlings.

088

Effect of Chilling on Cyanide-resistant Respiration and Carbohydrate Status in Chilling-sensitive and -resistant Species

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The effect of chilling stress on induction of the cyanide-resistant pathway was investigated using roots of 3-day-old cucumber (*Cucumis sativus* L.) and 5-day-old pea (*Pisum sativum* L.) grown at 26°C, and then chilled at 2°C for 48 or 96 hours for cucumber, and 72 or 192 hours for pea. A 24-hour post-chilling treatment at 26°C was imposed on different sets of chilled roots from both crops. Carbohydrate status was determined by gas chromatography with an autosampler using a 12.5-m cross-linked methyl silicone capillary column (0.1 mm). Exposing seedlings to 2°C, as well as to a postchilling treatment, induced differential responses in the activity of the cyanide-resistant pathway. Cucumber seedling roots exhibited an accumulation of fructose, glucose and sucrose during chilling, with a rapid decline observed during the post-chilling treatment at 26°C. Pea seedling roots maintained a constant level of carbohydrates throughout the chilling period, and exhibited a slight decrease by the end of 192 hours at 2°C. There was an increase in carbohydrate levels during the post-chilling treatment. The involvement of the cyanide resistant pathway and carbohydrate changes will be discussed.

089

Sugars and Chilling Tolerance in Two Cultivars of Dry and Germinating Cucumber Seed

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Various carbohydrates have been shown to be associated with stress tolerance in some plant species. Specifically, the content of soluble sugars have been correlated with desiccation tolerance and winter hardiness. We have previously demonstrated that radicles of cucumber seed become progressively more sensitive to chilling injury during the early stages of germination and that cultivar differences exist. Sucrose, raffinose, and stachyose contents of 'Poinsett 76' and 'Ashley' seed were determined in dry seed during imbibition and at three stages of radicle emergence. The more chilling-tolerant cultivar (Ashley) contained lower raffinose and higher stachyose contents than the less chilling-tolerant 'Poinsett 76'. In both cultivars, the contents of raffinose and stachyose declined dramatically between the 1-mm and 5- to 7-mm stage of radicle emergence. At the 1-mm stage, when cultivar chilling-tolerance differences are most pronounced, 'Ashley' appears to have a higher content of stachyose and lower raffinose content.

090

A Comparison of Methods to Assess Oxidative Damage Associated with Chilling Stress

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Preliminary studies on the effects of chilling stress during the early stages of germination and radicle emergence in cucumber have suggested that damage may be due to the accumulation of active oxygen species. Several methods are available which are capable of assessing various types of oxidative damage and were selected for use in determining the involvement of active oxygen species in the chilling response of emerging cucumber roots. Oxygen radicals have been shown to interact with cellular proteins resulting in the formation of carbonyl derivatives. A procedure using 2,4-dinitrophenylhydrazine was tested to determine carbonyl protein content. Cellular lipids are also subject to peroxidation by active oxygen species resulting in the production of malondialdehyde and can be quantified by reaction with thiobarbituric acid. Sulfydryl groups may also be attacked by oxygen free radicals and changes monitored by a procedure using 5,5'-dithio-(2-nitrobenzoic acid). A comparison of these three methods for detecting oxidative damage associated with chilling stress in radicles of germinating cucumber seed will be discussed.

091

Effects of Ethanol on Membrane Integrity and Enzyme Expression in Chilled Cucumber Seedlings

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Previous experiments have shown that chilling-stressed cucumber seedlings treated with ethanol have greater chilling tolerance when compared to untreated seedlings. To determine whether this increased chilling tolerance would diminish with time after treatment, cucumber seedlings were treated with ethanol and placed at chilling temperatures for 0, 2, 4, 6,or 8 hours after ethanol treatment. Ethanol-induced chilling tolerance declined as the time interval between treatment and chilling exposure increased. A second ethanol treatment was given 3 hours after the first treatment in an attempt to extend the enhanced chilling tolerance response. Ethanol has been reported to function as an anesthetic in some systems, interacting with cellular membranes. To determine the effect of ethanol and chilling on membrane integrity, a malondialdehyde assay was used. Since chilling stress effects may result from accumulation of active oxygen species, the activity of one radical scavenging enzyme (catalase) has been assayed. Ethanol treatment resulted in a rapid increase in catalase activity, and was associated with increased chilling tolerance. The effect of a second ethanol treatment will be discussed as related to induced chilling tolerance, membrane effects, and catalase activity.

79 ORAL SESSION 14 (Abstr. 092–098) Growth and Development–Ornamentals

092

Programming Flowering of the *Phalaenopsis* Orchid

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Blooming *Phalaenopsis* orchids have become a popular pot plant in recent years. Plants start producing spikes after experiencing cool air in early fall, bloom in early spring, and become limited in supply after April when market demand is strong. Deferring spiking and flowering by maintaining the greenhouse air constantly above 28°C is cost prohibitive. Previous research has discovered that plants must be given light while being exposed to cool air to induce spiking. In Fall 1994, 2-year old *Phalaenopsis* TAM Butterfly plants were exposed to repeated cycles of 1 day in darkness and another day in light (1D/1L), 4D/3L, 7D/7L, or 0D/7L (continuous lighted control) between 15 Sept. and 16 Dec. Each plant was removed from the treatment once it had started spiking. The control plants bloomed on 20 Jan. 1995, whereas the 4D/3L plants did not reach anthesis until April 17, nearly three months later. Flowering of the 1D/1L and 7D/7L plants was also deferred until early April. The treatments had no adverse effect on flower count or size. In 1995, 3-year old plants were exposed to 0D/7L (control), 2D/5L, 3D/4L, 4D/3L,or 5D/2L from 15 Sept. to 22 Jan. 1996. The control plants spiked on 17 Oct. and bloomed on 8 Feb. 1996 when spikes had just emerged from plants in the 5D/2L treatment. The 5D/2L plants are expected to bloom in late May or early June. The other treatments were not as effective as that in 1994 and resulted in blooming only 2–3 weeks after the untreated control. The results of this research will help producers to stagger or precisely program the time of flowering to meet the market demand.

093

Effects of Cold and Photoperiod on Flowering of Several Herbaceous Perennial Species

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Thirty herbaceous perennial species were treated at 5°C for 0 or 15 weeks. Critical photoperiods for flower initiation and development with and without a cold treatment were determined. Photoperiods were 10, 12, 13, 14, 16, or 24 hours of continuous light or 9 hours plus a 4-hour night interruption. Continuous photoperiodic treatments consisted of 9-hour natural days extended with light from incandescent lamps. Species were categorized into nine response types based on the effects of cold and photoperiod on flowering. Plants had three flowering responses to cold treatment: obligate, facultative, or none. The perennials were obligate long-day, facultative long-day, or day-neutral plants. For example, *Campanula carpatica* 'Blue Clips' had no response to cold and was an obligate long-day plant requiring photoperiods of 16 hours or longer or night interruption for flowering. *Rudbeckia fulgida* 'Goldsturm' had a facultative response to cold and required photoperiods of 14 hours or longer or night interruption for flowering. *Veronica longifolia* 'Sunny Border Blue' had an obligate cold requirement and was day-neutral. Some species responded differently to photoperiod before and after cold. *Leucanthemum ×superbum* 'Snow Cap' flowered as an obligate long-day plant without cold and as a facultative long-day plant after cold. Response categories are discussed.

094

Gibberellin Status of Spectral Filter-grown Chrysanthemum Plants

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Endogenous gibberellins of chrysanthemum [*Dendranthema ×grandiflorum* (Ramat)] cv. Bright Golden Anne were characterized in apices from plants grown under control and $CuSO_4$ spectral filters. Expanding shoots were separated into young expanding leaves and apices. Methanolic extracts of young expanding leaves were purified by solvent partitioning, PVPP column chromatography and reversed-phase high performance liquid chromatography. Two bioactive regions corresponding to the HPLC retention times of GA_1 and GA_{19} standards were detected in fractions using the recently-developed non-dwarf rice bioassay. Di-deuterated internal standards of GA_{12}, GA_{53}, GA_{19}, GA_{20}, and GA_1 were added to similar extracts of shoot apices. The presence of endogenous GA_{53}, GA_{19}, GA_{20}, and GA_1 in chrysanthemum apices was confirmed by isotope dilution using gas chromatography-mass spectrometry-selected ion monitoring and Kovats retention indices. In a preliminary quantification study, GA_{20} and GA_1 levels were found to be higher in apices from plants grown under control filters while GA_{19} levels were higher in apices grown under $CuSO_4$ filters. The possibility that light transmitted through $CuSO_4$ filters alters gibberellin levels in shoot apices is discussed.

095

Anatomical and Morphological Modifications of the Periclinal Chimera *Dracaena sanderana* 'Ribbon' in Response to Four Light Intensities

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Effects of four shade levels (47%, 63%, 80%, and 91%) on growth of *D. sanderana* 'Ribbon' were evaluated. *D. sanderana* exhibited morphological and anatomical plasticity manifested in differences in all growth parameters examined. Plant growth rate was significantly influenced by the light levels. Under 63% and 80% shade plants grew faster and achieved greater biomass than plants grown under 475% and 91% shade. Leaf variegation was affected by the shade level. Plants grown in 47% and 63% shade had less total variegation than plants grown in 80% and 91% shade.Leaf thickness was greater in plants grown under higher light levels. Marginal leaf growth was suppressed in plants grown in 47% and 63% shade, thus reducing the width of the achlorophyllous margins. The reverse occurred in leaves of plants grown in 80% and 91% shade. The change in variegation pattern occurred very early in leaf ontogeny—during lamina formation and expansion. This change was attributed to differences in relative contribution of the three shoot apical layers under different light conditions. Thus, *Dracaena sanderana* 'Ribbon' when grown in the southeastern United States is shade obligate, with an optimum light intensity level of less than 53% of full sunlight.

096

Molecular Properties of Three Soluble Invertase Forms from *Lilium longiflorum* Flower Buds

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Three soluble invertase isoforms from *Lilium longiflorum* flower buds that had been separated by DEAE-Sephacel chromatography were purified to near homogeneity by further chromatography on hydroxylapetite, Con-A sepharose, phenyl agarose, and Sephacryl S-200 gel filtration. Nondenaturing polyacrylamide gel electrophoresis (PAGE) gave a single band in all three invertases that corresponded to a band of invertase activity in a duplicate gel. The SDS-PAGE of the purified invertase I resulted in a single band with apparent relative molecular mass of 78 kDa. Invertase II and III were resolved to a similar polypeptide pattern by SDS-PAGE with three bands of 54, 52, and 24 kDa. Antiserum of tomato acid invertase cross-reacted with all three invertase protein bands. Antiserum of wheat coleoptile acid invertase cross-reacted only with 54 and 52 kDa bands of invertase II and III but did not recognize invertase I protein. Con-A peroxidase was bound to invertase I protein and all three protein bands of invertase II and III, suggesting that all proteins were glycosylated. Invertase I protein could be completely deglycosylated by incubating with peptide-N-glycosidase F to result in a peptide of 75 kDa. Invertase II and III were partially deglycosylated by peptide-N-glycosidase F resulting proteins bands of 53, 51, 50, and 22 kDa.

097

Developmental Changes in Soluble and Cell Wall-bound Invertases in Floral Organs of *Lilium longiflorum*

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Easter lily flower buds at five stages of development (stage 1, 3–4 cm in length; stage 2, 6–7 cm; stage 3, 9–10 cm; stage 4, unopened buds, 13–14 cm; and stage 5, open flower 1 day after anthesis) were harvested, and flower organs were dissected for invertase assay. On a fresh weight (FW) basis, anthers had the highest soluble invertase activity (about 10-fold greater) than all other organs reaching to 15 units/g FW by the stage 2. The activity dropped to about 3 units/g FW at stage 3 and 4, and then increased up to 10 units/g FW in open flowers.

Specific activity (units per mg of protein) also showed the same trend. On a specific activity basis, sepal invertase activity steadily increased during bud development, but was relatively constant on a fresh weight basis. stigma, style, and ovary, soluble invertase activity expressed on a FW and specific activity basis steadily increased as bud development. Filament soluble invertase activity on FW basis dropped at the stage 2 and 3, while specific activity steadily increased during bud development. Cell wall-bound invertase activity (released with 1 M NaCl) was present in all flower organs. However, soluble activity accounted for the most of total activity in sepal, ovary and filament (about 90%). About 75% of total activity was soluble in anther and style, whereas nearly equal amounts of soluble and cell wall activities were present in the stigma. The cell wall bound invertase activity increased throughout the bud development in sepal, stigma, style, and ovary parallel to soluble activity. Anther cell wall-bound activity fluctuated in a similar pattern as the soluble activity.

098

Phasic Development of *Fagus sylvatica* based on 240 Years of Continuous Tree-height Observations

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Duration of growth is dependent on morphological events or changes in growth rate. It is the latter that is associated with phasic development. The most productive phase of plant growth is the linear or constant rate phase, primarily because it endures longer than the exponential phase. The purpose of our research was to objectively determine the true tree-height growth pattern, the linear and stationary phases of height growth, and to mathematically derive the maximum slope (maximum growth rate) of the growth curve, its location (inflection point), and the maximum slope of the logarithmic form (maximum relative growth rate) of the growth curve. The data were composed of 333 tree-height records covering 240 years from 200 beechwoods in the U.K. Height-age data were fitted using a splined function (S) and the Chapman-Richards function (CR). The growth curve and critical points on the curve were derived from the CR model. The linear phase began when trees were 9 and lasted 43 years. However, the stationary phase did not begin until age 162. Anecdotal evidence suggests that very little fruiting occurs before age 50. Based on derived critical points and anticipated source-sink dynamics, the reproductive stage should have taken place during the progressive "deceleration phase" when trees were between 31 (location of the maximum slope, also inflection point) and 162 (from quadratic root). The linear phase ended at 52 years, (coinciding with minimum acceleration) and may prove a more accurate estimate than 31. Maximum slope was 1.2 m per year occurring at age 31. Maximum slope of the log curve was 0.14 $m \cdot m^{-1}$ per year. The advantage of the CR function and the importance of the derived quantities and growth phases will be discussed.

87 ORAL SESSION 15 (Abstr. 099–106) Culture and Management–Tree Fruits/Nuts

099

Treatments to Encourage Earlier Dormancy in Apple

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Active growth in late Fall 1993, followed by very low temperatures in November, resulted in widespread loss of scaffolds and leaders of 'McIntosh' in the Champlain Valley. Treatments to encourage earlier dormancy are being investigated to address this problem in future seasons. Initial studies showed that 39 mM CuEDTA or 16 mM CuEDTA + 0.25% ultrafine spray oil (sprayed to drip) resulted in 3–4 weeks earlier leaf drop of 'Empire' in the Mid-Hudson Valley. Evaluation of cold-hardiness, measured as electrolyte leakage after controlled freezing in a Tenney chamber, indicated greater cold-hardiness from these treatments in early December without reducing mid-winter hardiness. CuEDTA treatments ranging from 4–32 mM, all with 0.25% ultrafine spray oil, were applied to fifth leaf 'Marshall McIntosh' on M.9/MM.111 interstems in the Champlain Valley on 12 Oct. 1995. Defoliation was accelerated with each increase in rate examined in this study. The highest rate again advanced defoliation 3–4 weeks compared to controls and increased cold-hardiness on 1 Dec. 19/95 as measured though electrolyte leakage. Evaluation of cold-hardiness in shoots collected on 8 Feb. 1996 showed no significant difference between electrolyte leakage from controls and trees treated with CuEDTA.

100

Effect of Preplant Fertilization, Annual Fertilization, Irrigation, and Fertigation on 'Empire' Apple Fruit Size and Yield

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A field experiment was established in 1992 with 'Empire' apple trees on either M.7 or M.9 rootstock. Preplant fertilization with NPKB plus lime compared to the lime only control did not increase tree growth during the first 4 years, but did increase cumulative yield (10%) and average fruit size (7%). The addition of annual applications of ground-applied NKB after planting increased total shoot growth 17%, as well as yield (26%) and fruit size (14%) compared to the lime only control. Trickle irrigation significantly increased trunk cross-sectional area (17%), shoot growth (16%), yield (18%), fruit size (5%), and yield efficiency (7%). The interaction of ground fertilization and trickle irrigation showed that trickle irrigation increased the benefits of ground applied fertilizers. Without trickle irrigation, ground-applied fertilizers increased shoot growth only 6% and yield 14% compared to the unfertilized controls, but, with the addition of trickle irrigation, the ground-applied fertilizers increased shoot growth 21% and yield 21% over the irrigated but unfertilized control. Ground fertilization increased yield efficiency and fruit size by the percentage by whether or not trickle irrigation was present. Fertigation gave similar results as the trickle plus ground fertilizer treatment on tree growth, yield, fruit size, and yield efficiency. Our results indicate that trickle irrigation in the eastern United States can improve tree growth, yield, and fruit size in the first few years after planting. The addition of ground-applied fertilizer or fertigation can improve tree performance even more. However, in the humid New York climate, there does not appear to be a significant benefit from injecting the fertilizer into the trickle water compared to applying the fertilizer on the ground.

101

Differences in Flower and Spur Characteristics of Apple Cultivars

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Flower and spur characteristics of eight apple cultivars were determined at bloom and following cell division and related to fruit growth over the season. Flower number per spur was higher in 'Jonagold', 'Fiesta', 'Southern Snap', 'Royal Gala', than in 'Red Chief Delicious', 'Pacific Rose' and 'Fuji', and the latter three cultivars also had the lowest total flower dry weight per spur. Generally, pedicel length of the king flower was shorter than the lateral, with 'Fuji' having the longest king flower pedicel and 'Red Chief' and 'Pacific Rose' the shortest. At full bloom, 'Jonagold' and 'Fiesta' had the most leaves/spur, followed by 'Fuji', 'Southern Snap', 'Royal Gala', 'Pacific Rose', with 'Red Chief' having fewer leaves/spur than all other cultivars. Leaf area/spur was highest in 'Jonagold', 'Fiesta', 'Royal Gala', and 'Fuji', followed by 'Southern Snap', with 'Red Chief' and 'Pacific Rose' having lower leaf areas and fruit set than all other cultivars. At the end of cell division, 'Fuji' and 'Jonagold' had the highest leaf area per spur and 'Fuji' and 'Royal Gala' the highest bourse leaf area. 'Braeburn' and 'Red Chief' had lower bourse leaf areas than all other cultivars. 'Royal Gala', 'Southern Snap', and 'Fuji' had the longest bourse shoots and 'Red Chief' the shortest.

102

Ta Tao Peach Interstems Influence Cultivar Phenology, Vigor, and Fruiting in South Carolina

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Twenty-six peach and six plum cultivars budded to 20–50 cm Ta Tao five or twenty-four interstems on Lovell rootstock were observed in four trials at two locations in South Carolina. The locations were in the Piedmont near Clemson and the Sandhills near Pontiac, S.C. The objective of growing peach cultivars on interstems was to delay scion phenology to reduce risk from late spring freezes. Data from these trials were collected from 1989 to 1996. Average bloom delay for peach cultivars on interstems was significant each year from 1991 through 1996

and ranged from 5 to 9 days later than the noninterstem controls. Bloom of plum cultivars on interstems was not significantly affected. Interstem peach trees had significantly smaller trunk cross-sectional areas and averaged from 32% smaller in 3-year-old trees to 35% in 7-year-old trees. Interstem trees also had fewer lateral vegetative budbreaks (i.e., blind wood). Fruit maturity was significantly delayed on most peach cultivars on interstems. Fruit of early cultivars (90 days past bloom) ripened 2–4 days later on interstems. Likewise, mid-season cultivars ripened 5–6 days later and late season cultivars (>130 days past bloom) 3-4 days later. Fruit size was smaller on interstem trees when trees were either inadequately thinned or drought-stressed.

103

Probit Analysis for Quantitative Comparisons of Time and Duration of Peach Bloom

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The population of flower buds in a peach orchard do not all bloom at the same time, but instead expand to bloom stage over time as a cumulative normal curve. This relationship is similar to seed germination and other processes restricted between 0% and 100% of response. Frequent sampling of bloom development over all treatments to be compared is frequently not possible. Treatment means may be compared on a given day for differences in % bloom, but the opposite question of whether differences exist in time of 50% bloom cannot be answered. Transforming the % response axis to Probits allows comparisons of bloom time and duration. Probit transformation linearizes the cumulative normal distribution curve by converting the % response axis to units of standard deviation. Best fit of a line to data is optimized by the method of maximum likelihood (least squares regression is not appropriate). In an example study on peach, % of total flower buds at or past bloom (pistil exposed) was counted daily on tagged shoots in control trees. Percent bloom on trees treated with different chemical bloom thinning treatments were counted only when control trees reached 10%, 50%, and 90% bloom. Bloom data were converted to Probits and response lines for each treatment were graphed. On this basis, quantitative comparisons among treatments could be made along the time axis for a) time of 50% bloom and b) duration of bloom.

104

Monitoring Peach Flower and Fruit Development with a Phenology–Heat Unit Model

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Phenological studies were conducted over a 3-year period beginning in Winter 1993–94 to relate flowering and fruiting stages of peach to heat accumulation [growing degree hours (GDH)]. Mature trees of 'Loring' and 'Redhaven' peach in the same orchard were used annually. Some variation from year to year was apparent in GDH levels related to 50% flower and other stages of development. Major sources for this variation appear to be timing and severity of pruning, tree vigor, and shoot diameter. Temperature predict models were used successfully to properly forecast GDH accumulation and and various flowering and fruiting stages once rest was satisfied.

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Comparison of Soybean Oil and Ammonium Thiosulfate for Peach Bloom Thinning in a Short Bloom Duration Year

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Dormant application of soybean oil formulations (SBO) effectively thin peach flower buds and delay bloom. Alternatively, thinners applied at bloom, such as ammonium thiosulfate (ATS), must be applied before pollination is complete. Consistent thinning with ATS is complicated by bloom duration and weather at bloom. Overall, 1995 peach bloom in South Carolina was delayed and progressed rapidly from 20% to 90% bloom in 2 days. Under these conditions, we compared thinning response of control (untreated), ATS (2%) applied at 70% bloom, SBO concentrations (2.5%, 5%, 7.5%, or 10%) applied 3 weeks before bloom (WBB), and application time of 5% SBO (1, 2, or 3 WBB). SBO was not available for applications earlier than 3 WBB. Treatments were applied by hand gun to six replications of single-tree plots of Redhaven. ATS had no effect on fruit set, yield, or fruit size, contrary to normal bloom years. Flower bud death increased linearly from 8% to 28% with increasing rate of SBO. Delay in SBO application decreased bud death. SBO at 5%-10% rates caused minor delay of 50% bloom, did not effect bloom duration, and increased mean fruit weight over control. Maximum effect was achieved with 10% SBO, reducing fruit number/ha and firmness by 72% and 18% and increasing fruit weight and soluble solids by 67% and 5% from control, respectively. Results show the advantage of bud thinning with SBO during the dormant season in a short bloom duration year.

106

Cross-pollination within Pecan Orchards

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Pecan is wind pollinated, exhibits heterodichogamy and are either protandrous (I) or protogynous (II). Orchards are typically established using two complimentary flowering types but with no further scrutiny as to the degree of compatibility of these two types. Additionally, orchards are sometime established with a very low frequency of pollinator. An evaluation of several orchards revealed that yield losses are due to poor pollination is likely common. Data indicate that trees beyond about 46 m (150 feet) from a complementary pollinator exhibit substantial reductions in fruit-set; therefore, large block-type plantings are disadvantaged. Flowering data over several years show that Type I and Type II cultivars are often functionally noncomplementary, suggesting that pecan cultivars should also be identified with a seasonal identification (i.e., early, mid, and late). Data also indicate that dichogamy patterns substantially change as trees age or with abnormally warm or cool springs; hence, pollination patterns will vary depending upon orchard age. Data indicate that orchards should be comprised of 3+ cultivars. RAPD-DNA analysis of "hooked-nuts" indicates that this trait is not reliable as an indicator of selfing.

88 ORAL SESSION 16 (Abstr. 107–114) Culture and Management–Floriculture I

107

Growth of *Dieffenbachia maculata* 'Camille' in Growing Media Based on Spaghnum Peat or Coconut Coir Dust

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A comparison was made of Philippine coconut coir dust and Canadian spaghnum peat as components of three growing media for greenhouse production of *Dieffenbachia maculata* 'Camille'. The soilless media were prepared using coir or peat in various amounts (by volume) combined with pine bark, vermiculite, and/or perlite (Media A–50% coir/peat : 25% vermiculite : 25% perlite; Media B–40% coir/peat : 30% vermiculite : 30% bark; Media C–50% coir/peat : 50% bark). Chemical and physical properties of the soils were determined at the beginning and the end of the five-month production cycle. Plant root and top growth and grades were determined at the end of the experiment. Initially, saturated media extracts from coir-containing media had elevated K, Cl, and soluble salts levels compared to peat-containing media; however, by the end of the experiment those levels were lower in coir- than in peat-based media. Water-filled pore space and water-holding capacities were generally higher and air-filled pore space lower in coir- than in peat-based media, probably due to differences in particle size distributions. There were no interaction effects on plant growth between growing media and coir versus peat. Plant root and top growth in Media A > Media B > Media C and plant top growth was greater in coir- than in peat-based media. Differences in growth could be due, in part, to differences in media water-holding capacities.

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Wetting Characteristics of Different Peat and Peat : Bark-based Potting Media: Influence of Wetting Agents in Improving Wetting and Rewetting Performance

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Eight different peat-based or peat : bark-based potting media were evaluated for their wetting performance when treated with the media wetting agent AquaGro 2000 (2–5 oz/yd^3). Upon initial irrigation, no differences in wetting uniformity were observed in seven of the eight test media regardless of their media wetting

agent treatments. In four media, water retention was reduced by media wetting agent treatment, however, uniform distribution of water was achieved. AquaGro 2000 improved uniformity of initial wetting in one medium in which the initial moisture content was 6.5%. Uniformity of wetting and water retention improved with increasing wetting agent rate. All media were allowed to air dry and then were re-irrigated. Wetting agent-treated media rewet uniformly, while rewetting varied greatly in untreated media (7.5%–82.5%). Less than 50% of the mass of untreated media wet subsequent to drying. Those portions of the untreated media that did wet retained up to three times more water per unit volume compared to AquaGro 2000-treated media. AquaGro 2000 enhanced uniformity of rewetting, reduced water logging, and improved drainage at all rates (2–5 oz/yd^3) tested. Media composition (peat vs. peat : bark did not affect wetting agent efficacy.

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Relationship between Applied Fertilizer and Accumulated Levels of Nitrogen and Sulfur in a Soilless Mix

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Three cultivars of poinsettia, Freedom Red, Lilo and Red Sails, were grown in a peat:perlite:vermiculite mix according to a commercial production schedule. Twelve selected nitrogen–sulfur fertilizer combinations were applied (125, 150, 175 ppm N with either 12.5, 25, or 37.5 ppm S, 225 and 275 ppm N with either 37.5 or 75 ppm S). The experimental design was a split plot with cultivars as the whole plot and fertilizer levels as the split-plot factor. Mix samples were taken initially, at production week 7 and at the end of the experiment. Nitrate-nitrogen, sulfate-sulfur and total nitrogen were determined. Data were analyzed using SAS PROC MIXED. Visually all cultivars responded similarly to all treatments and were salable. Thus, levels of N as low as 125 or 150 with 12.5 ppm S produced quality plants. Sulfate-S tended to accumulate in the mix while nitrate-N and total N did not. Both nitrate-N and sulfate-S concentrations were affected by an interaction between the cultivar and the amount of S applied with 'Freedom' better able to utilize available sulfur. 'Lilo' removed more nitrate-N and total N from the mix than 'Freedom' which removed more than 'Red Sails', but only at specific levels of sulfur. There was no cultivar by nitrogen interaction for any variable measured.

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Effect of Compost Sources and Fertigation Frequency on Growth of Potted Poinsettia

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Treatment combinations of four cultivars, 26 mixes, and three fertigation treatments were evaluated in a completely randomized design. Poinsettia cultivars included 'V-14 Glory', 'Red Sails', 'Lilo Pink', and 'Annette Hegg'. The 26 mixes were 25%, 33%, and 50% of eight compost sources blended with 1 peat : 1 perlite (v/v), and Sunshine mix and Pro-Gro were the control. The eight compost sources were yard waste, lime and polymer dewatered biosolid, municipal solid waste (MSW), co-composted MSW 1 and 2, crab waste, and poultry litter. Fertigation treatment was began on first, second, or third week after potting. Fertigation solution was 250 mg/L N from 21N–2.2P–15.8K. The controls produced premium quality plants with 38 cm in canopy diameter, 11 total number of branches, and 28 cm in shoot height. Poultry litter, yard waste, polymer dewatered biosolid, crab waste, and MSW produced good quality plants with canopy diameter ranging from 30 to 35 cm. The canopy diameter with 25% compost treatments were 6% to 20% greater than those with 50% compost treatments. Total number of branches, shoot height, canopy diameter, and plant grade with first week fertigation were only 3% greater than those with fertigation delayed 1 or 2 weeks.

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Pulse Irrigation Strategies for Poinsettias

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Three irrigation strategies [10% leaching, 0% leaching (pulse), and ebb-and-flood] and two constant liquid feed fertilizer treatments, 150 and 300 ppm N, were applied to poinsettias, 'Freedom Red' and 'V-17 Angelika Red', with a harvest date of November 25, 1995. There were no differences in plant dry weights among the three irrigation strategies at the 150 ppm N treatment. At 300 ppm N, 10% leaching irrigation grew plants with the greatest dry weights, followed by the ebb-and-flood treatment and the pulse treatment, respectively. The 10% leaching and ebb-and-flood plants had the greatest growth index, while the pulse treatment growth index was lower. Growth index was greatest for the 10% leaching strategy for 'Freedom Red', while ebb-and-flood had the lowest index. The growth index was greater at 150 ppm N for 'Freedom Red' compared to 300 ppm N. 'V-17 Angelika Red' was not influenced by fertility level. Pulse irrigation grew marketable poinsettia plants at lower fertility levels.

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Effect of Radiant-to-thermal Energy Ratio on Poinsettia Plant Quality

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Plant growth and development are driven by two forms of energy: radiant and thermal. This study was undertaken to determine the effect of the ratio of radiant energy to thermal energy on plant quality of *Euphorbia pulcherrima* 'Freedom'. Plants were grown under 27 combinations of temperature (thermal energy), light (radiant energy), and spacing, i.e., factorial combinations of three levels of constant temperature (19, 23, or 27°C:), three levels of daily light integral (5, 10, or 20 mol·m^{-2}·d^{-1}), and three levels of plant spacing (15 × 15, 22 × 22, or 30 × 30 cm), from pinch to the onset of short-day flower induction. Plants were treated for 450 degree-days (base temperature = 5°C) in Expt. 1 or 5 weeks in Expt. 2. The results showed that increasing radiant energy or decreasing average daily temperature during accumulation of 450 degree-days increased plant dry weight. When radiant and thermal energy were calculated into the ratio, plant dry weight increased linearly as the ratio increased Plants exposed to low light: levels and high temperatures, i.e., those at a low ratio, developed thin, weak stems. Higher radiant-to-thermal energy ratios produced thicker stems.

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Benzyladenine and Daminozide Sprays Applied after Initial Anthesis Affect Bract Necrosis in Poinsettia

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Bract necrosis (BN) in poinsettia is thought to be caused by a localized calcium deficiency in the margins of bracts. Both calcium and silicate sprays can suppress the post-anthesis development of BN if applied repeatedly during bract development. However, studies conducted in 1993 and 1994, with BN-susceptible scions ('Supjibi') grafted onto either 'Supjibi' rootstock or the BN-resistant 'Annette Hegg Dark Red' (AHDR) rootstock, failed to support the calcium hypothesis. In these studies, higher calcium concentrations were found in the margins of 'Supjibi' bracts on 'Supjibi' rootstock, then in 'Supjibi' bracts on 'AHDR' rootstock, even thought the incidence of BN was highest on plants with 'Supjibi' rootstock. These studies suggested that non-nutritional factors (possibly hormonal factors) may play a role in BN. In 1995, 'Supjibi' plants were produced in the greenhouse, and at initial anthesis, were sprayed once with either deionized (DI) water, benzyladenine (BA) (100 ppm), or daminozide (2000 ppm). At initial anthesis, plants in all treatment groups showed a low level of BN (0.75% of bracts with symptoms). Four weeks after initial anthesis, 18.5% of bracts on DI water sprayed plants and 38.7% of bracts on daminozide treated plants had developed BN; but BA treated plants developed BN on only 1% of bracts. At final harvest (38 days after treatments were applied), BN was evident on 3.4% of BA-treated bracts, 28.7% of DI-treated bracts, and 46.3% of daminozide-sprayed bracts.

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Efficacy against Silverleaf Whitefly of Insecticidal Dips for Rooted Poinsettia Cuttings

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Since whiteflies preferentially oviposit on the newest leaves, it is the early life stages that are most likely to be present on poinsettia cuttings from infested stock or infested during rooting. This study evaluated efficacy of insecticidal dips against eggs and first nymphal instars of the silverleaf whitefly, *Bemisia argentifolii*. Dip efficacy was investigated by dipping rooted cuttings of whitefly-infested 'Freedom' in the following insecticide emulsions: 2% insecticidal soap (M-Pede), 1% horticultural oil (Ultrafine), fluvalinate (Mavrik), oxythioquinox (Joust), kinoprene (Enstar II), azadirachtin (Margosan-O), fenoxycarb (Precision) and imidacloprid (Merit). Two dip durations, 10 seconds and 1 hour, were tested for each insecticide. Water dips for the two durations were used as control treatments. Fenoxycarb

and azadirachtin dips for durations of 10 seconds and 1 hour and oxythioquinox dips for 1 hour resulted in greater egg mortality than the other treatments. No insecticide/dip duration treatment gave 100% mortality of eggs. Dips found to be efficacious killed proportionately fewer eggs than first instar nymphs.

89 ORAL SESSION 17 (Abstr. 115–121) Biotechnology–Molecular Biology

115

Cloning and Expression of Dehydrin Genes in Blueberry

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Previous studies identified three major chilling-responsive proteins of 65, 60, and 14 kDa whose levels increase in floral buds of blueberry during cold acclimation and decrease during deacclimation and resumption of growth. Characterization of these proteins found them to be members of a family of proteins responsive to drought and low temperature stress called dehydrins. The 65- and 60-kDa proteins were purified, digested into peptides, and several peptides from each were sequenced. The sequence information was used to synthesize degenerate DNA primers for amplification of a part of the gene(s) encoding these proteins. One pair of primers amplified a 200-bp fragment, which now has been cloned and sequenced. Within the 200-bp sequence is a motif conserved amongst dehydrins. Hybridization of the 200-bp fragment to RNA blots revealed homology to two chilling-responsive messages of 3.7 and 1.6 kb. The 200-bp fragment currently is being used to screen a cDNA library (prepared from RNA from cold acclimated blueberry floral buds) to isolate the full length cDNA clone.

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Molecular Responses of Plants to Phosphate Starvation

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Phosphate deficiency is wide spread in the nature. The deficiency results in several morphological and biochemical changes in plants. Some of these changes have been shown to involve altered gene expression. We have isolated two full--length cDNAs (AtPT1 and AtPT2), showing significant amino acid sequence similarity with the high-affinity phosphate transporters of yeast, *Neurospora* and the mycorrhizal fungi *Glomus versiforme*, from a phosphate-starved *Arabidopsis* root library. The transcripts of both genes are highly induced under Pi starvation and they are expressed in roots. Using *Arabidopsis* cDNAs as probes, we have isolated several tomato root cDNA clones representing the two different genes. The expression characteristics of the tomato isoforms of the putative high affinity phosphate transporter genes will be discussed. The northern blots of RNA isolated from phosphate-deficient and phosphate-sufficient roots of tomato indicated that both genes are strongly induced in response to Pi starvation in roots. Furthermore, by the method of differential display of mRNA, we have cloned and characterized a full-length cDNA representing a Pi starvation induced gene (TPSI1) from tomato. The gene is expressed as a specific response to Pi starvation in roots and leaves. The TPSI1 is an intron-less gene represented by a single copy in the tomato genome. The structure, expression, and functional significance of these genes will be discussed. This research has been supported, in part, by USDA grant 94-37100-0834 to KGR.

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Early Nodulin Gene (*ENOD2*) Expression in *Maackia amurensis* Rupr. & Maxim. (*Amur maackia*)

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A complete picture of legume nodulation has yet to be elucidated. Most studies of the molecular mechanisms responsible for nodule organogenesis have focused on herbaceous legumes. We investigated the presence of a putative *ENOD2* gene and studied the temporal and organ-specific production of its transcripts in an ornamental woody legume, *Amur maackia*. Primers derived from proline-rich pentapeptide repeats of conserved *ENOD2* sequences and the genomic DNA of *Amur maackia* were used to obtain a 543-bp PCR fragment. Southern and Northern blots were probed with this cloned fragment. The *Amur maackia* genome contained an *ENOD2* sequence that is similar to sequences in other species. Expression of the putative *ENOD2* gene was detected in roots, 4 days after rhizobial inoculation, but not in leaves or stems. New data on the characteristics of nodulin genes in woody legumes will be beneficial in clarifying the nature and evolution of nodulation in legumes and may have implications for developing sustainable nursery production protocols.

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Isolation and Preliminary Characterization of a Receptor-like Protein Kinase from Cold Acclimated Peach Bark

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To identify components of a possible signal transduction pathway associated with woody plant cold acclimation, a cDNA library prepared from peach bark collected in December was screened using a small DNA fragment from a maize receptor-like protein kinase (ZMPK1) as probe. Six isolates were obtained and partially sequenced to confirm protein kinase identity. One isolate (PPPKB5) contained a relatively large insert (about 1.9 kbp) and was selected for further analysis. Both strands of PPPKB5 were sequenced and the derived amino acid sequence was compared with a variety of known plant protein kinases, leading to the tentative identification of this clone as encoding a partial cDNA for a serine/threonine class protein kinase. PPPKB5 has a classic protein kinase catalytic domain with all the features required for phosphorylation activity and with greater similarity to the known plant receptor-like protein kinases (RLKs) than other classes of these enzymes. In addition, it contains a potential transmembrane region separating the catalytic portion of the molecule from the receptor region. The receptor region has greatest identity with the class of RLKs known as the S-locus type based on conservation of a stretch of 10 cysteines on the amino-terminal side of the transmembrane region. PPPKB5 shares greater amino acid identity with ZMPK1 (50%) than with the *Brassica*, rice or *Arabidopsis* S-locus RLKs (34%–40%). Furthermore, PCR analysis of 'Loring' suggests that, like maize ZMPK1, the genomic sequence encoding PPPKB5 contains no introns, in contrast to the genomic sequences of *Brassica* and *Arabidopsis* which contain six.

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Isolation and Characterization of Chalcone Synthase and Chalcone Isomerase cDNAs from Grapefruit (*Citrus paradisi* Macf.)

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Many *Citrus* species accumulate large amounts of flavonoids, specifically flavanone glycosides, that impart an intensely bitter flavor to the fruit. In grapefruit, this bitterness decreases the acceptability of fresh fruit and juice; in other species, these compounds entirely prevent fruit consumption. No physiological purpose for the accumulation of these compounds has been determined; they do not function in color production or, as far as is known, in defense responses. As has been found in other plants, the accumulation of specific flavonoids in citrus appears to be under genetic control, but no definitive genetic analyses have been done. The long-term objective of this research is to determine whether the production of bitter-tasting flavanone glycosides (neohesperidosides) in citrus can be manipulated using molecular genetic techniques. As a first step, cDNAs for chalcone synthase and chalcone isomerase, the first two biosynthetic enzymes specific to the flavonoid pathway, were isolated from a grapefruit leaf cDNA library using heterologous probes. Southern analyses showed that both genes appear to be part of multigene families, as expected. Northern analyses are underway to determine steady state mRNA levels in various grapefruit tissues, and Western blots to characterize protein expression are also being attempted.

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Classification of *Cephalotaxus* Species Based on *rbcL* Sequences

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Cephalotaxus species are needle evergreens offering the aesthetic qualities of *Taxus*, yew, yet are heat- and drought-tolerant, sun- and shade-adaptable, and resist deer browsing. They are adaptable to nursery and garden cultivation in USDA hardiness zones (5)6–9. Unfortunately, the various species are frequently

confused in the American nursery trade due to their extreme similarity in morphology. Recently, molecular data have been widely applied in the taxonomic studies, especially DNA sequencing. The chloroplast gene *rbcL* of *Cephalotaxus* has been sequenced for determining species relationships. The preliminary results show that *C. oliveri* Mast. has 10 base changes from *C. drupacea* Sieb. et Zucc., while only one base difference occurred between *C. drupacea* and *C. harringtonia* (Forbes) Koch. There are between one and 10 base substitutions among *C. fortunei* Hooker, *C. koreana* Nakai, and *C. sinensis* (Rehd. et Wils.) Li. Compared with other closely related conifers, *Cephalotaxus* has a substantial number of differences among species except between *C. drupacea* and *C. harringtonia*, which may not be distinct species. Detailed data relative to gene sequencing, growth morphology, and horticultural characteristics should lead to correct identification of species and great horticultural uses. Furthermore, the method of *rbcL* sequence can be applied to distinguish other morphologically homogeneous ornamental plants.

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Fine Population Structure of *Discula destructiva*

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Fifty-one isolates of *Discula destructiva* obtained from various *Cornus* species were evaluated using arbitrary signatures from amplification profiles (ASAP). ASAP analysis is based on dual-step arbitrary primer-based amplification procedure that produces "fingerprints of fingerprints" and in many instances increases detection of polymorphic DNA. This novel technique was able to distinguish groups of isolates from the northeast, middle and southeast range of the disease as well as western United States and Canada. The data supports the contention of recent and independent introduction of the disease on both east and west coasts, a genetic "bottleneck" that has limited diversity of the pathogen, and directionality of introduction of disease from coastal ports-of-entry to interior populations of *C. florida* and *C. nuttalli*.

92 ORAL SESSION 18 (Abstr. 122–127) Growth and Development–Vegetables

122

Air and Water Temperature Effects on Growth of Lettuce in a Hydroponic System

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This research explored cool crop production in various climate zones using CEA facilities and hydroponics ponds to control growth rate and quality through root zone temperature control. The precise controls were used to vary air and water temperatures to study the temperature gradient between root and shoot zones. Effect of this gradient was measured by growth rates and final harvest dry weights. *Lactuca sativa* L. cv. Ostinata seedlings were germinated and grown 11 days in a growth chamber and moved to greenhouse ponds. Air temperatures chosen were 17, 24, and 31°C. These were constant for the 24 days that lettuce grew in the ponds with a 5°C decrease for 14 hours. during the night. Water temperatures of the three ponds in the greenhouse were set and maintained at 17, 24, and 31°C. Maximum final harvest weights were obtained at 24°C air/water 24°C. Final weights for the 17 and 31°C water setpoint were comparable at 24°C air. The 31 °C air /water inhibited quality and final dry weight, while 17 and 24°C water produced equivalent dry weights at 31°C air. At 31°C air heads were tighter at 17 than at 24°C, and loose at 31°C. At air 17 °C maximum weight was at 24°C water and minimum at 31°C water. At 17°C air, the 24°C water plants were of good quality, with thicker leaves but visibly smaller than the 31°C water crop. Significant differences in harvest dry weights were shown at each 7-day harvest beginning on day 14, due to both air and water setpoint factors and there was significant interaction between them.

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Growth and Yield Response of Bell Peppers (*Capsicum annuum* L.) to a Nitrogen Fertigated Plastic-mulched System

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The yield of bell peppers (*Capsicum annuum* L. cv. King Arthur) was measured when grown in the field under eight mulching/irrigation/nitrogen fertilization systems, was studied at the Macdonald Campus of McGill Univ., using a randomized block design replicated three times. All treatments received a preplant fertilizer application of 60 kg N/ha with four of the treatments receiving additional fertigation during the season. Of the four treatments receiving fertigation, one silver reflective mulched plot and one black mulched plot received an additional 40 kg N/ha in 4 kg N/ha/week over a 10-week period beginning 12 June weekly up to and including 14 Aug. 1995. The remaining two fertigated treatments only received additional N, when leaf nitrogen, based upon leaf chlorophyll content, dropped below a 95% sufficiency index as measured by a Minolta SPAD 502 meter. Marketable yields of the fertigated plots range between 100%–126% higher than those of the control plot for the entire growing season. However, most notably was the early yields (first three harvests), which ranged from 146%–493% higher than that of the control plot, economically, significantly increasing the producers income. The experiment will be duplicated in Summer 1996 to confirm our findings.

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Low Light Stress Influences lower Abscission and Yield of Six Bell Pepper Cultivars

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High temperatures during flowering frequently limit yields of some bell pepper cultivars in New York fields. Previous research has shown that subjecting the plants to low light at flowering can have similar effects. To determine if cultivar differences in flower abscission and yield could be accentuated by such a shade stress, field plots of six cultivars were subjected to 1 week of low light during flowering. Shade cloth tunnels were erected over the plant rows in two experiments, reducing incident light by 80%. Nondestructive abscission counts were taken at the start, and 7 days after the end of a 7-day shade period. Mature green fruit were harvested periodically. Low light stress resulted in 68% and 86% abscission at the first three fruiting nodes in 1992 and 1994, respectively. Cultivars showed differential abscission in unshaded plots, and after shade, producing a significant cultivar : shade interaction. 'Ace' showed least abscission and maintained yields with shading; 'Camelot' lost nearly all flowers and buds with low light stress, and was reduced by 75% and 91% in marketable yield in 1992 and 1994, respectively. Results indicate that shade stress accentuates abscission susceptibility in bell pepper cultivars. Pepper lines selected for low light tolerance may show promise in resisting flower abscission at high temperature.

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Asparagus Yield Cycles and Heat Unit Correlations

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Asparagus is a unique crop in that the yield of the crop is entirely dependent on the storage of carbohydrates from the previous season. The number of spears produced is determined by the number of buds on underground rhizomes and the size of each spear is related to the size of the bud from which it originates. Growth of spears begins in the spring when some minimal temperature is reached in the soil. We have determined that the minimum temperature for spear growth is 10°C (50°F) and that temperatures in excess of 35°C (95°F) inhibit growth. Using data from growth response to temperature experiments, we have compared the accumulative effects of hourly temperatures preceding harvest to subsequent yields. There was a significant effect of the number of hours above 10°C for the 24 hours preceding harvest and the yield obtained. Yield of spears cycled over an 11-day period which correlated to an eleven day weather cycle determined from the heat unit accumulations. Heat unit and yield cycles for seven cultivars over a 4-year period will be discussed.

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Growth Analysis of 'Daliva' Chicory Grown Under Bare Soil or Straw Mulch Conditions

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Some chicory (*Cichorium intybus* L.) cultivars, especially early and extra-early cultivars, often bolt and flower the first year of growth, contrary to the expected behavior of biennials. The extra early hybrid cultivar 'Daliva' was grown in the field under bare soil and straw mulched conditions to examine possible correlations between growth rates, leaf and root sizes and bolting. Plants, sown on 19 June, were harvested weekly from 4 July to 1 Oct.; a total of 14 harvests. Root variables of length and diameter were best described by linear equations but root dry weight was decidedly quadratic in response. Leaf number, area and dry weight and crown diameter data were fitted to the Richards function to describe their sigmoidal phases of growth. In most cases, when using the Richards function, the two treatments (mulch vs. no-mulch) required different parameters to fit a line to the observed points with r^2 values >0.95. A statistical comparison between treatment parameters (as obtained from SAS PROC NLIN and SigmaPlot) will be discussed.

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Elevated and Super-elevated CO_2 Effects on Stomatal Behavior and Yield of Tomato Cultivated Hydroponically

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The growth of candidate crops in high CO_2 environments is being investigated as part of NASA's goal of using higher plants for bioregenerative life support systems. Tomato (*Lycopersicon esculentum* Mill.) cvs. Red Robin and Reimann Philipp were grown in recirculating hydroponics at 400, 1200, 5000, or 10,000 $\mu mol \cdot mol^{-1}$ CO_2 for 105 days. The plants received a 12/12 hour photoperiod at 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$ PPF, 26/22°C (light/dark), and 65% continuous relative humidity. Stomatal conductance increased at the highest CO_2 levels, which is similar to what we have reported with Soybean, radish, and potato. Fruit number increased with increasing CO_2, where Red Robin produced 663 fruit/m^2 and Reimann Philipp produced 6870 fruit/m^2 at 10,000 $\mu mol \cdot mol^{-1}$ CO_2. Fruit fresh mass was greatest at 10,000 $\mu mol \cdot mol^{-1}$ CO_2 for Red Robin (7.4 $kg \cdot m^{-2}$) and at 5000 $\mu mol \cdot mol^{-1}$ CO_2 for Reimann Philipp (27 $kg \cdot m^{-2}$), suggesting that very high CO_2 was not detrimental to yields. These findings contrast with those of wheat, soybean, and potato, which have shown slightly depressed yields at CO_2 levels above 1200 $\mu mol \cdot mol^{-1}$.

93 ORAL SESSION 19 (Abstr. 129–135) Cell and Tissue Culture

128

Ontogeny of Grape Somatic Embryos

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The development of grape somatic embryos (*Vitis vinifera* cv. Thompson Seedless) was studied using high-resolution light microscopy and scanning electron microscopy. Somatic embryos develop either from discrete embryogenic cell clusters (indirect somatic embryogenesis) or from previously formed somatic embryos (direct somatic embryogenesis). In both instances, embryo development begins when a small, isodiametric, densely cytoplasmic cell undergoes a series of organized divisions, which are identical to those observed during zygotic embryogenesis. Developing embryos pass through recognizable embryonic stages, remaining white and opaque through maturity. Upon germination, embryos begin to enlarge, become yellow, then green, and develop into morphologically correct plants. The cells of somatic embryos contain little starch, but abundant storage proteins. However, lipids comprise the primary storage compound. Some developmental abnormalities occur during embryogenesis, including overly enlarged hypocotyls and fewer or more than two cotyledons. In addition, relatively few somatic embryos grow into plants primarily due to inadequate shoot apical meristem development. These abnormalities are best attributed to inadequacies of the in vitro environment of medium in a culture vessel when compared to the in vivo environment of a seed.

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Photoautotrophic Micropropagation of Triploid Melon: II. Rooting and Plantlet Growth on Sugar-free Media

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Two triploid clones of melon from the same tetraploid parent were grown in vitro with and without sugar, rooted without sugar in media both in a laboratory controlled environment chamber (in vitro) and a greenhouse acclimatization unit (ex vitro), and compared for subsequent nursery growth in the greenhouse unit. The clone '(L-14 c B) x L-14' produced more shoots in both photomixotrophic (with sucrose) or photoautotrophic (sugar-free) conditions. Both genotypes were equally likely to root in sugar-free media, and '(L-14 x B) x L-14' rooted as well from either photoautotrophic and photomixotrophic shoots but '(L-14 x B) x Mainstream' rooted less frequently from photoautotrophic shoots. Seventy-six percent (76%) of the shoots were able to root photoautotrophically in vitro, whereas 47% of the ex vitro shoots were rooted. About 85% of plantlets from all treatments survived after transfer to the nursery. After growth in the greenhouse nursery, the sizes of plants (fresh and dry weight, leaf area) were the same for either clone, from either photoautotrophic or photomixotrophic shoots. Also, after growth in the nursery, plantlets that had been rooted in vitro were larger than those rooted ex vitro. Photoautotrophic rooting demonstrates a concept for integrating micropropagation and plug-type vegetable transplant production.

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Growth of Plant Tissue Cultures in Ultra-high Levels of Carbon Dioxide under Autotrophic and Heterotrophic Conditions

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A comparative study was undertaken to determine the influence of lighting, carbohydrate concentrations and ultra-high levels of CO_2, i.e., >10,000 ppm, on sterile culture growth. Past CO_2-sterile studies have confirmed that elevation of CO_2 to as high as 1000 ppm resulted in beneficial growth. Within special constructed chambers, tissue cultures were given a variety of CO_2 levels for 12–16 hours/day using artificial lighting and natural sunlight. Several different plants (lettuce, beans, pine) and plant culture types were grown in CO_2-enriched environments, ranging from 350 to 50,000 ppm. In almost all cases, plant tissue cultures not only tolerated but exhibited enhanced growth using ultra-high levels of CO_2. For example, lettuce cultures were found to grow 2 to 4 times faster under ultra-high CO_2 levels than under normal atmospheric CO_2 levels, i.e., 350 ppm. Natural sunlight was found to be suitable for sterile culture growth. Modes of administration of CO_2 in vitro and gas permeability of various culture vessels are presented.

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Micropropagation of Two Apricot (*Prunus armeniaca* L.) Cultivars

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Shoot tip and single-node cutting explants of 'Hamawy' and 'El-Amar' apricot cultivars were initiated from forced shoots of field-grown, virus-free trees. Explants were cultured on Murashige & Skoog (MS) Nitsch & Nitsch and Anderson media. Different modifications of MS medium were also evaluated. Antioxidant pretreatment reduced phenolic compounds and decreased necrosis. Modified MS was the best medium for plantlets regeneration, with positive effectiveness of adenine sulfate addition to the modified MS. Shoot multiplication was best on 2.0 $mg \cdot L^{-1}$ BAP and 1.0 $mg \cdot L^{-1}$ thidiazuron (TDZ). Also, half-strength MS medium was superior for shoot elongation Surface coverage, 16 hours light/ 8 hours dark cycle, and 2.0 $mg \cdot L^{-1}$ IBA induced good rooting. Rooted plantlets were successfully acclimated ex vitro.

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Shoot Proliferation of *Gardenia jasminoides* in Vitro Culture

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Shoot proliferation of *Gardenia jasminoides* was achieved from cultured shoot tips on Nitsch and Nitsch medium supplemented with different levels (0.0–0.6 $mg \cdot L^{-1}$) of zeatin, BAP, BA, TDZ, and kinetin. Zeatin proved to be the most effective cytokinin for stimulating shoot proliferation. Shoot length obtained with zeatin

was shorter than with other cytokinins and shoot leaves were narrower. Shoot tips were cultured on Nitsch and Nitsch medium supplemented with BA at 4.0 $mg \cdot L^{-1}$ combined with IAA at 0.0–0.2 $mg \cdot L^{-1}$. The results indicated that BA at 4.0 $mg \cdot L^{-1}$ with 0.1 IAA produced greater shoot proliferation. Plantlets regenerated in vitro were then transferred to a mixture of 1 peat : 1 perlite : 1 soil and acclimatized for potting. Our results show that micropropagation of *Gardenia* has high potential for use in commercial industry.

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Asymbiotic in Vitro Propagation of Temperate Terrestrial Orchids (Orchidaceae)

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The temperate native terrestrial orchids are endangered species. Their propagation from seeds poses specific problems. It is well known that orchid seeds are devoid of endosperm and in nature they need microscopic fungi in a symbiotic relationship for germination. We developed a successful asymbiotic in vitro culture method for germinating seeds of several temperate orchid species and for maintaining the cultures of young plantlets. The medium used for both germination and seedling culture was a modified FAST medium. Seeds were surface-disinfested for 10 minutes in a 10% calcium hypochlorite solution. After sowing, the cultures were kept under dark condition at 10–12°C for 4 weeks. After that the cultures remained in the dark, but the temperature was raised to 25–26°C until germination occurred. Thereafter cultures required alternating seasonal temperatures: 25–26°C from the beginning of April to the end of September and 17–19°C from October to March. For the development of the young plantlets natural dispersed light and prevailing day-length was favorable. After 2 years of aseptic culture they were suitable for transfer ex vitro. Different stages of seed germination and plant development were observed using a scanning electron microscope and will be included in this presentation. Further observation of the effects of different environmental factors is currently under investigation.

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The Role of Sucrose Alone and Combined with Different Cytokinin-like Compounds on in Vitro Tuberization of Potato

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The role of sucrose alone and in combination with different cytokinin-like compounds on the microtuberization of potato, *Solanum tuberosum* 'Atlantic', was investigated. Single nodal segments were placed in Magenta boxes containing Murashige & Skoog medium supplemented with one of 15 treatments in a 3 × 5 factorial. Treatment factors were sucrose at 3%, 6%, or 9%, and cytokinin-like compounds at five levels [cytokinin-free; 2 mg kinetin/L; 0.1 mg thidiazuron (TDZ)/L; 1.0 mg AC 243,654/L; 0.1 mg AC 239,604/L]. Except in a few cases in kinetin and TDZ treatments, nearly all cytokinin treatments failed to induce tuberization at the 3% sucrose, noninductive level. However, all cytokinin treatments induced tuberization in the presence of 6% sucrose. By raising the sucrose level from 6% to 9%, more and larger microtubers were obtained in the cytokinin-free medium. At the 9% sucrose level, even though more tubers per box were produced by TDZ and AC 243,654 treatments, less total fresh weight of tubers per box resulted from kinetin, TDZ and AC 243,654 treatments because tubers formed were smaller. Higher sucrose concentrations (9%) favored tuberization in the cytokinin-free medium, whereas 6% sucrose was optimum for the medium containing cytokinins. Sucrose might produce a strong tuberization signal that might either change endogenous hormone levels affecting tuberization or activate a number of genes coding tuber proteins and enzymes related to starch synthesis.

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A Breeding Program for *Cornus florida* that Uses Molecular Markers and Seedling Tissue Culture

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DNA amplification fingerprinting (DAF) was Used to characterize both parents (different cultivars) in breeding experiments with *Cornus florida*. Putative hybrids were fingerprinted and true crosses identified by finding unique male parent products in amplification profiles. Both manual and honey bee mediated pollinations successfully produced hybrid seed. Axillary buds from seedlings were used to initiate proliferating shoot cultures on woody plant medium with 4.5 μM BA. Initiation and development of adventitious roots were dependent on IBA (4.1 μM), sucrose (0–2%), and agar (0.2–0.6%) concentrations. About 40–50% of the microshoots produced roots and were acclimatized to greenhouse conditions. Cultures have been maintained without loss of regeneration potential for over 2 years. Clonal material can be reentered into the breeding program or used to evaluate horticultural characteristics in different environments and locales.

94 ORAL SESSION 20 (Abstr. 136–143) Education–World Wide Web

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World Wide Web Access to Multimedia Resources

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Agricultural producers in the United States require timely and accurate information on critical issues, environmental crises, and best management practices to make effective production decisions and to remain competitive in a global economy. Sources of information (university departments, extension, industry, consultants, scientific and trade publications) often take a single discipline approach that makes it difficult for growers to process and utilize information effectively. The high cost of printed publications make frequent updates impractical, while rapidly changing technologies and issues demand continual publication changes and updates. The rapid development and peer review of multi-discipline, research based information is possible through computer information transfer technology. The Univ. of California's Vegetable Crops Research and Information Center (VRIC) has developed a new World Wide Web site to disseminate peer-reviewed fact sheets, research results, updated publications, and multi-media educational resources relating to critical issues, best management practices, postharvest handling, and marketing of vegetable crops. The website disseminates multi-discipline information originating from the Univ. of California, the USDA, and cooperating agencies and universities. The VRIC website proactively sends peer-reviewed critical issue fact sheets to selected news media, government, industry, and academic contacts. These fact sheets help personnel frequently contacted by the media during crises to answer questions effectively. The website directs visitors to additional agricultural information resources and contains information on careers and educational opportunities available in the field of vegetable crops.

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Publishing Newsletters on the World Wide Web Using Database Software

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Preparing newsletters for distribution over the World Wide Web generally requires one to learn HTML (hypertext markup language), purchase an HTML editor, or convert existing wordprocessing documents through a utility program. As an alternative, an input form was developed for county agents that facilitates the direct publishing of their weekly *Buckeye Yard and Garden On-line* newsletter over the Internet. Using FileMaker Pro 3.0 for Macintosh and the ROFM acgi script for WebSTAR, agents cut and paste text from their word processing file into specific input boxes on the screen and then submit it to the server located in Columbus. Their newsletter articles are then made available to anyone on the Web through a searchable database that allows for searching by date or title. Preparation of the input form and corresponding search form creates two distinct advantages: county agents do not have to spend time learning about HTML coding and all their newsletters are indexed in a searchable database with no additional effort by the site manager. Modification of this procedure has been done to facilitate the creation of online term projects for students and a directory for horticultural internships.

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Analyzing Web Server Statistics

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The World Wide Web is regarded widely as an invaluable asset to teaching and extension programs. Data supporting this assertion can be gathered actively

or passively and can be analyzed to aid decision makers in matters of personnel evaluation and resource allocation. Most Web server software applications keep a log of connections by time, location, and file size transferred. The server logs of Aggie Horticulture, the Web site of the Texas Horticulture program, are analyzed bi-weekly using WebStat 2.3.4 and the number of logins, file size transferred (total and amount per sub-site), and client domain are tabulated. The number of "hits" increased from 15,000 to 120,000 per month (mid-February to mid-March of 1995 and 1996, respectively) over the last year. The logins came from 61 Internet domains representing 56 different countries. The "net" and "com" domains exhibited the greatest increase. "Active" data acquisition through a guest register at one of the sub-sites indicated that only 9% of the visitors registered. However, the data obtained from the active registrants were useful in determining the distribution of users by state and county within Texas.

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Remote Sensing Imagery on the Web and Its Potential for Use in Horticulture Classes

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As the World Wide Web (WWW) expands, information is rapidly becoming more accessible. Using satellite data previously required high-end computers running complex imaging software, sophisticated downloading equipment, and high monetary support. Satellite data is now available on the internet for little or no cost and can be handled on standard desktop computers using common software programs. The purpose of our project was to determine the availability and cost of different types of data and how this data may benefit horticultural instruction. Satellite data currently is archived at NASA, NOAA, the Department of Defense, the US Geological Survey, and various meteorological departments throughout the world. Satellite data such as large-scale thermal imagery can be used to determine microclimate effects within urban areas, including the cooling effects of urban plants. Natural Density Vegetation Index (NDVI) imagery can indicate changes in vegetational cover or give general indications of plant health in large areas. NASA photographic imagery can show the effects of erosion on a large scale. Higher resolution imagery can give indications of plant stresses in large plantings such as orchards or vegetable plots.

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BioBLAST—A New Approach to Teach High School Biology

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BioBLAST is a NASA-funded multimedia curriculum supplement, targeted to enrich high school biology classes. It is modeled after the CELSS scenario and currently is being developed by the Classroom of the Future at Wheeling Jesuit College. Through innovative applications of educational technologies and interactions with active researchers in life sciences based at the various NASA centers and by incorporating alternative assessment measures, the BioBLAST project seeks to improve student learning and assist biology teachers. The studentsed life-support system, which uses biological processes to supply astronauts with recycled food, water, and oxygen. The students will be encouraged to formulate hypotheses, devise hands-on experiments to investigate key processes, and use computer simulations to investigate what systems are required to achieve stability of these life-support systems in a simulated lunar base. To succeed in their mission, students will learn basic principles in plant physiology, microbiology, human physiology, nutrition, and the interdependence of systems, and the impact of physical constraints such as temperature, light, and water availability on biological system functioning. BioBLAST will be supported by extensive interactive CD-ROM-based materials and World Wide Web and other internet resources, together with intelligent tutor, frequently asked question lists, and mentor networks that will include the ability to contact NASA and other scientists on-line. An early version of this software will be prototyped to selected schools throughout the United States in Fall 1996.

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Electronic Advancements in Teaching Floral Design at Texas A&M University

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Floral Design (HORT 203) is an increasingly popular course offered at Texas A&M Univ. HORT 203 is offered as a university core curriculum humanities elective and, thus, enrolls many nonhorticulture majors, averaging 95 students per semester. HORT 203 is taught in a large lecture room that does not always lend itself to teaching a hands-on, visual design course. To increase student understanding of the materials, traditional 35-mm slides and overhead transparencies are being replaced by visual computer technology. Colorful, scanned-in images of floral designs are created in Microsoft PowerPoint and incorporated into computer presentations and color transparencies that supplement each instructional presentation. In addition, the Internet is incorporated in the course by providing students with instructors' and lab assistants' e-mail addresses, individual lab section pages, slides for plant identification, reading assignments, as well as classroom lectures. The technologies used for HORT 203 enhance student understanding and ease of teaching while providing a visual alternative to traditional teaching methods. The technologies used for HORT 203 will be discussed and demonstrated including a tour of home-pages, lectures, and plant id lists.

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Development of a National, On-line, Interactive Database of Internship Opportunities for Students of Horticultural Science

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Internships are becoming an increasingly used mechanism of providing undergraduates with experience in their chosen profession before job placement, and potential employers view internships favorably in making hiring decisions. Many horticulture programs require internships as part of their curricula, while others are considering the option. Because internship opportunities in horticulture have been compiled in a wide variety of discipline-specific resources with no central, inclusive "clearinghouse," students often overlook potential opportunities, particularly those outside of their home state, leaving some industry members without interns. The internet-based database of internships developed jointly by Virginia Tech and Ohio State will be discussed within the context of being a resource for all horticulture programs. Other schools will be shown how to contribute to and to use the database so its national scope can be fully used and expanded.

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Teaching in the Virtual Classroom: Using Internet and Computer Resources to Enhance Educational Opportunities in a General Plant Sciences Class

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To enhance the opportunities for students to access information and the instructors of a large, general plant science class, "Virtual Classroom" concepts using computers resources were implemented. The Virtual Classroom uses three computer resources: 1) a closed subscription LISTSERV for the extramural class discussions, 2) electronic mail for homework assignment and submission, and 3) a World Wide Web Internet homepage for the course. In a large, introductory-level class, student–teacher interaction can be limited. The size of the class and the content may inhibit questioning and discussion among the class participants. The LISTSERV allowed for questions to be posed by students at their leisure and facilitated discussion among students and the instructor outside of the confines of the class meeting. The LISTSERV also allowed instructors to to respond to the students by referring questions to "experts" on a particular subject. Using e-mail for homework assignment and submission was useful for tracking when student read assignments and submitted completed assignments. Electronic assignment grading and returning was paperless and easy for instructors to maintain. The homepage provided students with a permanent syllabus, lecture outlines, homework assignment descriptions, and study aids. Additionally, from the homepage students were able to send e-mail to instructors and search library databases and other electronic databases. Experiences from the instructors using these computer resources will be presented and discussed.

95 ORAL SESSION 21 (Abstr. 144–151) Postharvest Physiology–Fruit I

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Effect of Carbon Dioxide on Stability of Anthocyanins and Other Phenolic Compounds during Storage of Fresh Strawberries

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Carbon dioxide-enriched atmospheres are used to reduce decay incidence and severity and extend the postharvest life of strawberries. However, depending on the cultivar, carbon dioxide concentrations of ≥20% can be detrimental to color (change from red to purple) and flavor (development of off-flavors). Our objective was to determine the effect of elevated carbon dioxide levels on the stability of the anthocyanins and other phenolic compounds to examine their role in color changes of strawberries. Freshly harvested strawberries were placed in jars ventilated continuously with air or air enriched with 10%, 20% or 40% carbon dioxide at 5°C for 10 days. Anthocyanins and other phenolics were extracted at 0, 5, and 10 days from homogenized samples. The samples were purified using Sep-pac C18 cartridges. The purified methanolic extract was injected directly into HPLC coupled to a photodiode array detector. Cyanidin-3-glucoside, pelargonidin-3-glucoside, and pelargonidin-3-rutinoside were identified as the major anthocyanins. After 5 and 10 days in storage there was a reduction in the total amount of anthocyanins. This degradation was lower in air than in carbon dioxide-treated strawberries, but the anthocyanin profile remained the same. Flavonols (e.g., quercetin and kaempferol derivatives) and phenolic acids (e.g., ellagic acid) decreased during storage, and this decrease was exacerbated by elevated carbon dioxide atmospheres. Carbon dioxide-induced changes in the quantities of the previously listed anthocyanins and phenolic compounds may be the cause of color changes from red to purple in strawberries.

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Diffusivity of CO_2 and Water Vapors in 'Gala' and 'Granny Smith' Apples

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Previous observations have shown that the diffusivity of water vapors is much larger than the value that is predicted theoretically from the magnitude of the diffusion coefficient of CO_2, C_2H_4,or both. This has been ascribed to the ability of water to diffuse through the cuticle and to the transport of water via the capillaries of cellulase micorfibrels to the surface of the lenticels, where it evaporates. We measured the diffusivity of CO_2 in 'Gala' and 'Granny Smith' apples. The former are more permeable to CO_2 than the latter cultivar, in particular after prolonged storage at 2°C. The diffusivity of H_2O was 10- to 20-fold larger than that of CO_2. Furthermore, the ratio of $D(H_2O)/D(CO_2)$ was similar for both cultivars. Infiltration of dyes and gas flow through apples submerged in water show that in 'Gala' apples, the number of open lenticels is larger than in 'Granny Smith'. Thus, the data indicate that lenticels are the main avenue of gas exchange in apples.

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Hexanal Vapor Acts as Residueless Antifungal Agent that Enhances Aroma Biosynthesis in Apple Fruit

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Hexanal vapor inhibited hyphae growth of *P. expansum* Link. and *B. cinerea* Pers. on PDA media and on apple slices. After 48 hours exposure to 100 $\mu l \cdot liter^{-1}$ hexanal, the hyphae growth of both fungi was ≈ 50% that of nontreated controls. At a concentration of 250 $\mu l \cdot liter^{-1}$, neither fungi grew during the treatment period, however, some growth of both fungi occurred 120 hours after treatment. At concentrations of hexanal vapor of ≥450 $\mu l \cdot liter^{-1}$, the growth of both fungi ceased, and the organisms were apparently killed, neither showing regrowth when moved to air. When fungi were allowed to germinate and grow for 48 hours in hexanal-free air, a subsequent 48-hour exposure to 250 $\mu l \cdot liter^{-1}$ hexanal slowed colony growth relative to controls for several days and a 48-hour exposure to 450 $\mu l \cdot liter^{-1}$ stopped growth completely. Concentrations of hexanal that inhibited fungal growth on PDA also retarded decay lesion development on 'Golden Delicious' and on 'Jonagold' apple slices. Hexanal treatment stimulated aroma volatile production in 'Jonagold' and 'Golden Delicious' apple slices with hexanol and hexylacetate production strongly enhanced after 20 to 30 hours of treatment. A small amount of butylhexanoate and hexylhexanoate production also was noted. Since hexanal was converted to aroma-related volatiles by the fruit, the possibility of developing a system for nonresiduel antifungal agent is promising. This possibility was examined in modified-atmosphere packages.

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Electronic Determination of Blueberry Fruit Quality Using Aroma Sensing Technology

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An electronic sniffer that nondestructively detects aromatic volatiles was used to grade commercially packaged blueberries. A total of 1,358 containers of commercial blueberries entering MBG grading facilities were first "sniffed" using the electronic sniffer, graded by USDA or MGB inspectors, and then subjected to discrimination analyses. The electronic sniffer separated the fresh top grade (grade 1) of fruit from the rest of the grades of blueberries with ≤ 82.79% accuracy when grading into five classes, and ≤89.3% when grading into three quality classes. The sniffer was also able to distinguish hand-harvested fruit from machine-harvested fruit from all cultivars tested (Bluecrop, Jersey, and Elliot). Highest classification accuracy was achieved with four gas sensors operating simultaneously within the sniffer. A stable signal response was achieved in 10 seconds, with each berry pack sampled at 10, 20, 40 and 80 seconds.

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Postharvest Application of Natureseal Heat Treatments for Extending the Shelf Life of Stored Blueberries

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Fruit of Rabbiteye blueberry (*Vaccinium ashie Reade* cv. 'Tifblue') were handpicked at horticultural maturity and received postharvest liquid coating and heat treatments at 37.7°C for 30 minutes. After precooling for 2 hours and subjected to the treatments, fruit were placed in ventilated card boxes and stored at 1 ±2°C and 90% to 95% relative humidity for 4 weeks. Heat, liquid coating, or both benefited fruit by reducing storage moisture loss and prolonging fruit shelf life compared to nontreated fruit. However, combining liquid coating with heat treatment did not result in higher differences in storability or fruit quality characteristics.

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A Systematic Approach to the Determination of Maturity Indices for Melting-flesh and Nonmelting-flesh Peach Cultivars for Fresh Market

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Potential maturity indices were determined for two melting-flesh (FL 90-20 and Tropic Beauty) and two nonmelting-flesh (Oro A and FI 86-28 C) peach cultivars. A range of developmental stages was obtained by conducting two harvests and separating fruit based on their diameter. Fruit in each category were divided into two groups. One group was used for determining potential maturity indices: soluble solids, titratable acidity, soluble solids : titratable acidity, peel and flesh color on the cheeks (CH) and blossom end (BE), CH and BE texture, ethylene production, and respiration rate. The other group was stored at 0°C for 1 week and ripened at 20°C for 2 days to simulate actual handling conditions, and were presented to a trained sensory panel, which rated the fruit for three textural (hardness, rubberiness, and juiciness) and three flavor aspects (sweetness; sourness; bitterness; and green, peachy, and overripe character). Principal component (PC) analysis was used to consolidate the results of the descriptive sensory evaluation into a single variable that could be correlated with the objective measurements at harvest. The first overall PC explained 40% of the total variation. Following are the attributes that best correlated with PC 1 and, thus, are promising maturity indices: for FL 90-20, peel hue, peel L, and CH texture; for Tropic Beauty, peel L, CH texture, and BE texture; for Oro A, CH texture, BE texture, and CH chroma; for 86-28C, BE texture, CH hue, and CH texture.

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Cold Storage and Harvest Date Modifies the Ethylene Requirement for Kiwifruit Ripening.

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The development of ethylene preconditioning treatments for kiwifruit have made it possible to deliver ripe kiwifruit to consumers early in the season. We report on how maturity and length of storage time affect the ripening responses of kiwifruit [*Actinidia deliciosa* (A Chev) Liang et Ferguson cv Hayward] preconditioned with 100 ppm ethylene at 0°C for 24 hours and ripened for 10 days at 20°C. Kiwifruit freshly harvested at weekly intervals continued to soften faster in response to ethylene preconditioning compared to air controls for at least 5 weeks following commercial harvest. In contrast, kiwifruit commercially harvested and stored at 0°C for more than 2 weeks no longer responded to low-temperature ethylene preconditioning. However, kiwifruit stored more that 5 weeks were still responsive to exogenous ethylene and softened faster when exposed to continuous ethylene at either 0 or 20°C. Kiwifruit had relatively high respiration rates 1 days after transferring from 0 to 20°C, which quickly dropped to base levels within 1 day. Fruit stored >1 week at 0°C always had higher initial respiration than freshly harvested fruit on transfer to 20°C, and ethylene preconditioning increased initial respiration of freshly harvested fruit but had less of an effect on initial respiration of stored fruit. Plotting firmness against individual fruit's respiration and ethylene production revealed a distinct rise in respiration and ethylene production only after fruit softened to <6.5 N. Preconditioning fruit at 0°C did not significantly alter the timing of the climacteric respiration or ethylene peaks.

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A Packaging System for Rapid Measurement and Analysis of Fruit Volatiles and Permeability

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A simple packaging system was developed to simultaneously measure volatile production by plant organs and the permeability of the packaging film to those volatiles. In this system, apple (*Malus domestica* Borkk cv Golden Delicious) was packaged in low-density polyethylene (LDPE) bag and placed into a glass jar with a low air flow. The package and jar head spaces were sampled for aroma volatile analysis by gas chromatograph. Analysis was by gas chromatography/mass spectrometry. This system allowed at least 10 volatile compounds and their permeabilities to be measured. This system permits volatile production to be measured for products in the package so the product need not be removed from its storage environment. This may be a useful method for determining the dynamic relationship between flavor volatile synthesis and package atmosphere for packaged produce.

117 ORAL SESSION 22 (Abstr. 152–158) Breeding and Genetics–Fruits/Nuts

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Screening Trifoliate Hybrid Citrus Rootstocks for Resistance to *Phytophthora parasitica* by in Vitro Inoculation

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Phytophthora parasitica Dast. causes several root and trunk diseases of citrus, including damping-off, root rot, foot rot, and gummosis. *Phytophthora* resistance is needed in *Citrus* rootstocks and is available in *Poncirus trifoliata* (L.) Raf. and some hybrids between *Citrus* and *P. trifoliata*. Field or greenhouse tests of rootstocks require large amounts of space and time. To provide a preliminary indication of rootstock resistance to *P. parasitica*, nucellar seedlings of *P. trifoliata* selections, and *Citrus* x *P. trifoliata* hybrids were tested for response to *P. parasitica* by in vitro inoculation. Seeds of individual selections were germinated in sterile culture and 3-week-old shoots were excised and inoculated with a cultured isolate of *Phytophthora*. After 1 week of incubation, response to the disease organism was measured by length of stem discoloration. Progression of *Phytophthora* in the stem also was measured by plating sequential 5-mm segments of the shoot and determining presence or absence of Phytophthora in individual segments. Stem discoloration length corresponded with location of Phytophthora in the stem. Relative resistance, as measured by this technique, approximated field resistance for several common rootstock cultivars. Resistant, intermediate, and susceptible selections were found in populations of *Citrus* x *P. trifoliata* rootstock hybrids using in vitro inoculation.

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Effect of Season, Cultivar, Location, and Storage Regime on Kernel Color in Pecans

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The Munsell system of color notation was used to study differences in kernel color arising between four pecan cultivars ('Cheyenne', 'Choctaw', 'Western', and 'Wichita') grown at four locations (Tulare, Calif., and Brownwood, Crystal City and El Paso, Texas) during two seasons (1987 and 1988) and were stored under different temperatures (ambient and frozen). The hue, value, and chroma of pecan kernels varied significantly in the 2 years of the test. Kernels collected in 1987 were more yellow and lighter and had greater color saturation than kernels collected in 1988. Cultivars differed in hue, value, and chroma at the initial color determination. 'Cheyenne' kernels were the most yellow (hue of 18.8) and were the lightest (value of 6.4) of any cultivars tested. 'Wichita' kernels were more intensely colored (chroma of 4.7) than 'Cheyenne' or 'Choctaw' kernels. Kernels from pecan trees in El Paso were more yellow than those from other locations and were lighter than kernels from either Brownwood or Tulare, Calif. Kernels evaluated after being frozen 6 or 12 months could be distinguished from fresh kernels on the basis of hue. Frozen samples were more red than fresh kernels. Kernels frozen 12 months were less intensely colored than fresh kernels or those frozen only 6 months. There was a significant linear relationship between time in the freezer and each color attribute. Hue and chroma were negatively correlated with storage time, while value was positively correlated.

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Identification of Random Amplified Polymorphic DNA (RAPD) Markers for Self-incompatibility Alleles in Hazelnut

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Random amplified polymorphic DNA (RAPD) markers were identified for self-incompatibility (SI) alleles that will allow marker-assisted selection of desired S-alleles and assist in cloning the locus responsible for the sporophytic SI displayed in hazelnut (*Corylus avellana* L.). DNA was extracted from young leaves collected from field-planted parents and 27 progeny of the cross OSU 23.017 (S_1 S_{12}) × VR6-28 (S_2 S_{26}). Screening of 10-base oligonucleotide RAPD primers was performed using bulked segregant analysis. DNA samples from six trees each were pooled into four "bulks," one for each of the following: S_1 S_2, S_1 S_{26}, S_2 S_{12}, and S_{12} S_{26}. "Super bulks" of twelve trees each for S_1, S_2, S_{12}, and S_{26} then were created for each allele by combining the appropriate bulks. The DNA from these four super bulks and also the parents was used as a template in the PCR assays. Amplification products were electrophoresed on 2% agarose gels and photographed under UV light after ethidium bromide staining. 200 primers were screened and one RAPD marker each was identified for alleles S_2 (OPI-07_{700}) and S_1 (OPJ-14_{1700}).

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Allozyme and RAPD Analysis of the Geographic Variation and Genetic Diversity in Natural Populations of the American Chestnut

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The population structure and genetic diversity of American chestnut trees collected in nine states along the natural range of the species was evaluated using 20 isozyme loci. Genetic heterozygosity (Ht:Nei, 1978) ranged from 0.089 in the Georgia and 0.094 in the North Carolina population to 0.172 in the northernmost (Connecticut) and 0.181 in the southernmost (Alabama) population. Four populations (Pennsylvania, New York, Virginia, and Alabama) were selected for RAPD analysis using 22 loci randomly distributed across the chestnut genome. The highest level of heterozygosity was in the Alabama population. UPGMA phenograms generated for the isozyme and RAPD markers using Nei's genetic identity showed similar genetic relationships among American chestnut populations.

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Allozyme Variation and Geographic Differentiation in Pawpaw [*Asimina triloba* (L.) Dunal]

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The pawpaw is the largest tree fruit native to the United States and the only temperate member of the tropical Custard Apple family (Annonaceae). In 1995, Kentucky State Univ. was established as the USDA-ARS-National Clonal Germplasm Repository for Asimina spp. Seedling trees from 400 pawpaw accessions representing 70 distinct geographic regions from 17 states are currently being grown at our research farm. In a preliminary study, 18 pawpaw cultivars were assayed in 30 enzyme systems using an isoelectric focusing polyacrylamide slab gel system of pH 4-9. Twelve enzymes produced high resolution without tissue specificity and were further used for evaluation of allozyme diversity of geographic populations. Degree of genetic diversity within populations and differentiation between populations as evaluated by the expected heterozygosity (He), the proportion of polymorphic loci (P), the average number of alleles per locus (A), chi-squared analysis of allele frequency heterogeneity, Nei's standard genetic distance (D), and identity (I) will be discussed. Dendrograms were generated by cluster analysis using the unweighted pair group method to demonstrate the relationships of geographic populations in the 17 states evaluated. The strategy for germplasm conservation and cultivar development through breeding will also be discussed.

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Generation of a Highly Saturated Linkage Map in Peach [*Prunus persica* (L.) Batsch] Using AFLP and RFLP Markers

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We have developed a highly saturated genetic linkage map in peach (diploid, 2n = 16) using two separate crosses. The first population consists of 48 randomly selected F_2 individuals which were generated by selfing an F_1 from the cross of 'New Jersey Pillar' x KV 77119. This progeny set exhibits segregation for gross morphological traits including: canopy shape, fruit flesh color, and flower petal color, size, and number. The second population contains 48 F_2 progeny derived from the cross of 'Suncrest' x 'Bailey'. These progeny segregate for quality traits such as fruit diameter, weight, flesh color, cling vs. free stone, soluble solids, pH of juice extract, and fruit developmental period. Nine linkage groups were identified in the first cross, which cover 590 cM of the genome. In the second cross, eight linkage groups were found that contain several significant chromosomal intervals contributing to fruit quality characteristics by QTL analysis. Anchor loci present in both maps were used to join the linkage groups to create a single combined map of the peach genome. Physical mapping is currently underway to assign the each linkage group to the appropriate chromosome.

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Founding Parents of Low-Chill Peaches

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A computer program was developed to calculate the percent contribution of the founding parents for any given peach or nectarine (*Prunus persica*) cultivar. The founding parents used most frequently for three low-chill (0 to 500 chill units) peach and nectarine breeding programs (Florida and Pelotas and Campinas, Brazil) were determined. The Florida program used several low-chill honey type peaches ('Hawaiian', 'Okinawa') as a source of low chilling and then did extensive crossing with higher quality cultivars developed mainly in the northeastern United States. About 50% of the background of the Brazilian peach releases consists of local selections that were originally brought by the Portuguese explorers. Although each of the Brazilian programs used local peach materials, the local peaches used by each program are different. In addition, the program at Pelotas used germplasm from the Georgia–Florida and New Jersey breeding programs and the Campinas program used 'Jewel' (honey peach) and several Florida nectarines ('Sunlite', 'Sunred') in their development work. The founding parents among these three programs, although there is some common parentage, are different, and the intercrossing of materials from the various programs would be a useful approach to create more diversity in this germplasm.

118 ORAL SESSION 23 (Abstr. 159–166) Nutrition–Vegetable Crops

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Potato Seed Piece Calcium can Influence Tuber Yield

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Pathogenic bacteria (*Erwinia* spp.) can have a significant impact on stand establishment and sprout health. These bacteria cause soft rot of the seed piece, which is common in wet spring conditions resulting in great economic loss. Recent studies have demonstrated that the incidence and severity of soft rot can be significantly reduced by increasing tuber calcium. We investigated the influence of seed piece calcium on tuber production. Field growing potato plants were treated with supplemental calcium during tuber bulking (calcium at 168 kg·ha^{-1} from calcium nitrate or N-Hib) to increase the seed tuber medullary calcium levels. All three cultivars ('Superior', 'Atlantic', 'Dark Red Norland') responded to supplemental calcium application with increases in mean calcium contents, even though soil tests showed high native calcium levels (1000 kg·ha^{-1}). Seed tubers were sampled for calcium by removing a longitudinal slice from the center of each tuber and planting one of the resulting halves for seed piece decay evaluation and the other for yield evaluation. Calcium nitrate-treated seed tubers produced higher yields compared to ammonium nitrate and N-Hib in 'Atlantic' in 'Dark Red Norland'. This trend did not hold true for 'Superior'. Our results suggest that a) it is possible to increase seed piece tuber calcium levels with supplemental calcium application even in soils testing high in calcium and b) improving the calcium concentration of the seed piece can increase tuber yield in some cultivars.

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Potassium Fertilizer Effects of Potato Yield and Petiole Sap Potassium Concentrations

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A 2-year field study was conducted on a low- to medium-K testing sandy soil 1) to evaluate the effects of various K management strategies on potato (cv. Russet Burbank) yield and quality and 2) to calibrate a petiole sap test for determining plant K status. Treatments included banded applications of potassium chloride fertilizer at planting with K ranging from 0 to 300 kg·ha^{-1} in 75 kg·ha^{-1} increments. Comparisons of preplant broadcast + banded applications and evaluation of in-season applications of potassium nitrate also were made. In both years, tuber yield increased with increasing banded K fertilizer up to 150 kg ha-1 K the first year and 225 kg ha-1 K the second year. In-season applications of potassium nitrate increased tissue K levels, but at equivalent K application rates, timing of K application had no effect on yield. Petiole K concentrations, measured on a dry weight and sap basis, increased with increasing K fertilizer application. Potassium concentrations in nondiluted sap determined with the Cardy K electrode were ≈200 to 2500 ppm lower than those determined by flame emission. The greatest discrepancy occurred at the higher K sap concentrations. Potassium concentrations determined with the Cardy electrode in sap diluted with aluminum sulfate or deionized water were much closer to those determined by flame emission. These results suggest that dilution of the sap is necessary to obtain accurate K concentrations in petiole sap.

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Nitrogen Fertilization Management for Bell Pepper (*Capsicum annuum* L.)

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'Camelot' bell pepper was grown in a N fertigation study on sandy soil using polyethylene-mulched and fumigated beds. Portions of N (0%, 33%, 67%, 100% of total season N) were applied at bed formation. The remaining N was injected weekly into the drip irrigation system. Total N application treatments were 64, 128, 192, and 256 kg·ha^{-1}. Early and total-season marketable fruit yields increased linearly with N rate. Preplant fertilizer proportion did not influence early yields, but late and total-season marketable fruit yields decreased linearly as preplant fertilizer proportion increased. Petiole sap NO_3-N concentration increased

with increasing N rates, but decreased linearly as preplant fertilizer proportion increased. Petiole sap NO_3-N concentrations fell below critical levels for all N rates and preplant fertilizer proportions early in the season. Whole-leaf N concentrations were higher than critical values (>40 g·kg^{-1}) throughout the season. Preplant fertilizer proportion had a significant linear effect on whole-leaf N concentrations for all sampling periods. Petiole sap was better correlated to yield data than whole-leaf N.

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Potassium Rates Affect Yield of Two Muskmelon Varieties in Florida

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Optimum economic yield is produced when nutrients in the proper amounts are supplied to the crop. Crop nutrient requirements (CNR) of essential elements have been determined for the major vegetables produced in Florida. However, for minor crops, such as muskmelon, little research has been conducted to determine the CNR, especially potassium. In many vegetables, yield has responded to increasing K rates when other elements were not limiting. Our objective was to determine the K fertility requirement for optimum yield of muskmelon and to evaluate the Mehlich-1 soil test calibration for soil testing low in K (<20 mg·kg^{-1}). Experiments were conducted in the spring and fall seasons of 1995. Potassium at five rates (0, 56, 112, 168, and 224 kg·ha^{-1}) was injected weekly, approximating the growth curve of 'Galia' and 'Mission'. There were significant yield responses to K fertilization for both cultivars during both seasons. During spring, average marketable yield was 14.5, 26.1, 31.9, 31.5, and 36.3 Mg·ha^{-1} and for fall, average marketable yield was 15.8, 32.9, 37.8, 37.2, and 36.4 Mg·ha^{-1} for the previously described K treatments, respectively. The cultivar response for both seasons was described by a linear-plateau model. In spring, yield was maximized with K at 116.8 and 76.3 kg·ha^{-1} for 'Galia' and 'Mission', respectively. In fall, K at 73.3 and 68.3 kg·ha^{-1} produced the peak response for the same cultivars. These results indicate that maximum yield of muskmelon in Florida can be obtained at considerably less K than the current recommendation of 140 kg·ha^{-1}.

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Potassium Requirements for Optimal Processing Tomato Yield and Fruit Quality

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Trials were conducted in nine commercial processing tomato fields in California from 1994 to 1995 to assess the effects of potassium fertilization on fruit yield and quality. Sites were selected to represent a range of ammonium acetate extractable soil K levels (91 to 284 mg·kg^{-1}, top 30 cm) and K release rates (K at 1.8 to 8.5 mg·kg^{-1}·d^{-1}). Potassium was applied in furrow or drip irrigation during the fruit bulking stage at seasonal rates from 90 to 135 kg·ha^{-1}. Significant yield increase (4% to 24%) was observed at three of the four sites with extractable soil K <125 mg·kg^{-1} (K released at <3.1 mg·kg^{-1}·d^{-1}); no yield response was observed at the five sites with greater soil K supply. Fruit color and soluble solids content was unaffected by K fertilization at any site. Additionally, red fruit of two cultivars ('Halley' and 'Heinz 8892') were collected from 80 commercial fields in 1995 and evaluated for soluble solids content, color (of a comminuted sample as well as visual ranking of internal and external ripening disorders), and tissue K concentration. Fruit K concentration was poorly correlated with any quality characteristic. We conclude that yield response to K fertilization can be adequately predicted by either soil test method and that K supply plays a relatively minor role in tomato fruit quality under representative field conditions.

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Influence of Boron Rate, Timing, and Application Method on Skin Discoloration of 'Hernandez' Sweetpotato

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In the last 3 years, ≤50% of the North Carolina sweetpotato crop has been produced with the variety Hernandez. A brown to black discoloration on the epidermis of the 'Hernandez' sweetpotato may develop when maintained in storage for several months. The symptoms resemble blister—blister is caused by a boron deficiency. Preliminary studies in 1994 indicated that boron reduced the discoloration on 'Hernandez' but did not eliminate the problem. To help confirm these findings and further define the role of boron in defining skin discoloration, boron was applied in 1995 at several rates (0 to 5.6 kg·ha^{-1}) and stages of plant development using two application methods (foliar or soil). Yields and plant analysis data were obtained. Marketable yields ranged from 18.4 to 29.3 mt/ha. Leaf boron concentration ranged from 50 to 100 mg·kg^{-1} throughout the production season when 1.1 kg·ha^{-1} boron was soil applied shortly after planting. Excessive levels of boron (200+ mg·kg^{-1}) were measured in plant tissue when application levels exceeded 2.2 kg·ha^{-1} regardless of timing. Soil application appeared to be an adequate method for boron application. Roots were examined for symptoms of discoloration after 5 months. Results indicated no affect of boron on incidence or severity of the symptoms.

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Evaluation of Stomatal Density and Calcium Concentration on Pods of Six Commercial Cultivars of Snap Beans (*Phaseolus vulgaris* L.) at Four Planting Dates

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Pod stomatal density and Ca concentration levels were analyzed for six commercial snap bean cultivars harvested at four planting dates in an attempt to find morphological traits that are related to cultivar differences in pod Ca concentration. The experimental layout was a randomized complete-block design with two replications per planting date, all grown in one location. Snap beans were planted at 1 week intervals beginning 9 June 9 1995 and were harvested in August. Sampling consisted of five pod sizes (1, 2, 3, 4, and 5 according to commercial standards) from each genotype. Stomatal countings were performed using a microscope linked to a television camera. Determinations for pod Ca concentration were made using an atomic absorption spectrophotometer. No differences were detected for pod Ca concentration among planting dates, although there were differences for pod Ca concentration and stomata density among cultivars. Pod stomatal density was positively correlated to pod Ca concentration (R^2 = 0.60), while pod maturity appeared to be negatively correlated to pod Ca concentration (R^2 = 0.37) and pod stomatal density (R^2 = 0.49).

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The Earth Box: A Containerized Gradient Concept

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The Earth Box, a completely enclosed system made of recycled plastic, is designed to provide a continuing source of water and nutrients to replace that as removed by the crop. Nutrients move by gradient from a surface source to the root; water moves to the root by seepage upward from a water reservoir. The Box holds 2.3 cubic feet of media (soil or potting mix) supported on an aeration screen 0.5 inch above a water reservoir that holds 2.3 gallons. The total concept is designed to synchronize the nutrient–water input with removal, thus, providing an undiminishing nutritional stability in the soil solution. Two tomato plants per box have produced 30 to 50 pounds of fruit with a quality that reflects the continuing optimal nutrition. Other vegetable crops, strawberries, and flowers have been grown in the Earth Box with similar results. Nutritional stability in the conventional soil solution can deteriorate with variations in the soil-plant-season, which limits productivity. Whereas with the gradient, nutritional stability is constant regardless of the soil-plant-season or whether grown in the field or a container. The gradient procedure is not conventional or hydroponic; hydroponic cultures are nutritionally stable to begin with, but like conventional procedure, that stability is vulnerable. The gradient concept, whether it be in a container or in the field, has the potential to become a globally sustainable production system—minimal water, minimal pollution, minimal management with a maximum productivity. The Earth Box is primarily for the home gardener but the feasibility as a commercial edition is now being evaluated.

119 ORAL SESSION 24 (Abstr. 167–174) Educational Outreach

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Surveys and Other Methods Used to Determine User Green Space and Other Requirements: Harmony Playground, Van Saun Park, Bergen County, New Jersey

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Harmony Playground is a retrofitted, 2.25-acre site in Van Saun Park, River Edge, Bergen County, N.J. It is part of a 140-acre parcel, the largest in the 8000-acre Bergen County park system. The original playground was opened in 1960 and is visited by one million people annually—county, state residents, out-of-state and foreign visitors. The new playground was designed by Lawrence Porter, CLA, Bergen County Dept. of Parks and was dedicated in Oct. 1994. The facility reflects user demands in priority areas. They include the physical environment (topography, a water resource, shade, and vegetation), visibility, safety, play equipment and numerous amenities. User preference was determined through pre- and postconstruction surveys, interviews, and other measurements conducted by Fennell Gerber during Summer 1993 and Fall 1994. Vegetation and existing conditions are documented also. The landscape architect's use or rejection of the data (in some categories) to execute the design has been documented and analyzed. Vegetation selection is documented as well. User residual fears that surfaced after the completion are noted. While visitors stood in an award-winning facility (Porter was given the New Jersey Chapter American Society of Landscape Architects Honors Award), they expressed lingering concerns demonstrating a common fear and distrust prevalent among public landscape users. The study demonstrates the need for and value of user data. It can be used by designers to create a valid green space without lessening creativity or sacrificing professional integrity. In fact, user input and data used properly to design green spaces increases appropriate use and community support.

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The Landscape Industry Council of Hawaii—An Experiment in Cooperation

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The Landscape Industry Council of Hawaii was formed in 1987 to bring the landscape professional and trade associations together. The organization's goals are communication between segments of the industry, education, promotion, and legislative action. Current members of the council include: Aloha Arborists Association; ASLA Hawaii Chapter; Hawaiian Association of Nurserymen; PGMS HI Chapter; Hawaii Landscape and Irrigation Contractors Association; HI Professional Gardeners Association; HI Turfgrass Association; and the HI Island Landscape Association. The Council publishes *Hawaii Landscape* magazine, presents statewide educational programs and trade shows, and works for the common good of the entire green industry. It has been successful in gleaning grant support for several efforts. The Council is on the verge of broadening membership to individuals as well as associations and making significant strides to meet its goals and needs of the Hawaiian landscape industry. The evolution and successes have not been without problems, setbacks, ruffled feathers, and a lot of hard work from a dedicated group of volunteers.

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Wetland Plants for Wastewater Treatment: A Tremendous Opportunity for Horticulture

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A current trend in environmental practices concerns using constructed wetlands for wastewater treatment. The ecological values of wetlands have long been known. Wetland plants aid in the treatment of water pollutants by improving conditions for microorganisms and by acting as a filter to absorb trace metals. Wetlands now are being considered for industrial, municipal, and home wastewater treatment. Constructed wetlands are an economical and environmentally sound alternative for treating wastewater. These constructed "cells" are designed to function like natural wetlands. In constructed wetlands, water flow is distributed evenly among plants in a cell where physical, chemical, and biological reactions take place to reduce organic materials and pollutants.Increasing numbers of environmentally conscious homeowners are installing wetland wastewater treatment systems in their backyards with the aid of licensed engineers. This installation is occurring despite of the lack of educational materials to aid in site selection, selection of appropriate plant materials, and long-term maintenance. Traditional wetland plant species currently are being selected and planted in these sites, and the resulting effect is often an unsightly marsh appearance. With increasingly more homeowners opting for this alternative system, a strong need exists for educational materials directed at this audience. Therefore, educational resources that can provide information to the public regarding the benefits of wetland wastewater systems, while promoting aesthetically pleasing ornamental plant species is needed. A hands-on guide for installing constructed wetlands, a home page on the World Wide Web, and an instructional video currently are being developed at Texas A&M Univ. These technologies will be demonstrated and the values, needs, and opportunities available for the horticultural industry in the area of wetland construction will be discussed.

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Horticultural Science and Rare Plant Conservation

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Horticultural science has an essential role to play in the conservation of rare plants, but to date, most horticultural research in this field has taken place on an informal rather than experimental basis. Plant conservation as a scientific and practical discipline would benefit greatly from applying the more rigorous approach characteristic of commodity-oriented horticultural research. In turn, the profession of horticultural science has a great deal to gain by participating more actively in plant conservation programs. Benefits include an influx of new ideas, new people, and new resources. Some of the traditional research fields within horticulture that are directly relevant to rare plant conservation include: seed technology, propagation and tissue culture, nutrition, growth regulation, soil management, and protection from pests and diseases. Three case studies illustrate various ways in which the theory, technology, and knowledge base of horticulture can be applied to plant conservation. They include the rare plant propagation program at Bok Tower Gardens, Lake Wales, Fla.; mountain meadow revegetation projects in Mount Rainier and Olympic National Parks in Washington; and research activities of the recently established Georgia Plant Conservation Alliance.

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Extending Crop Nutrient Information: Involving the Whole Industry

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Replicated fertility trials with four vegetable crops on the limestone soils of Dade County, Fla., have been conducted for 3 years (1993–94 through 1995–96). The purpose was 1) to determine crop nutrient requirements, 2) to calibrate a soil testing model, and 3) to develop additional information for plant sap quick tests. The crops included snap beans, Irish potatoes, sweet corn, and malanga (a.k.a. yautia or tannia, *Xanthosoma sagittifolium* Schott). Another two field demonstrations using reduced rates of phosphorus on tomatoes were conducted in 1995–96. The involvement of the local fertilizer industry in these trials and grower outreach efforts will be discussed.

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Smoking Zucchini—Introducing Commercial Vegetable in Tobacco Country

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"We are a tobacco state" is frequently heard among farmers and agricultural leaders in Kentucky; the state's farm economy has always revolved around burley tobacco production. Tobacco, grown in Kentucky for nearly two centuries, remains the most valuable crop earning approximately $694 million in 1995. Even our unusual terminology of "alternative," "supplemental," or "opportunity" crops denotes the prime position of tobacco and attitudes toward vegetable crop production. This long tradition and attitudes associated with it contribute to a serious lack of confidence and low expectations when it comes to diversification with vegetable crops. These low expectations and the consequent circular pattern of experience with vegetable production were revealed in a multidisciplinary, 5-year research project designed to determine opportunities for and constraints to veg-

etable production in the state. The study showed that nearly half of Kentucky's commercial vegetable growers also were tobacco growers and that there were no fundamental incompatibilities in tobacco–vegetable cropping systems. Although farmers considered lack of markets a major constraint, economic research revealed that growers were often unwilling to use and take the risks associated with existing market structures and channels. As a result of these findings, a major on-farm demonstration program was implemented to raise expectations and break the "circular syndrome". More recently, new partnerships and collaborative relationships have been established between university horticulture and marketing specialists and the Burley Tobacco Growers Cooperative Association for the promotion of "supplemental crops" among Kentucky's tobacco growers.

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Addressing Organic Sustainable Growers' Needs

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Organic production of vegetable and fruit crops in Kentucky is gaining ground. Acreage and grower numbers are increasing. Health concerns and certain economic advantages for the grower are the impetus for rise in organic production. There is a need to collate cultural practice information and present it in a usable form for Kentucky. Work is being done to consolidate information on cultural practices, current research, and marketing opportunities. To address these concerns, older extension horticultural publications are being amended and new bulletins are being written. To accomplish this, grower meetings, farm visits, scouting for problems in crops, conducting research, and sifting through literature are some of the steps being taken. The greater implementation of cultural practices such as rotations, cover crops, green manures, living mulches, and minimum tillage are helping to reduce dependence on chemical sprays, chemical fertilizers, and soil destroying practices. Through this liaison, we are bringing together a new group of agricultural producers with interdepartmental specialists within the university and new insights and partnerships are being forged.

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Master Gardener—Tree Stewards: Advanced Training to Enhance Community Volunteerism

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Virginia Cooperative Extension's (VCE) Master Gardener!Tree Steward program (MGTS) provides advanced training in leadership development and arboriculture to Master Gardener (MG) volunteer educators so that they may expand the influence of extension through leadership in community forestry. According to a statewide survey, 70% of VCE MGs and agents with MG programs would like to be involved in community tree programming. Only 26% were currently involved. Typically, agents cite limited staff and volunteer resources as the primary factors in restricting program expansion. Furthermore, 90% of municipal foresters indicated they would like to work with trained volunteers. The MGTS program simultaneously answers the desire of MGs to expand their role in the community landscape and the need of VCE to expand its outreach with increasingly limited resources. MGTS training, guided by a 10-unit resource book, integrates technical and program management expertise to foster volunteer pride and self-sufficiency. This allows MGTSs to coordinate much of their own training and recruit and manage large numbers of non-MG volunteers to whom they can provide limited training for specific projects, thus, allowing program expansion without additional staff.

120 ORAL SESSION 25 (Abstr. 175–182) Breeding and Genetics–Vegetables I

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Phenotypic and Marker-assisted Breeding of *Capsicum* for Cucumber Mosaic Virus Resistance

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Resistance to cucumber mosaic virus (CMV) in *Capsicum* from two sources is being transferred into three commercial types (bell, jalapeno, and Anaheim) using a backcross breeding scheme. We have optimized our CMV seedling screening protocol, which involves multiple inoculations beginning at the cotyledon stage with a severe CMV serogroup I isolate. Both sources of resistance, *C. annuum* 'French Perennial' and a *C. frutescens* accession (BG2814-6), exhibit oligogenic recessive inheritance and share some but not all resistance alleles. Selection for type in the BCF_1 generation had no effect on the frequency of resistant individuals in the BCF_2 generation. We have determined that it is necessary to self-pollinate every other backcross generation to screen for resistance. Occasionally disease symptoms appear in adult plants that were initially resistant to multiple inoculations at the seedling stage, and we are investigating the correlation between seedling resistance and adult plant resistance. We are also exploring the extent to which the different sources of resistance behave differently as a function of genetic background. Additionally, we are mapping quantitative trait loci (QTLs) for CMV resistance in pepper with the goal of converting RFLP and/or RAPD markers into PCR-based markers to facilitate molecular marker-assisted selection for CMV resistance.

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Use of RAPD Marker Analysis to Assess Changes in the Genetic Diversity of Potato Genebanks

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Effects of genebank seed increases on the genetic integrity and whether germplasm in the genebank still represents the in situ populations from which it was collected are major concerns of the recently formed Association of Potato Intergenebank Collaborators (APIC), a consortium of world potato genebank leaders. This cooperative APIC research used RAPDs and morphological markers 1) to establish genetic relationships between seed increased populations within accessions and (2) to measure genetic differentiation between diploid and tetraploid potato germplasm maintained for many years and current in situ populations from the same collection sites in the wild. *Solanum jamesii* Torrey (2n = 2x = 24) and *S. fendleri* A. Gray (2n = 4x = 48), two wild potato species native to North America, were used as plant material. These species represented two major breeding systems found among Solanum species: outcrossing diploids and inbreeding disomic tetraploids, respectively. Comparisons made between populations one generation apart and between sister populations generated from a common source indicated that there has been minimal loss of genetic diversity in captive germplasm using the genebank techniques standard at NRSP-6 and other world potato genebanks. RAPD markers also revealed that significant genetic differences were found between genebank-conserved and re-collected in situ populations for all diploid potato comparisons and for about half of the comparisons within tetraploid potato populations.

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Inheritance and Biochemical Analysis of a Carrot Carotenoid Mutant

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Pigments in orange carrot tissue, such alpha and beta carotene, are important vitamins in the human diet. Previously identified white or nonpigmented carrot roots, such as those from wild carrot and white derivatives of yellow or orange types, are dominant to the production of pigment, which is recessive. A nonpigmented carrot root was discovered during routine propagation of the inbred line W266 in 1992. Subsequent segregation analysis in the F_2 and BC_1 generations in three genetic backgrounds demonstrated the lack of pigmentation is due to a single recessive gene (reduced-pigment: *rp*). Total carotenoid content was reduced 92% in the roots of *rprp* genotypes compared to *RPRP* genotypes, however there were no differences in carotenoid content in leaves. Plants carrying *rprp* also exhibit white-speckled leaves during early stages of development, suggesting *rp* has an effect on leaf chlorophyll content. This character may prove useful in dissecting the complex inheritance of carotenoids in carrot.

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Evaluation of Flavor and Potential Anticancer Properties of Fall Onions

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Fall onions, grown for their long shelf life, have become popular both in domestic and export market. Sixty cultivars of onion from 14 major seed companies were grown in Quincy, Wash., and were analyzed for their flavor, quality, and anticarcinogenic flavonol, quercetin. The highest quercetin concentration (in $mg \cdot kg^{-1}$ fresh weight) was observed in the red onion 'Feugo' (495.6) followed by 'Tango' (396.8), while the least amount was in the yellow onion 'Pinnacle'(152.5). The pyruvic acid content varied from 1.5 to 18.7 $mmol \cdot g^{-1}$ and total sugar (glucose, fructose, and sucrose) levels ranged from 9.4 to 36.9 $mg \cdot g^{-1}$ fresh weight among different cultivars. The ratio of sugar:pyruvic acid showed marked variation (1.6 to 64.00) among different cultivars. The variation in oligosacharides were ≈60-fold over all cultivars. The maximum degree of polymerization (DP) observed was DP8. We conclude that there is a potential for developing a mild onion for longer shelf life and better health properties. Yield at harvest and storage performance based on rot also was evaluated during storage.

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Changes in Antiplatelet Activity, Pungency, and Percent Solids of Four Diverse Onion (*Allium cepa*) Lines During Cold Storage

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Raw onion extract contains organosulfur compounds that prevent aggregation of platelets in human blood plasma and influence onion pungency. An increase in antiplatelet activity has the potential of reducing cardiovascular diseases. Accumulating organosulfur compounds directly influences pyruvic acid concentrations and may determine antiplatelet activity. Organosulfur compounds are volatile and may change concentration during storage. A study was conducted to evaluate antiplatelet activity, pyruvic acid content, and percent solids during cold storage. Two low-pungency lines (8155B and Exhibition) and two high-pungency (W420B and W434B) lines were grown in replicated plots at two Wisconsin locations in 1994 and 1995. Bulbs were evaluated for antiplatelet activity, percent solids, and pyruvic acid content at 40-day intervals after onion harvest. We found significant differences for antiplatelet activity and pyruvic acid content among dates of sampling and lines. Averaged over lines antiplatelet activity increased by 73% and 29% over 160 days in storage during the 1994–95 and 1995–96 storage seasons, respectively. Mean pyruvic acid concentrations increased 27% for the 1994–95 storage season and decreased 27.5% for the 1995–96 storage season. There were no significant changes for solids during storage for both years. These data indicate that antiplatelet activity increases during storage, which may be beneficial for human health. Since onions are often stored for long periods of time before sale, an increase in antiplatelet activity may be an added benefit for this crop.

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Evaluation of AFLPs as Tags for the MS Locus in Onion

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The production of hybrid-onion seed depends on cytoplasmic male sterility (CMS) systems. The male-sterile line is seed propagated using a normal (N) cytoplasmic maintainer line homozygous recessive at the nuclear male-fertility restoration locus (MS). Because of onion's biennial generation time, 4 to 8 years are required to establish the genotype at the MS locus. The development of maintainer lines would benefit greatly from a genetic marker linked to the MS locus. Such a marker would allow breeders to establish the nuclear genotype in seedlings and flower only those plants that are maintainers (N msms) or plants that can be used to develop maintainers (N MSms), reducing the number of plants to be testcrossed or backcrossed to a sterile line. We evaluated restriction fragment length polymorphisms (RFLPs), random amplification of polymorphic DNA (RAPDs), and amplified fragment length polymorphisms (AFLPs) to tag the chromosome region carrying the MS locus. No RAPDs or RFLPs cosegregated with MS. AFLP markers were identified that phenotypically correlated with restoration of male fertility.

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Genetic Mapping in Onion: Insight to the Evolution of a Large Diploid Genome

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The bulb onion (*Allium cepa* L.) is a diploid with an very large nuclear genome of 15300 Mbp/1C (107x arabidopsis, 16x tomato, 6x maize). We developed a low-density genetic map with morphological, RAPD, and RFLP markers to examine genome organization and to study QTL controlling phenotypically correlated bulb quality traits. A mapping population of 58 F_3 families was derived from a cross of the inbreds Brigham Yellow Globe 15-23 (BYG) x Alisa Craig 43 (AC). These inbreds are distinct in solids, storability, pungency, and bulb shape. Analysis of 580 RAPD primers detected 53 (9%) polymorphisms between BYG and AC, but only 12 (2%) segregated at expected ratios among F_3 families. Using probes from onion cDNA libraries and four restriction enzymes, 214 RFLPs were identified between mapping parents. A 112-point map includes 96 RFLPs, 13 RAPDs, a locus controlling complementary red bulb color, and two loci hybridizing with a clone of the enzyme alliinase (EC 4.4.1.4), which produces the flavors characteristic of *Allium* species. Duplicated loci were detected by ≈25% of RFLP probes and were unlinked, loosely linked (2 to 30 cM), or tightly linked (<2 cM). This frequency of duplication was comparable to species with polyploid ancestors (paleopolyploids) and was higher than that found in most true diploids. However, the distribution of duplicated loci suggests that, in contrast to whole genome duplications typical of paleopolyploids, the contemporary size and structure of the onion genome may be a product of intrachromosomal duplications (cryptopolyploidy) and subsequent structural rearrangements.

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Restriction Enzyme Analyses of Cytoplasmic Diversity in Leek

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Hybrid leek (*Allium ampeloprasum*) is significantly more uniform and higher yielding than open-pollinated populations. Because leek has perfect flowers, a male-sterility system is required to produce hybrid seed economically. No cytoplasmic male sterility (CMS) has been described in leek. Restriction fragment length polymorphisms (RFLPs) in the chloroplast and mitochondrial genome have correlated with the expression of CMS in many crops. We undertook restriction-enzyme analyses of the chloroplast and mitochondrial DNAs to identify polymorphic organellar genomes among 65 accessions of cultivated leek. Polymorphisms were detected in the chloroplast and mitochondrial genomes. Reciprocal crosses were generated to establish the transmission of the organellar genomes of leek.

130 ORAL SESSION 26 (Abstr. 183–188) Culture and Management–Floriculture II

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Effect of Storage Temperature on Survival and Regrowth of Vegetatively Propagated Plug-grown Seedlings

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The effect of 6 weeks of storage at 2.5, 5.0, 7.5, 10.0, or 12.5°C in a glass greenhouse was determined on 11 vegetatively propagated annual species. Fresh weight (total, shoot, and root) and height of 30 plants per species in each storage temperature were measured at the end of storage. Another 30 plants were transplanted into 15-cm pots (three plants per pot) and grown under natural light in a 20°C glass greenhouse for 3 weeks. Three species showed chilling injury or died during storage at ≤7.5°C. Plant height and shoot fresh weight at the end of storage for most species increased linearly as storage temperature increased. Storage temperature did not affect the net increase in height or weight significantly during recovery growth, except for plants that exhibited chilling injury at the end of storage.

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Production Characteristics of High-quality Single-stem Roses

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Commercial-quality cut roses were produced in a single-stem production system from single node cuttings. About 1800 rose cuttings in seven sequential crops were identified from 7500 cuttings grown from Feb. through May, 1995. More than 70% of the cut stems harvested from these cuttings were 46 to 75 cm long. Longer stem roses had significantly more nodes and grew from lower, older nodes than shorter rose stems. Longer stem roses required significantly more days to flower harvest because the number of days to axillary bud break was longer than for shorter rose stems. The number of days for rooting, days from axillary bud break to visible bud, and days from visible bud to flower harvest were similar in longer and shorter rose stems. Axillary buds began to grow before rooting in shorter stems and began to grow a mean of 8 days after rooting in the longest rose stems.

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Growth and Flowering of Interspecific Hybrids of Sri Lankan *Exacum* species (Gentianaceae): A Challenge in Domestication

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Interspecific hybrids of *Exacum* species (Gentianaceae) endemic to Sri Lanka possess excellent qualities for domestication as a new floriculture crop. The exact mode of floral induction and development responses are unknown, impeding the introduction of this potential crop. The interspecific hybrids evaluated are the result of controlled cross pollinations of *E. macranthum*. Arn. ex Griseb., *E. trinervium* (L.) *Druce* ssp. *trinervium*, and *E. trinervium* ssp. *ritigalensis*. (Willis) Cramer. The hybrids exhibit great genetic variability for horticultural traits. In addition, two growth and flowering patterns exist within the Penn State germplasm. Continuous-flowering genotypes flower throughout the year but more profusely and rapidly under late spring and summer conditions. In contrast, periodic-flowering genotypes exhibit two distinct seasonal habits. Under winter conditions, these accessions have a rosetted habit, much secondary branching, and few or no flowers. In summer conditions, they break their apical dominance, bolt, and produce flowers. As members of the Gentianaceae, *Exacum* hybrids produce an elegant blue flower with a striking yellow eye and bottle-shaped anthers. We evaluated the growth and flowering responses of *Exacum* interspecific hybrid accessions to photoperiod and irradiance. Accessions were evaluated under greenhouse conditions for floral production, rate of floral development, and growth characteristics. For the 20 accessions evaluated, supplemental irradiance under winter conditions resulted in greater floral production and much greater shoot and root mass accumulation. Little height and branching response occurred with supplemental irradiance. Of the 15 accessions evaluated under four photoperiod regimes, flowering and growth responses to photoperiod occurred under summer conditions but not in winter. An interaction among season, accession, and photoperiod revealed the complexity of *Exacum* germplasm and environmental responses.

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Influence of Stock Plant Photoperiod on Cutting Production and Rooting

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Five vegetatively propagated perennial species that received 0 or 15 weeks of cold treatment were placed under seven photoperiods (10-, 12-, 13-, 14-, 16-, 24- , and 4-hour night interruption). Cuttings were harvested every 3 weeks, and their number and total fresh weight were recorded. Cutting bases were dipped in a 1200 ppm IBA solution for 5 seconds, stuck in perlite, and placed under mist for 3 weeks. Results varied by species. Stock plants of *Achillea* 'Moonshine' produced the most cuttings under a 12-hour photoperiod. Noncold treated *Coreopsis verticillata* 'Moonbeam' only produced cuttings under photoperiods longer than or equal to 14 hours. Cold treated 'Moonbeam' produced cuttings under all photoperiods in the first flush. Eighty percent of cuttings from the first flush of *Phlox paniculata* 'Eva Cullum' rooted when taken from plants growing under the 10-hour photoperiod, but only 1.2 cuttings per plant were harvested; 2.5 cuttings per plant were taken from *Phlox* grown under the 24-h photoperiod, but only 20% rooted. Only stock plants of *Sedum* 'Autumn Joy' receiving a 14-hour photoperiod produced significant numbers of vegetative shoots. Cutting production and rooting of *Veronica* 'Sunny Border Blue' was not affected by photoperiod.

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Influence of Plant Growth Regulators on Postharvest Quality of *Zantesdeschia* and Preplant Treatment for Preventing Erwinia Infection

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Zantesdeschia has been grown for cut-flower production for many years, but more recently it has been grown as a containerized plant. Problems with height control and disease, however, have limited *Zantesdeschia* production in warmer climates. Our objectives were to evaluate paclobutrazol and uniconazole on control of plant growth of three *Zantesdeschia* species and evaluate four preplant treatments for preventing Erwinia infection on rhizomes. Paclobutrazol at 1 mg a.i. gave the best control of flower height, foliage height, and plant width. After 20 d in a postharvest chamber, plants drenched with paclobuturazol at 2 mg a.i. and uniconazole at 6 mg a.i. were still suitable plants, plants drenched at 3 and 4 mg a.i. paclobutrazol remained short, and plants drenched at 2 and 4 mg a.i.uniconazole became tall and weak, with flower stems breaking over. Rhizomes were dipped in dimethylbenzyl ammonium chlorides, sodium hypochlorite, 4% formaldehyde, or streptomycin. Streptomycin provided the best control against Erwinia infection followed by formaldehyde. Dimethylbenzyl ammonium chlorides and sodium chloride provided the poorest protection.

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GA_{4+7} Plus Benzyladenine Reduce Leaf Yellowing of Greenhouse Easter Lillies

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Chlorosis of Easter lily (*Lilium longiflorum*) lower leaves causes significant economic loss. Lily plants growing in 15-cm pots were sprayed 30, 60, or 90 days after emergence or at 60 and 90 days after emergence with 25 to 100 ppm each of benzyladenine and GA_{4+7} from Promalin (Abbott Chemical Co.) and were grown pot-to-pot until flower. Chlorotic leaf count at flower decreased as Promalin concentration increased; plants sprayed at 60 days had the smallest chlorotic leaf count. Chlorotic leaves at flower varied from 28% for control plants to 10% for plants sprayed with 100 ppm at 60 days and from 36% to 17% 3 weeks later, respectively. The Promalin sprays promoted significant stem elongation, but differences in height at flower were only 2 cm. Plants sprayed with 100 ppm at 30 days averaged one deformed flower per plant; plants sprayed at 60 days and 60 and 90 days averaged 0.0 and 0.1 deformed flower per plant, respectively. Additional trials in which only the lower part of the plant was sprayed prevented any chlorotic leaves without any significant effect on final height or flower bud quality.

131 ORAL SESSION 27 (Abstr. 189–195) Growth Regulators–Fruits

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Effect of CPPU and NAA on Fruit Growth and Cropping of Redchief 'Delicious'

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NAA is commonly used for fruit thinning of apples. However, with spur-type 'Delicious' fruit, size may be less than expected based on the remaining crop load. Attempts to enhance fruit size on NAA-thinned trees with benzyladenine (BA) resulted in an interaction causing an increase in small (≤64 mm) fruit. CPPU [N-(2-chloro-4-pyridinyl)-N'-phenylurea], a highly active cytokinin in promoting parthenocarpy and growth of a number of fruit, was evaluated alone and with NAA for its effects on cropping and fruit growth in Redchief 'Delicious'. High-volume sprays of CPPU were applied at 0, 2.5, 5, and 10 $mg \cdot L^{-1}$ to 13-year-old trees at 7.26 mm king fruit diameter. NAA was applied at 15 $mg \cdot L^{-1}$ with and without CPPU at 5 $mg \cdot L^{-1}$. Each treatment consisted of a single tree replicated four times. Response was evaluated by determining yield per tree and fruit size distribution at harvest. CPPU increased the amount of large (≥70 mm) fruit produced without significantly reducing yield. The amount of large fruit produced was 35, 71, 91 and 85 kg/tree for the nonthinned control (NTC) and CPPU at 2.5, 5, and 10 $mg \cdot L^{-1}$, respectively. NAA (15 $mg \cdot L^{-1}$) reduced yield by 39 kg/tree

and increased amount of large fruit by 44 kg/tree. When CPPU (5 mg·L^{-1}) was oversprayed with NAA (15 mg·L^{-1}), yield was reduced by 30 kg/tree, and amount of large fruit was increased by 56 kg/tree compared to the NTC. The interaction was not significant for yield but was significant (P = 0.01) for amount of large fruit produced. Seed content was significantly reduced by NAA and CPPU, the effect being greater for NAA and in small (51 to 56 and 57 to 63 mm) than in large (76 to 82 mm) fruit. These data showing no significant inhibition of fruit growth with a combination of NAA and CPPU in Redchief 'Delicious' are in contrast with findings for a related cytokinin, BA, where fruit growth was depressed significantly when combined with NAA.

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Further Studies on Enhancement of Transcuticular Penetration of NAA with Spray Additives

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The cuticle is the prime barrier to penetration of foliar applied plant growth regulators, which must penetrate and be transported to a reaction site before a response can be induced. Urea has enhanced performance of Fe and Zn foliar sprays and a mixture of urea and ammonium nitrate (WAN) the performance of some herbicides. The mechanism of this enhancement is not clear. We find that urea and UAN increased ^{14}C-NAA transport across enzymatically isolated tomato fruit cuticular membranes (CM) from simulated spray droplets using a finite-dose diffusion system. The initial rate and total amount of NAA penetrated was significantly increased relative to NAA alone, the enhancement being greater for UAN than urea (total amount 101% vs. 78% at 120 hours) and for the NAA anion (pH 5.2, pK_a 4.2) than for the nondissociated (pH 3.2) moiety. When evaluating the concentration effect of urea and NH_4NO_3 individually, the greatest enhancement with urea was at 62 mM and with NH_4NO_3 at 8 mM. Generally the effect of urea was significantly less than NH_4NO_3 (+24% vs. 296%). NAA penetration was greater with NH_4NO_3 than with KNO_3 or $Ca(NO_3)_2$ or when the nitrate anion was replaced with sulfate or phosphate. Transcuticular penetration of NAA was enhanced greatly (190% in 120 hours) on removal of cuticular waxes; however, penetration was further increased (252% in 120 hours) by adding 8 mM NH_4NO_3. Methylamine hydrochloride (CH_3NH_2.HC1, 8 mM) also increased NAA diffusion, the initial slopes (>8 hours) were 23, 14, and 2 pmols·h^{-1} for methylamine, ammonium nitrate, and NAA alone, respectively, while the percent of applied that penetrated after 120 hours was 68.5, 67.6, and 21.4 for methylamine, ammonium nitrate, and NAA alone, respectively. The enhancement of NAA penetration by NH_4NO_3 equaled or exceeded that obtained with a group of surfactants of diverse chemistries. When the surfactant Triton X-100 was compared with NH_4NO_3, initial penetration was more rapid with ammonium nitrate (11.7 vs. 7.3 pmols·h^{-1}) but percent penetrating after 120 hours was greater for Triton X-100 (80.5 vs. 66.8). The possible action of NH_4NO_3 on NAA uptake will be discussed.

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Effective Vegetative Growth Control of Apples with BAS 125W

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When applied as a dilute spray (at 125 and 250 ppm), BAS 125W effectively reduced shoot extension growth on 'York' Imperial (YI) and 'Spartan' (S) apple trees but was less effectively on 'Delicious' (D). In 1994, lateral shoot growth of YI/M.26 trees (1 to 2 m tall) from 10 May to 7 July was reduced (35 vs. 7 cm) by sprays applied on May 13. The initial surge of growth by vertical shoots was suppressed by the treatments (16 vs. 35 cm), but there was more regrowth (6.5 vs. 0.5 cm). Some leaf injury was seen on YI. The 1995 experiments were conducted on S/M.111 and D/M.111 in an orchard spaced 3.7 m by 7.3 m. On S, lateral shoot length on five dates from 7 June to 20 Sept. was reduced by the sprays (44 vs. 32 cm on 20 Sept.). The initial surge of growth by vertical shoots was suppressed by the treatments (30 vs. 85 cm), but there was more regrowth (34 vs. 4 cm). There were fewer apples that were <25% red and more that were 25% to 40% and 66% to 85% red. On D, lateral shoot length on five dates from 7 June to 20 Sept. was reduced by the sprays (51 vs. 38 cm on 20 Sept.). The growth of vertical shoots was not influenced by the treatments, possibly due to a light fruit load in the tops of the trees. Growers viewing the 1995 plots estimated enhanced income of $933/ha for D and $780/ha for S.

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Gibberellic Acid Application Timing Influences the Bud Viability and Fruitfulness of Seedless Table Grape Cultivars

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A study initiated in Spring 1995 examined the influence of gibberellic acid (GA_3) application timing on the return fruitfulness of Thompson Seedless and Flame Seedless table grapes. Vines treated with GA_3 at prebloom, bloom, or berry set were compared to vines treated at prebloom + bloom + berry set and nontreated vines. Application amounts for each cultivar and timing were based on commercial label recommendations. Nodes from each treatment were collected in mid-winter and dissected, and their viability and fruitfulness were recorded. Bud viability (shoots per bud) and fruitfulness (clusters per shoot) also were evaluated at budbreak in 1996. The results indicate that GA_3 applications at prebloom and bloom are most detrimental to bud viability and cluster initiation in these cultivars.

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The ABA Binding Proteins and Their Properties in Grapevine Fruit

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The abscisic acid (ABA) has a key role in the regulation of grapevine fruit ripening, but the cellular and molecular biological mechanism of the hormone action in the fruit ripening remains unknown. By means of differential centrifugation, microsomes were prepared from Kyoho grapevine (*Vitis vinifera* L. x *V. Labrusca* L.) berries, and using the microsomes, we have obtained evidence for the occurrence of specific ABA-binding sites on the membranes with the microvolume radio-ligand binding assay. The binding sites had saturability, high affinity, and low capacity. The results of trypsin and dithiothreitol treatments to the microsomes suggested that ABA binding sites had the properties of proteins that might have disulfide group located at or near the binding site. The binding maximum amount of ABA in the microsomes was at pH 6.0 and the activity of ABA binding proteins was higher at 25 than at 0°C (temperature).The amount of ABA bound reached 54% of the ABA binding maximum (Bmax) for 10 minutes of incubation and Bmax reached for 30 minutes. The dissociation constant (Ka) and Bmax of ABA binding proteins in the microsomes were 17.5 nmol/L and 98.4 fmol/mg protein, respectively.

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WITHDRAWN

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Using Ethephon to Stimulate Synchronous Ripening of Saskatoon Fruit

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Ethephon was applied in two consecutive years to saskatoon (*Amelanchier alnifolia* Nutt.) shrubs ('Northline' and 'Smoky') to determine its effects on synchronizing fruit ripening. Ripeness can be visually assessed by color (green = immature; red = mature, not ripe; purple = mature, fully ripe). Ethephon (applied when fruit were ≈ 70% red) at 250, 500, and 1000 ppm increased the percentage of ripe fruit obtained from 'Northline' by 2%, 4%, and 6%, respectively. Due to pronounced seasonal yield differences for 'Smoky', ethephon had no effect on the percentage of ripe fruit obtained in 1994. However, in 1995, ethephon (applied at 70% red fruit stage) at 500 and 1000 ppm increased the percentage of ripe fruit obtained from 'Smoky' by 4% and 2%, respectively. Fruit quality, evaluated with respect to surface color development, flesh firmness, fruit size, soluble solids concentration, titratable acidity, and the soluble solids : titratable acids ratio, was not significantly affected by ethephon treatments. This work was supported in part by AARI-FFF grant no. 940442.

132 ORAL SESSION 28 (Abstr. 196–204) Postharvest Physiology–Vegetables

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Sensory and Chemical Analyses of Tomato Flavor

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Consumer acceptance of sensory quality was significantly correlated (P = 0.05) with overall eating quality of tomatoes (*Lycopersicon esculentum* Mill.) determined by a trained taste panel. The overall eating quality was partitioned into three flavor components (sweetness, sourness, and aroma) and internal texture. Relationships between the sensory flavor components and concentrations of several chemical compounds were analyzed in tomatoes of eleven varieties within a range of acceptable texture. Sweetness was significantly correlated with total sugar concentration and overall flavor at P = 0.01 and 0.001. High concentrations of two ketone volatiles (6-methyl-5-hepten-2-one and 1-penten-3-one) were significantly correlated with aroma and overall flavor at P = 0.05 to 0.001. This study indicates that positive tomato flavor may be characterized by high sweetness, moderate acidity, and high concentrations of certain ketone volatiles.

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Qualities of Hot-water-treated Tomatoes

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Hot water treatment at 38, 42, 46, 50, and 54 °C for 30 60 and 90 minutes were applied to mature green tomatoes before storing at 2°C for 2, 4 and 6 weeks. Control fruit were treated at 20°C water. After storage all fruit were held at 20°C for 7 days. Control fruit showed lower weight loss, lycopene content, pH, and TSS but higher decay, chlorophyll content, TA, and more Firmness than hot-water-treated fruit. Weight loss, lycopene content, pH, and TSS were progressively increased with increased water temperature from 38 to 54°C, while chlorophyll content, TA and fruit firmness were declined. Among hot-water-treated fruit, least decay were detected in fruit treated at 46°C water 6 weeks stored fruit showed higher weight loss, more decay, lower chlorophyll and lycopene content, TSS, TA, less firmer and higher pH than those fruit stored for 2 or 4 weeks. Increased immersion time from 30 to 90 minutes resulted higher weight loss, lower decay, chlorophyll content, TA, and less firm, but higher lycopene content, TSS, and pH.

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Pectin Solubilization and Enzymic Activity of Tomato Fruit Locule Tissue Cell Wall

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Hydrolytic activities in liquefying locule tissue of mature-green tomato (*Lycopersicon esculentum* Mill. 'Solar Set') fruit were studied in pursuing the understanding of mechanisms involved in the rheological changes occurring in this tissue. Ethanol-insoluble solids (EIS) were prepared with and without enzyme-inactivating treatment. The release of uronic acids from enzymically active EIS incubated under autolysic conditions was 5-fold higher than recoveries from inactive EIS. Uronic acid release was partially inhibited by 1 mM Hg^{2+}. Cell-free proteins extracts from active EIS exhibited hydrolytic activity against inactive EIS. Pectins released from active EIS showed no evidence of main-chain hydrolysis. Neutral sugars recovered as 80% ethanol-soluble products of autolytic reactions included glc, gal, rha, ara, xyl, and man. Gal was recovered at significant higher levels in autolysates of active EIS. Glycosidases present at high activities in locule tissue included α- and β-galactosidases, β-mannosidase, β-arabinosidase, and β-glucosidase. The results confirm our earlier findings that the metabolism of water, chelator, and alkali-soluble pectins in tomato locule tissue involves deglycosylation with no apparent depolymeriation. These changes alone appear to be inadequate in explaining the unique rheological characteristics in locule gel tissue.

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Regulation of Gycolytic Metabolism in Asparagus under Low-oxygen, High-carbon-dioxide Atmospheres

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Asparagus (*Asparagus officinallis* L. 'Giant Jersey') was stored a in flow-through system at 0°C under levels of O_2 ranging from 0.1 to 21 kPa in combination with three levels of CO_2 (0, 10 and 20 kPa) for 21 d. The resulting changes in RQ and soluble sugars were monitored. The levels of sucrose were higher at 0 kPa of CO_2 and at O_2 levels >2 kPa; however, those levels were extremely reduced at combinations of high CO_2 and low O_2. Glucose levels were higher at 0 kPa CO_2 when O_2 concentrations levels were >1.5 kPa compared to CO_2 at 10 and 20 kPa. Fructose levels were maintained higher with CO_2 at 20 kPa for all levels of O_2, showing lower levels as CO_2 decreased. Glycolytic intermediates were evaluated to support the sugar accumulation data. Phosphorylated intermediate levels were altered in spears by CO_2 and O_2 treatments. Glycolytic control point enzymes were analyzed and may account for sugar accumulation and/or degradation induced by the atmospheric treatments.

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Early Changes in Wound-induced and Ethylene-induced Phenylpropanoid Metabolism in Lettuce

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Mechanical wounding and exposure to ethylene induces an increase in phenylpropanoid metabolism in lettuce and an increase in the concentration of several soluble phenolic compounds that are easily oxidized to brown substances by polyphenol oxidase. To study the early response of lettuce to wounding and ethylene, leaves of iceberg, butter leaf, and Romaine lettuces were either wounded or exposed to ethylene at 10 $\mu L \cdot L^{-1}$ in flows of humidified air at 5 or 10°C. Soluble phenolic compounds were extracted at intervals up to 72 hours and were analyzed by HPLC. After 72 hours, wounded leaves of all three lettuce types showed elevated levels of caffeoyl tartaric acid, Chlorogenic acid, dicaffeoyl tartanc acid, and 3,5-dicaffcoyl quinic acid at both temperatures. In contrast, there were no significant increases in soluble phenolic compounds in iceberg lettuce exposed to ethylene at 10°C. At 5°C for iceberg, and at both temperatures for the other two types, there was the same pattern for ethylene treated and wounded leaf tissue. The kinetics of wound and ethylene-induced phenolic metabolism are different and will be discussed in relation to phenolics produced and browning susceptibility.

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Postharvest Factors Affecting Quality of Butternut Squash during Storage

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Butternut squash was harvested at two stages of maturity in 1994 and was cured for 10 days at 26°C and 80% or 95% relative humidity (RH) before storage in air at 12°C and 65% or 80% RH for 144 days. Fresh weight was assessed right after harvest along with carotene (milligram per 100 grams fresh weight), carbohydrates (milligrams per gram dry weight) and internal color (L, a, b). Percent weight loss and all quality components were assessed immediately after curing and every 48 days thereafter. Weight loss increased with days in storage and was

substantially minimized by a humidified environment down to 6%. The 95% curing treatment reduced weight loss to levels below the upper threshold for consumer acceptance (<15%) after 144 days. Maturity at harvest did not affect weight loss during storage, but rather the percent dry weight. Beta-carotene increased by >100% during storage. A positive correlation was established between weight loss and beta-carotene and also between the a value and beta-carotene. Curing at 95% RH obviously reduced beta-carotene content to less than one-third of its corresponding amount in noncured fruit. Sucrose increased as glucose and fructose and starch decreased during storage in cured and noncured fruit. Starch was found to decrease by 26% after 144 days in storage. The lowest levels of starch were found early during storage in fruit cured at 95% RH, but the difference between treatments disappeared by the end of storage.

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Environment and Storage Time Influence on Pungency and Sugar Profiles in Long-day Onions

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Sweet onions have gained global importance because of their mild flavor and tear-free properties. A field investigation with seventeen Walla Walla Sweet onion entries grown at the IAREC of Washington State Univ. were evaluated in 1994 and 1995. The flavor and quality characteristics such as pyruvic acid and total sugar (fructose, glucose, and sucrose) concentrations were analyzed by spectroscopy and HPLC respectively. The pyruvic acid concentration in bulbs stored (5 °C and 65% to 75 % relative humidity) for 0, 2, and 4 months increased as the storage time increased. During 1994 and 1995 the pyruvic acid ranges during storage were 4.8 to 7.9 and 2.9 to 9.6 mmols$\cdot g^{-1}$, respectively. Total sugar concentration in 1994 decreased as the storage period increased, while in 1995 the trend was reversed. There was a higher concentration of sucrose in 1995. In general, Walla Walla onions showed a higher sugar : pyruvic acid ratio among different entries compared to short-day (Vidalia and Texas Grano 1015Y) onions.

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The Role of Desiccation in the Manifestation of Chilling Injury in Cucumber Fruit

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It has long been observed that chilling injury of warm-season fruit and vegetables during postharvest storage as well as during early seedling growth can be mitigated by maintaining high relative humidities during the exposure to low temperatures. A strong correlation between transpiration rates and chilling injury was observed among the fruit of several PI lines of greenhouse-type and field-type *Cucumis sativus* L. differing in their susceptibility to chilling injury. Transpiration rates and chilling injury of the F_1s from crosses between resistant and susceptible lines were intermediate. Immature fruit lost moisture at faster rates and chill injured more severely than mature fruit of the same genotype. Coatings, applied as postharvest treatments to the fruit either reduced or increased chilling injury depending on the concentration applied and whether or not they retarded or enhanced moisture loss during low temperature storage. Fruit coated with surfactant-based waxes lost more moisture and developed more chilling injury than uncoated fruit or fruit coated with carnauba wax or polyethylene emulsions. The causal relationship between transpiration at low temperatures and chilling injury is not known, primarily because the precise mechanism of chilling injury has not been unequivocally delineated. The manifestation of chilling injury, however, occurs concomitantly with an increase in respiratory rate. We have postulated that chilling injury is caused by active oxygen species generated when the mitochondrial electron transport chain is impaired. In studies with germinating seed, desiccation injury was associated with free radicals generated by mitochondria. Thus, desiccation at low temperatures may intensify respiratory activity resulting in the generation of oxygen free radicals and extensive peroxidative damage to cellular membranes and enzymes.

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Microbial Population Reduction on Cantaloupe Destined for the Minimally Processed Market Using Vapor Hydrogen Peroxide or SO_2

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Refrigerated fresh-cut fruit and vegetables are the most rapidly expanding area in produce sales. Shelf life for minimally processed produce depends on natural product senescence or spoilage organism decay. Shelf life limits, near-aseptic cutting facilities, refrigerated transportation, and refrigerated storage make it possible to ship precut cantaloupe coast to coast on a year-round basis. Thorough cantaloupe surface disinfection reduces potential spoilage organisms and harmful pathogens. We compared using vapor hydrogen peroxide and sulfur dioxide to the current practice of hypochlorite (HOCL) washing to reduce cantaloupe microbial load. After treatment, cantaloupe were stored in unsealed polyethylene bags at 2.2°C for 4 weeks. The HOCL treated fruit were scrubbed and soaked for 5 minutes in a commercial HOCL solution. After 4 weeks, the HOCL washed fruit had reduced visible molds compared to controls. Cantaloupes fumigated for 60 minutes with 5000 or 10,000 ppm sulfur dioxide developed sunken lesions but no significant decay after 4 weeks storage. Cantaloupes, treated 60 minutes with 3 mg$\cdot L^{-1}$ volume vapor hydrogen peroxide, did not show injury or significant decay after 4 weeks storage. Sulfur dioxide and vapor hydrogen peroxide show promise as alternatives to HOCL.

136 ORAL SESSION 29 (Abstr. 205–210) Stress–Heat and Water

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Evaluation of Heat and Flood Tolerance among Diverse Taxa of Hollies (*Ilex*)

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Temperature sensitivity of net photosynthesis (PSN), dark respiration, and chlorophyll fluorescence was evaluated among three taxa of hollies including *I. aquifolium*, *I. cornuta*, and *I. rugosa*. Variations in foliar heat tolerance among these species were expressed as differential temperature responses for PSN. Temperature optima for PSN was 22.0, 26.3 and 27.9 umol$\cdot m^{-2}\cdot s^{-1}$ for *I. rugosa*, *I. cornuta*, and *I. aquifolium*, respectively. Differences in temperature optima for PSN and thermotolerance of PSN appeared to result from a combination of stomatal and nonstomatal limitations. At 40°C, potential photosynthetic capacity, measured under saturating CO_2, was 4.1, 9.4, and 14.8 μmol$\cdot m^{-2}\cdot s^{-1}$ for *I. rugosa*, *I. aquifolium*, and *I. cornuta*, respectively. Based on these results, *I. rugosa* was identified as the most heat-sensitive species followed by *I. aquifolium* then *I. cornuta*. Comparative tolerance to root-zone inundation was evaluated among 14 holly taxa. Following 8 weeks of flooding, four of the taxa: *I. cornuta* 'Burfordii', *I.* x 'Nellie R. Stevens', *I. cassine*, and *I.* x *attenuata* 'Foster's #2' performed remarkably well during and after flooding with photosynthetic rates > 40% of the controls, root ratings >75% of the controls, <5% of the foliage showing deterioration, and 100% survival. Conversely, *I. crenata* 'Convexa', *Ilex* x *meserveae* 'Blue Princess', *I. rugosa* and *I. aquifolium* 'Sparkler' did not tolerate flooding well as indicated by severely depressed photosynthetic rates, deterioration of foliage and roots, and decreased survival. The remaining taxa were intermediate.0

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Evidence that Rhizospheric Calcium Level Modulates Potato Plant Response to Heat Stress

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Micropropagated 'Red Norland' plants were transferred to an inert mixture of 1 perlite : 1 medium-grain quartzite (v/v) and grown 21 days at 20°C day/15°C night on a 25% Hoagland solution without $Ca(NO_3)_2$ (Ca at 10 mg$\cdot L^{-1}$ from $CaCl_2$, N at 35 mg$\cdot L^{-1}$ from KNO_3). Thereafter, Ca treatments (Ca at 0.2, 1, 5, 25, 125 mg$\cdot L^{-1}$) were imposed for 21 days with other nutrients unchanged. Day/night temperatures were 20/15°C and 35/20°C for control and stress plants, respectively. Continuous drip supply of nutrient solution in excess of demand maintained target rhizospheric Ca levels. All experiments were conducted in controlled-environment chambers with 400-μmol$\cdot m^{-2}\cdot s^{-1}$ light level. The following results were obtained. 1) Stress, but not control, plants grown with Ca at 0.2 and 1.0 mg$\cdot L^{-1}$ displayed reduced leaf expansion, extreme senescence, and death of the primary shoot meristem. 2) Plants grown with Ca at 5, 25 and 125 mg$\cdot L^{-1}$ grew normally under both temperature regimens, although plants responded to tem-

perature with different biomass partitioning. (3) Total root mass at harvest was similar under all Ca–temperature combinations but low-Ca-treated plants had comparatively darker roots with fewer branches. (4) Light microscopic evaluation revealed normal staining patterns of lignified elements in leaves and stems of all plants. These data suggest that constant rhizospheric Ca levels >1 mg·L^{-1} are required for continued plant growth during exposure to heat stress.

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Water Stress-induced Heat Tolerance in Geranium and its Association with Accumulation of Dehyrins and HSC 70 Proteins

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Evidence is accumulating in favor of a linkage at the cellular level between various abiotic stresses. We conducted a study to evaluate the effect of water stress on the heat tolerance of zonal geraniums. Water-stress was imposed as previously described. Leaf water potential (LWP, MPa), relative water content (RWC, percent), and heat-stress tolerance (HST; LT50, defined as temperature causing half maximal percent injury based on electrolyte leakage) were measured in control, stressed, and recovered (watering restored as in controls) plants. Proteins were extracted from the leaves following the treatments. SDS-PAGE and immunoblotting were performed using standard procedures. Immunoblots were probed with antibodies to dehydrin (T. Close) and 70-kDa heat shock cognate (HSC 70 of spinach) proteins (C. Guy). Data indicate that 1) LXWP and RWC in control and stressed plants were –0.378 and –0.804 MPa and 92.31% and 78.69%, respectively; 2) stressed plants exhibited a significant increase in HST compared to control (LT50 of 55°C vs. 51°C), which was associated with the accumulation of several heat-stable, dehydrin proteins (26 to 50 kDa), and of cytosolic and ER luminal (BiP) HSC 70 proteins; 3) in recovered plants, LXWP, RWC, and HST reversed back to the levels of control concomitant with the disappearance or reduction of dehydrins and HSC 70 proteins. These results suggest that specific stress proteins may play a role in development of heat stress tolerance.

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Heat-shock-induced Chilling Tolerance in Malvaceous Seedlings

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Crops indigenous to the tropics and subtropics and some temperate crops suffer physiological injury when exposed to temperatures <12°C. Heat shock has induced chilling tolerance in a number of sensitive species (e.g., corn, cucumber, and tomato), but not in okra. To study this anomaly, we investigated the chilling sensitivity and heat shock response of a variety of Malvaceous species (i.e., cotton, hibiscus, kenaf, and okra). Seedlings with 8- to 12-mm long radicles were exposed to heat shock temperatures of 40 to 45°C for 2 to 12 minutes. Heat shocks were applied by two methods, floating the seeds in petri dishes on heated water and immersing the seeds in the heated water. The seedlings were held at 20°C for 2 hours after the heat treatments and then chilled at 2.5°C for 3 days. After chilling, seedlings were placed at 25°C for 3 additional days. The growth at 25°C was used as an assessment of chilling injury. Although there was a great deal of variability among the seedlings, a significant number of the okra and kenaf seedlings were more tolerant to chilling after heat shock: (i.e., more growth subsequent to chilling) compared to nonheat-shocked controls. More chilling tolerance was induced by the floating method than the immersion method. The response of cotton seedlings to heat-shock was variable, and the seedlings appeared damaged by even slight heat treatments (i.e., 4 minutes at 40°C). The variability in the capacity of heat-shocks to induce chilling tolerance in seedlings of Malvaceous species will be discussed.

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Comparison of Strawberry *F. chilocnsis* and *F. ×ananassa* in Response to Water Stress: I. Leaf Water Potential, Relative Water Content, and Gas Exchange Characteristics

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Leaf water potential (LWP), relative water content (RWC), gas exchange characteristics, and specific leaf weight (SLW) were measured six hours before, during, and after water stress treatment in *F. chiloensis* and *F. ×ananassa* grown in growth chambers. The leaves of both species showed significantly lower LWP and RWC as water stress developed. *F. ×ananassa* had consistency lower LWP under stressed and nonstressed conditions than *F. chiloensis. F. ×ananassa* had higher RWC under nonstressed conditions, and its RWC decreased more rapidly under water stress than *F. chiloensis.* In comparison to *F. ×ananassa, F. chiloensis* had significantly higher CO_2 assimilation rate (A), leaf conductance (LC), and SLW, but not transpiration rate (Tr), under stressed and nonstressed conditions. LC was the most sensitive gas exchange characteristic to water stress and decreased first. Later, A and stomatal conductance were reduced under more severe water stress. A very high level of Tr was detected in *F. ×ananassa* under the most severe water stress and did not regain after stress recovery, suggesting a permanent damage to leaf. The Tr of *F. chiloensis* was affected less by water stress. Severe water stress resulted in higher SLW of both species.

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Comparison of Strawberry *F. chiloensis* and *F. ×ananassa* in Response to Water Stress: II. Leaf Fluorescence, Chlorophyll Content, and 4th-derivative Spectra

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Leaf fluorescence characteristics, chlorophyll (Chl) content and 4th-derivative spectra were measured six times before, during, and after water stress development in *F. chiloensis* and *F. ×ananassa* grown in growth chambers. The younger strawberry leaves under water stress maintained higher Chl a, Chl b, and total Chl contents than those under nonstressed conditions, while the older ones lost Chl quickly under water stress and then died. In comparison to *F. ×ananassa, F. chiloensis* had significantly higher Chl a, Chl b, and total Chl contents and peak amplitudes of Cb 630 and Ca 693 in 4th-derivative spectra under stressed and nonstressed conditions. The differences in peak amplitude of Ca 693 between the two species increased under water stress. Fq was the most sensitive fluorescence characteristic to water stress and was reduced significantly under stress. Fm and Fv decreased significantly under more severe water stress. A reduction in Fv suggests that severe water stress might cause thylakoid damage and photoinhibition in the leaves, which resulted in a very depressed CO_2 assimilation level. *F. chiloensis* had significantly higher Ft and Fq before and under water stress development (but not after stress recovery) than *F. ×ananassa.*

137 ORAL SESSION 30 (Abstr. 211–218) Breeding and Genetics–Vegetables II

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Inheritance and Evolution of the Cucurbit Organellar Genomes

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The cucurbits have several-fold size differences in their mitochondrial genomes. Watermelon possesses a relatively small mitochondrial genome of 330 kb. Squash has a larger mitochondrial genome of 840 kb. Cucumber and melon possess huge mitochondrial genomes of 1500 and 2400 kb, respectively. We demonstrated predominately paternal transmission of the mitochondrial genome in cucumber. Squash shows maternal transmission of the chloroplast genome. We generated reciprocal crosses and identified restriction fragment length polymorphisms in the chloroplast and mitochondrial genomes of melon, squash, and watermelon to establish their transmission. Our analyses also revealed that intergenomic transfers contributed to the evolution of extremely large mitochondrial genomes.

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A Linkage Map and QTL Analysis using RAPD Markers in a Narrow Cross in Cucumber (*Cucumis sativus* L.)

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Linkage maps in cucumber have been constructed in broad and narrow genetic base populations, using mostly RFLPs. RAPD markers are believed to be more advantageous than RFLPs for mapping in narrow crosses. An F_3 population derived from F_2 intercrossing cucumber inbred lines (G421 and H19) was used to construct a linkage map and to perform QTL analysis for horticultural traits

recorded in two locations. One hundred three F_3 families were used for mapping purpose. The parents were screened using ≈1500 primers yielding 80 RAPD markers that exhibited expected 3:1 Mendelian segregation. Additionally, female sex expression (F), little leaf (l), and determinate (de) loci also were evaluated in the segregating population. The linkage analysis and mapping was performed with MAPMAKER software, using a LOD score of 3.0 and recombination frequency of 0.40. QTL analysis was performed using one-way analysis of variance (ANOVA) and MAPMAKER/QTL. The linkage map integrates 83 map-points assembled into nine linkage groups. F and de loci mapped to linkage group 'B', and the l locus was placed on linkage group 'D'. The total map length is 628 cM, with an average distance between loci of 8.4 cM. Results from using one-way ANOVA and MAPMAKER/QTL had a good agreement for most QTL detected. Some QTL were location specific. Across locations four, one and three QTL were detected for sex expression, mainstem length, and number of laterals, respectively.

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Utility of Random Amplified Polymorphic DNAs for Determining Intraspecific Relationships in *Cucumis*

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Principal component analyses of variation at 21 isozyme and 43 random amplified polymorphic DNA (RAPD) loci in eight cucumber (GY-14a, G421, H-19, WI 2757, and PIs 432860, 458845, and 183967) and seven melon [Top Mark (TM), Doublon, Green Flesh Honeydew (GFH), Juane Canari (JC), Freeman cucumber (FC), Snakemelon (SM), and PI 124111] cultigens were used to determine the use of these markers for assessing genetic variation among and within populations of each species (outgroup = *Cucumis metuliferus*). RAPD and isozyme marker variation was related to previous taxonomic classification and available pedigree information. Although dendrograms derived from cluster analyses using species' variation at marker loci were dissimilar, these disparities were consistent with differences in the pedigrees and/or other information (e.g., morphological) known about each accession and species. Elite U.S. processing cucumbers (G421, GY-14a, and H-19) shared distinctive biochemical affinities. Doublon was differentiated from TM, GFH, and JC. Doublon had biochemical affinities with FC, SM, and PI 124111.

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Melon PI 414723 Is Resistant to Papaya Ringspot Virus Watermelon Strain

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PI 414723 has received much attention from melon (*Cucumis melo* L.) breeders, pathologists, and entomologists for resistances to zucchini yellow mosaic and watermelon mosaic viruses, including resistances to virus multiplication and subsequent transmission by the melon aphid, powdery mildew resistance, and melon aphid (*Aphis gossypii* Glover). PI 414723 was derived from PI 371795, which was a contaminant in cucumber (*Cucumis sativus* L.) PI 175111 collected in 1948 by Walter N. Koelz in Mussoorie, Uttar Pradesh, India (altitude 1829 m). Its fruit, which have soft flesh and rind that split at maturity, are used in soups and stews, and the seeds are roasted and eaten. PI 414723, PI 371795, and the related Ames 20219 and progeny 92528a were resistant to California and Florida isolates of papaya ringspot virus watermelon strain (PRSV-W). Plants were either symptomless, or they exhibited local lesions, systemic necrosis, or systemic spots. Resistance to PRSV-W is conditioned by a single dominant gene. Allelism with Prv1 (PI 180280, Rajkot, Gujarat, India), Prv2 (PI 180283, Bhavnagar, Gujarat, India), Nm ('Vedrantais, Fance), and a recently described gene for PRSV-W resistance in PI 124112 (Calcutta, India) is yet to be determined.

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Genes for Retention of Green Fruit Color through Maturity of Acorn Squash

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Most cultivars of acorn squash (*Cucurbita pepo*), such as 'Table Queen', have fruit that are light green when young, become dark green by intermediate age, and remain dark green through maturity, carrying genotype *D/D l-l/l-1 L-2/L-2.* Many other forms of C. *pepo* that carry this genotype, the most familiar being the Halloween and pie pumpkins, turn orange at maturity. The genetic basis for green color retention of acorn squash was investigated by crossing 'Table Queen' with 'Vegetable Spaghetti', 'Fordhook Zucchini', and accession 85k-9-107-2 (the parental, filial, backcross, and testcross generation progenies being grown out in the field and observed and scored for fruit color at maturity, between 40 and 44 days past anthesis). The results indicated that the three stocks crossed with 'Table Queen' carry two recessive genes, designated *mature orange-1* (*mo-1*) and *mature orange-2* (*mo-2*), which act in concert to result in complete loss of green color before maturity in *1-1/1-1* plants. 'Table Queen' is *Mo-l/Mo-1 Mo-2~o-2.* Genes *D* and *mo-2* are linked, ≈15 map units apart.

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Interaction of Genes for Flesh Color in Watermelon

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Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] flesh color is controlled by several genes to produce red, canary yellow, salmon yellow, and orange. Our objective was to study the interaction of three gene loci with two or three alleles at each *C* (canary yellow vs. red), *y* (salmon yellow vs. red), y^o (orange), and *i* (inhibitory to *C* permitting Y to produce red flesh color). Five crosses were used to study gene action: 'Yellow Baby' x 'Sweet Princess', 'Yellow Baby' x 'Tendersweet Orange Flesh', 'Yellow Baby' x 'Golden Honey', 'Yellow Doll' x 'Tendersweet Orange Flesh', and 'Yellow Doll' x 'Golden Honey'. Based on the performance of six generations (P_A, P_B, F_1, F_2, BC_{1A}, and BC_{1B}), the parents had the following genotypes: 'Yellow Baby' = CCYYII, 'Yellow Doll' = CCYYII, 'Sweet Princess' = ccYY*ii*, 'Tendersweet Orange Flesh' = cc*yoyo*II, and 'Golden Honey' = cc*yy*II. Segregation of flesh colors in the progeny of the five families demonstrated that there was a multiple allelic series at the *y* locus, where YY (red) was dominant to y^o y^o (orange) and *yy* (yellow). Also, *yoyo* was dominant to *yy*. In conclusion, epistasis is involved in genes for the major flesh colors in watermelon, with *ii* inhibitory to *CC* (Canary), resulting in red flesh, and *CC* in the absence of *ii* epistatic to YY, producing canary flesh.

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A Tendrilless Mutant in Watermelon: Phenotype and Development

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A spontaneous watermelon mutant, previously named *branch less*, was re-evaluated in this study. The mutant watermelon plants from genetic stock *BI-91* and derived from F_2 and BC_1 populations, did not produce tendrils under field or greenhouse conditions. The mutants stopped producing branches after the fifth or sixth node. Leaf shape changed during development of the mutants. Early leaves were normal, but later leaves had fewer and fewer lobes, finally becoming triangular toward the end of the shoot. The most distinct effect of the mutant gene was to convert vegetative meristems into floral meristems; tendrils and axillary buds were replaced by flowers at the node. The mutant plants were determinate. A grafting experiment showed that the rootstock had no effect on the mutant phenotype. Genetic analysis of F_1, F_2, and BC_1 populations suggested that the mutant is inherited as a single, recessive nuclear gene. Based on the phenotype, a new name is suggested for this mutant: *tendrilless*, with a new gene symbol *tl.*

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Evaluation of the Luffa Germplasm Collection for Sponge Yield and Quality

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All available luffa (*Luffa aegyptiaca* Mill.) cultivars, breeding lines, and plant introduction accessions (collectively referred to as cultigens hereafter) were evaluated at Clinton, N.C., over 3 years. Plants were grown in plots 1.5-m-long on a 1.8-m-high trellis. Border rows and tiers on the sides and ends of the trial were used to reduce the edge effect. Plots were planted in May and evaluated for vine height and sex expression. Fruit were harvested in October to determine fruit number and length after frost killed the vines. Sponges were processed from the fruit and evaluated for seed cell number, wall thickness, sponge strength, fiber denseness, and other quality traits. The tallest vined cultigens were PI 286425 and Fletcher, and the shortest vined were PI 381869 and PI 540921. The highest yielding (sponge number per hectare) cultigens were PI 540921 and PI 391603, and the lowest yielding cultigens were Luffa 30310 and Luffa 97321. Of the cultigens tested, PI 391603 had the longest fruit overall, whereas PI 540921 had the shortest.

138 ORAL SESSION 31 (Abstr. 219–226) Growth and Development–Fruits/Nuts

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Cultivar and Phenological Variation in Foliar Phenolic Content of Apple

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The level of dihydroxyphenolics as influenced by cultivar and leaf phenology was determined for 10 apple cultivars. Newly unfolding leaves were tagged weekly. Once per month, the leaves were collected and analyzed to determine their phenolic content. Replicated collections were made at three times during the summer. Diphenyl boric acid ethanol was the reagent used in this spectrophotometric technique. The phenolic content changed throughout the season. However, no trend was observed for phenolic content variation with leaf age. Each cultivar varied independently in phenolic content with leaf phenology. There were variations in the phenolic content associated with cultivar. Possible hypotheses as to factors affecting the production of phenolics in apple are discussed.

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Episodic Growth and Shoot Differentiation in Apple (*Malus* ×*domestica* Borkh.)

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The flushing behavior of shoot growth and its consequences on shoot differentiation are important features in fruit tree development, with regard to flowering ability. In this respect, two different approaches were applied to young 'M26' apple trees. First, poorly branched 2-year-old trees were headed back, either in the second-year or in the first-year wood, at different times from right before to 6 weeks after budbreak. Early pruning resulted in rapid and prolonged regrowth, with a final very similar shaping of the tree to that of the intact controls. Late pruning, in contrast, leads to a two-step reaction (late spring and summer flushes), sometimes stronger on 2-year-old than on 1-year-old wood. In a second experiment, buds and young shoots were sampled on pruned trees in locations where they could be supposed to remain short shoots or grow long, with one or two flushes. They were weighed, their leaves and internodes measured, and the plastochron evaluated. During budbreak and the first month afterwards, shoot differentiation appears achieved. The primary difference between long and short shoot types does not consist in faster internode elongation but, rather, in faster production (reduced plastochron) of larger leaves.

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A Computer-aided Description and Comparison of the Free Development of Unpruned Young Apple Trees, cv. Cox's Orange Pippin and Jonagold

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During 5 years from grafting, all annual shoots or growth units appearing on unpruned apple trees were recorded, and their main characteristics (length, node number, location of flower buds) introduced in a database through a code permitting quick and unequivocal identification. From this comprehensive description, the most and highly probable structure of the tree was deduced from year to year. Both cultivars display very similar gross structures, despite minor differences in shape, flowering mode, and productivity. The development occurs in two phases. In the first one, a frame composed of trunk and several storied sets of branches is built. Flowering is rather strictly biennial along each branch system. The second phase is one of reinforcement of the branches by axillary growth but even more by sympodial branching due to increasing and repeated terminal flowering (successive "bourse" shoot formation). 'Cox's Orange Pippin' mainly differs from Jonagold by earlier transition to the second phase and regular production of more "bourse" shoots (two to three instead of one).

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Fine Root Production and Mortality in Apple over Winter

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Fine root lifespan has previously been estimated at 3 to 4 weeks for apple trees growing in England. We used nondestructive belowground imaging technology to investigate the accuracy of this estimate for apple trees growing in central Pennsylvania. Eight root observation tubes (minirhizotrons) were installed beneath each of six 20-year-old 'Red Delicious' apple trees on M26 rootstock. Videos of roots growing against the tubes were taken at intervals of 14 to 28 days between October to June, depending on the amount of root activity. Images were used to construct a database of life history information for over 500 individual roots. A flush of fine roots was produced in the early fall, followed by a period of low but constant mortality that lasted through December. Roots that survived to this time were generally maintained throughout the winter and following spring. A second flush of root production occurred in the spring, coinciding with bud burst and flowering. Root mortality was highest in late spring following this flush. In contrast to earlier estimates of apple root lifespan, we found that >30% of the fine roots produced in the fall lived for ≥200 days. Most of these roots developed red-brown pigmentation, a feature that previously has been associated with cortical cell death. However, the ability of these pigmented roots to produce new white laterals in the spring argues against categorizing these as dead roots. The information on root demographics provided by this study adds to our understanding of seasonal carbon and nutrient allocation patterns in apple.

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Regulating Budbreak, Flowering, and Fruit Maturity in Sweet Cherry (*Prunus avium* L.) cv. 'Bing' by Surfactant and Nitrate Applications

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The years 1995 and 1996 were low chill years in California with respect to stone fruit dormancy. Advancing reproductive budbreak and flowering was accomplished in 'Bing' cherry (*Prunus avium*) by single-spray treatments of a surfactant {a polymeric alkoxylated fatty amine [*N,N*-bis 2-(omega-hydroxypoly-oxyethylene/polyoxypropylene) ethyl alkylamine]} and potassium nitrate in combination when applied at "tightbud," ≈ 42 days (1 Feb. 1995) before full bloom and with surfactant and potassium nitrate in combination when 10% green calyx was apparent, 33 days before full bloom. Applying 2% surfactant (v/v) + 6% potassium nitrate (w/v) was most effective in advancing bloom , speeding progression through bloom, and advancing fruit maturity when applied at tightbud stage. Surfactant (2% or 4%) applied with 25% or 35% calcium nitrate (w/v) on 2 Feb. 1996 significantly advanced full bloom compared to nontreated controls. Fruit maturity (1995) was somewhat advanced by surfactant–nitrate treatments, but fruit set and final fruit weight were equivalent among treatments. No phytotoxicity was noted in foliage or fruit. In California, marginal and insufficient winter chilling often causes irregular, extended,or delayed bloom periods, resulting in poor bloom-overlap with pollenizers. As a result, flower and fruit development may be so variable as to have small, green and ripe fruit on the same tree, making harvest more time consuming and costly. Data indicate that this surfactant, in combination with a nitrogenous compound, has potential to advance reproductive budbreak and advance maturity in sweet cherry without reducing fruit set or fruit size. Advancing the ripening time of sweet cherry even 2 to 3 days can increase the price received per 8.2-kg box by $10 to $20.

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Seedling Selection in Pomegranate (*Punica granaturn*)

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Seedling selections in pomegranates began in 1986. 'Giant Green Sweet' (GGS) was used as the female parent. GGS was characterized by fruit size from 340 to 500 g, a green color with slight blush, thin fruit coat, hexalobate calyx, and semi-open ovary with 8 to 12 loculi. The seeds are red, abundant, juicy, and sweet. The seeds contain 15% to 16% soluble solids. The male, pollinating cultivars in the same garden were 'Giant Red Sweet', 'Giant Horse Teeth', 'White Sweet', 'Red Sour', 'Bing Tang Zi', and 'Qing Gang Liu'. Seeds were harvested from fruit that were open-pollinated and weighed 500 g. Seeds were germinated and planted at the end of March. One-year-old seedlings grew to 30 to 50 cm. Two-year-old seedlings grew to 1 to 1.5 m tall with many branches. Seedlings passed the juvenile period after 3 years of growth. Some seedlings blossomed, and a few blos-

soms developed into fruit. Seedlings were adult by the fourth year, and all of them blossomed and developed fruit. This is a shorter interval to maturation than the parent cultivars. Fruits were located from the lower middle of the tree crown to the top. Adult seedlings produced fruit of ≈400 g with a few seedlings producing fruits of 500 to 600 g. There were 400 to 500 seeds per fruit averaging 40 g per 100 seeds. Seeds from the offspring were bright red and larger than those of the female parent. Fruit flavor was similar to the female parent. Offspring were more cold hardy than the parent cultivars. There were no signs of cold injury in hybrid seedlings to –19°C. This study indicates that seedling selection in pomegranates has a high potential to create higher yield and quality pomegranates. Continuing experiments will reselect the best offspring to develop higher quality cultivars.

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Temperature Effect on Nut Filling in Three Pecan Cultivars

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The influence of temperatures during nut filling on nut size, kernel percentage, kernel color, percent oil, and fatty acid composition were evaluated over 3 years in 'Cheyenne', 'Mohawk', and 'Pawnee' pecans [*Carya illinoenensis* (Wangenh.) C. Koch]. Nuts were harvested at shuck split at 14 sites located in Texas, Oklahoma, Kansas, Nebraska, Arizona, and California and Coahuila, Mexico. Weather data for 12 weeks before shuck split at each site were used to determine degree days by the formula: degree days = summation n(m – t) where n = number of days, m = (max + min temperature) ÷ 2, and t = 10°C. The degree days ranged from 996 to 1675. The oleic : linoleic ratios in all three cultivars were positively correlated with degree days in 2 of 3 years. 'Mohawk' nut size was positively correlated with degree days all 3 years and 'Cheyenne' and 'Pawnee' were larger 2 of 3 years in the warmer climates. 'Pawnee' kernel percentage and oil content was higher in the warmer climates. Warmer developmental temperatures had no influence on 'Cheyenne' kernel color. 'Mohawk' kernels were not affected 2 of 3 years, but 'Pawnee' developed darker colors 2 of 3 years.

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Root System Characteristics of Young Papaya Plants

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Excavation of field-grown 'Red Lady' and 'Tainung #2' papaya plants was begun 3 months after transplanting to the field to characterize development of the papaya root system. The roots were separated into the taproot system and lateral roots within three size categories: <1, 1 to 5, and >5 mm. Length of the taproot system and the larger lateral roots was measured directly, and that of the smaller roots was determined using the line-intersect method. Mass of the various size categories was measured after drying at 70°C. A typical plant 3 months after field-planting was ≈ 60 cm tall and exhibited a root system radial spread of 34,636 cm^2, total root length of 9613 cm, and total dry mass of 17.3 g. The taproot system accounted for >70% of the mass and <5% of the length of the root system. Lateral roots <1 mm in diameter accounted for <10% of the mass and >70% of the length of the root system. A typical plant during the heavy fruit set stage, about 6 months after field planting, was 175 cm tall and exhibited a root system radial spread of 101,736 cm^2, total root length of 975 m, and total dry mass of 539 g. The taproot system accounted for ≈38% of the dry mass and <1% of the length of the root system. Lateral roots <1 mm in diameter accounted for ≈5% of the dry mass and 65% of the length of the root system. Plant age influenced root system characteristics more than cultivar, especially the proportional distribution of mass and length among the defined root classes.

139 ORAL SESSION 32 (Abstr. 227–234) Postharvest Physiology–Fruit II

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Using Banana Peel for Bioassay Development to Evaluate the Retardation of Senescence by Lysophosphotidylethanolamine, A Natural Lipid

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Recent work in our laboratory has shown that pre- and postharvest applications of lysophosphotidylethanolamine (LPE) retard senescence processes in several fruit and flower species (apple, tomato, carnation). Banana was selected to develop a rapid bioassay to test the effects of LPE and other substances on various processes associated with senescence. Excised peel pieces from fully yellow 'Grand Nain' bananas (Musa AAA) were incubated in petri dishes containing LPE solution (0, 25, 50, and 100 ppm) for 4 days. Fresh weight and ethylene production was measured daily. At the end of the experiment, tissue density, ion leakage, and soluble protein leakage was measured. Ion and soluble protein leakage was significantly lowered with 100 LPE. The 100 ppm LPE also significantly inhibited ethylene production after only 2 hours of treatment and this low level was maintained during the experiment. Peel tissue from the 100 ppm LPE remained firm and intact while tissue from the other treatments expanded and lost integrity. By day 2, peel from the 0, 25, and 50 ppm LPE gained significantly in fresh weight, while tissue treated with 100 ppm initially lost and then only slightly gained in fresh weight. Our results suggest that LPE is able to protect membrane function in senescence. Furthermore, these results provide evidence that LPE may also be retarding senescence by modulating the ethylene pathway.

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Low-temperature, Controlled-atmosphere Storage of Tree-ripe 'Keitt' Mangoes

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Tree-ripe 'Tommy Atkins' mangoes were not injured during storage in controlled atmospheres (CA) for 21 days at 8°C, and the fruit resumed ripening after transfer to air at 20°C (Bender et al., 1995). In our study, tree-ripe 'Keitt' mangoes were stored at 5 and 8°C in either 10% or 25% CO_2 combined with 5% O_2 with control fruit maintained in air. Control fruit had higher percentages of electrolyte leakage than CO_2-treated fruit at transfer from the CA and after 3 days in air at 20°C. Fruit stored in 25% CO_2 at 5°C had significantly higher concentrations of 1-aminocyclopropane-1-carboxylic acid (ACC), over 0.5 nmol ACC/g fresh weight in mesocarp tissue. All the other treatments had similar ACC levels (<0.3 nmol/g fresh weight) after 21 days in CA. Ethylene production rates at both temperatures were significantly lower in the 10% CO_2 treatment than in control fruit and were not detectable in 25% CO_2. Ethylene production was similar in all treatments after transfer to air. Fruit from the 25% CO_2 treatment at 5°C developed dull, green-grayish spots on the epidermis, but otherwise epidermal color, as determined by chroma and hue angles, did not differ among the treatments. There also were no differences in flesh color and flesh firmness.

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Harvesting and the Incidence of Green Mold on Texas Grapefruit

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The harvest of Rio Red grapefruit (*Citrus paradisi* Macf.) was "intercepted" at three stages: 1) unpicked fruit, 2) picked and carried to pallet box trailer, and 3) picked, carried, dumped in the pallet box and transported to the packing shed. Three harvesters picked fruit from four canopy locations on two trees each. At each intercept, half the fruit was dipped into a spore solution of green mold (*Penicillium digitatum*) and half left nontreated as controls. Intercept 1 fruit was dipped and left unpicked on the tree. After 10 days incubation, the rate of green mold infection and its location on the fruit was determined. Tests were run in May 1995 and Feb. and Apr. 1996. The rate of infection increased with each intercept, and treated fruit had 15 times the infection rate of the controls. The highest infection rate, 1.3%, occurred in May 1995 followed by Feb. (0.8%), and April (0.5%). Most infection sites appeared above and below the fruit's equator, rather than on its top or bottom exclusively. There were no effects associated with harvesters or the location of the fruit in the canopy.

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Stimulation of Citrus Pitting by Wax Application and High-temperature Storage

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A peel disorder of white grapefruit that has caused substantial losses over the past several seasons was examined. This disorder, which has been identified also in Fallglo and reported for oranges and other grapefruit varieties, is characterized by scattered clusters of pits and is caused by the collapse of oil glands. Applying commonly used waxes and subsequent high-temperature storage (15°C or higher) triggered pitting. Washing and exposure to ethylene during degreening

did not affect pitting. Shellac-based water emulsion waxes from three companies and a polyethylene-based wax stimulated pitting but carnauba-based wax did not. Evaluation of internal gases of the fruit showed that all but the carnauba-based wax resulted in low O_2 (<5%) and high CO_2 (>6%) internal atmospheres. Subjecting nonwaxed fruit to 4% O_2 and 9% CO_2 storage atmospheres also stimulated pitting. These results suggest that wax application, in conjunction with high-temperature storage, may stimulate pitting by affecting gas exchange and respiration.

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Volatile Cuticular Components Involved in Superficial Scald

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Autoxidation products alpha-farnesene of have been implicated in superficial scald induction for apple (*Malus domestica* cv. Cortland Apple) fruit. We suspect the apple cuticle acts as a sink where α-farnesene can accumulate and eventually autoxidize into hydroperoxides, conjugated trienes, 6-methyl-5-hepten-2-one (ketone), and other compounds. These oxidized byproducts may diffuse back into the peel, thereby initiating the scald process. Cortland apples were stored at 0.8°C. Volatile cuticular components were analyzed at 2-week intervals by gas chromatography–mass spectroscopy. Only two scald-related volatiles were found, 6-methyl-5-hepten-2-one and α-farnesene. The identification of these compounds may allow the determination of cuticular involvement in superficial scald, as well as a possible correlation between the volatiles and apple scald development. α-farnesene concentrations initially increased and was followed by a decline, possibly due to its autoxidation.

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Intermittent Warming Effects on Superficial Scald of Apple Fruit

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Fruit of 'Cortland', 'Delicious' and 'Law Rome' were warmed for 24 hours at 20°C either weekly, once every 2 weeks, or once every 3 weeks during storage. The effect of these treatments on fruit ripening and concentrations of alpha-farnesene and conjugated trienes in hexane extracts of the skin were measured during storage. Without warming, scald incidence of the cultivars was 70%, 14%, and 85%, respectively. Intermittent warming treatments resulted in a marked reduction of scald though effectiveness was affected by cultivar. In 'Cortland', scald was reduced only by the weekly warming treatment (10%) as was less effective than DPA (1%). In 'Delicious', all warming treatments were equally effective. In 'Law Rome', weekly warming resulted in better control of scald (3%) than DPA (14%) and less frequent warming was proportionately less effective in controlling the disorder. Concentrations of conjugated trienes at 281 nm did not relate consistently to scald incidence after storage. However, ratios of conjugated trienes of 258 nm or 269 nm with 281 nm strongly support a hypothesis that non-toxic and toxic oxidation products of alpha-farnesene interact and influence the effectiveness of postharvest treatments on scald control (Du and Bramlage, 1993; JASHS 118:807-813). A hypothesis relating the interactions between ripening and scald development will be presented. Supported in part by USDA Specific Cooperative Agreement 58-1931-5-017.

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Rethinking Apple Scald: New Hypothesis on the Causal Reason for Development of Scald in Apples

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Superficial scald is still one of the most important postharvest physiological disorders in apples. Commercial control of this disorder has been accomplished by selecting resistant cultivars, treating fruit with DPA and ethoxyquin, using oil-soaked fruit wraps and storing the fruit under low O_2. However, the causal reason for scald development is still a mystery. Research has indicated that the scald-promoting factor or inducing compound may be formed or accumulated in apple cuticle then rediffused back into the hypodermis, thereby causing damage. Hydroperoxides, auto-oxidative product from α-farnesene, have been thought to be the toxic compounds, inducing scald; however, it is not explained how the hydroperoxides move from the cuticle to the hypodermis. The identification and dynamic changes of 6-methyl-5-heptene-2-one as a natural volatile in apple fruit during ripening were made, which accumulated in higher quantitaty in cuticular wax than in headspace. The close relationship between the chloroplast breakdown and amount of α-farnesene changes, the induction of scald-like symptom on the surface of apple fruit by 6-methyl-5-heptene-2-one and the sensitivity of fruit to this ketone damage were investigated. Our results suggest that the accumulation of 6-methyl-5-heptene-2-one in the cuticular wax of apple fruit might be the causal reason for scald development in apples.

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Peel Discs as a Tool to Study Flavor Chemistry in Apple

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Peel discs (0.2 mm in diameter) of refrigerated, air-stored apple that were immersed in a medium isotonic with that of fruit sap were allowed to photosynthesize either in a closed or flow-through system. The photosynthetic net evolution of O_2 in the light or consumption in the dark was used to predict the duration of the experiment that would be within the critical limits of aerobiosis. Using GC-MS system, volatile emissions from these tissues were determined, in the head space and liquid medium. The volatile profile generated from head space analysis was essentially similar to that of whole fruit. Light, compared to the dark treatment, stimulated the synthesis of nearly all volatiles, especially α-farnesene. The synthesis of 6-methyl-5-hepten-2-one, an oxidative product of α-farnesene that causes scald like symptoms in whole fruit, was observed only under lighted conditions. While O_2 content in the medium seemed to have no effect on the volatile build-up in the head space, a C15 sesquiterpene with a mass spectrum similar to hydroperoxide breakdown products of α-farnesene was synthesized only in presence of O_2 in the reaction medium. Inhibition of light reactions of photosynthesis with DCMU, suppressed the synthesis of various volatiles in the head space suggesting the role of chloroplast activity in aroma development. We suggest that peel discs work well as a model system to study flavor chemistry in apple.

140 ORAL SESSION 33 (Abstr. 235–242) Culture and Management–Woody Ornamentals/Landscape

235

Fertilizer, Irrigation, and Root Ball Slicing Affects Shrub Growth after Planting

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Dwarf burford holly (*Ilex cornuta* 'Burfordii Nana') fertilized with N at 22.1 g per container yearly during production in the nursery generated more new shoot weight but less root weight after transplanting to a landscape than those receiving N at 14.8 g per container yearly. Slicing the root ball at planting, compared to not slicing, resulted in comparable regenerated root weight but reduced new shoot number, new shoot dry weight, and new shoot:regenerated root dry-weight ratio when irrigation was not applied daily after transplanting. Although irrigation frequency did not impact total weight of regenerated roots into landscape soil, more roots grew from the bottom half of the root ball when plants were irrigated periodically after planting than when plants received daily irrigation. Plants irrigated other than daily produced fewer shoots and less shoot weight than those receiving irrigation daily after transplanting. When plants were without irrigation for 4 or 6 days in the first week after transplanting, those planted without the nursery container on the root ball were more stressed (more negative xylem potential) than those planted with the container still on the root ball. However, 2 weeks later, plants without the nursery container were less stressed due to root growth into landscape soil.

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Production Method and Irrigation Effects Postplanting Root Morphology of *Quercus virginiana*

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Quercus virginiana trees were container-grown (CG) or field-grown (FG) to a mean trunk diameter of 9.4 cm (3.7 inches), transplanted into sandy soil, and established with frequent or periodic irrigation. Three years after transplanting, trees were harvested with a 1.5-m- (60-inch-) diameter tree spade. Root number and root cross-sectional area was evaluated at the periphery of the tree spade-

dug root ball. Despite similar increases in trunk diameter, FG trees had greater root number and root cross-sectional area than CG trees. The increase in root cross-sectional area occurred for roots 5 to 20 mm in diameter at the 0- to 25-cm and 75- to 100-cm soil depths. Irrigation frequency after transplanting had no effect on root number in FG trees; however, root number in CG trees decreased without frequent irrigation.

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Effect of Rootball Size On Growth, Leaf Nitrogen Content, and Total Stem Nonstructual Carbohydrate Content Of Landscape-sized Sugar Maple

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Two rootball sizes as well as a nontransplanted control were randomly assigned to *Acer saccharum* Marsh. (sugar maple) trees in four adjacent nursery rows at Waynesboro Nurseries in Waynesboro, Va. One size (75 cm in diameter) corresponded to the American Association of Nurserymen standards. The other rootball size was 90 cm in diameter. Trees were transplanted just before bud swell or during shoot elongation. Rootball size had no effect on height, stem diameter, or twig growth, total nonstructual leaf nitrogen content (LNC), or total stem nonstructual carbohydrate (TNC). Height growth was reduced by 81%, stem diameter growth by 71%, and twig growth by 82% for trees transplanted before bud swell compared to nontransplanted trees. LNC was 25% more on transplanted trees than on nontransplanted trees, presumably due to a dilution effect. TNC was 20% higher on transplanted compared to nontransplanted trees. Growth was severely curtailed on late-transplanted trees for all characteristics measured compared to all other treatments.

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Effect of Hole Size, Organic Amendments, and Surface Mulches on Tree Establishment in Southwestern Soils

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Southern live oak (*Quercus virginiana*), and South American mesquite (*Prosopis alba*) were planted in a shallow soil (≈15 cm deep) underlain by indurated calcium carbonate in Tucson, Ariz. Oaks were planted in three hole sizes, with backfill amended or unamended with undigested wood material and with or without 9 cm of an organic surface mulch. The surface mulch was a blend of undigested wood material and yard waste compost. Initial oak trunk diameters were ≈2 cm. Mesquites were planted according to these treatments: 1) a hole 150 cm square with amended backfill, 2) a hole twice as wide and 30 cm deeper than the root ball with amended backfill, and 3) a hole five times as wide and no deeper than the root ball with unamended backfill. Initial mesquite trunk diameters were ≈4 cm. Sixteen (oaks) and 28 (mesquites) months after planting soil was removed from the planting holes by a sewage vacuum truck. We will report the effect of treatments on trunk and canopy growth, and root growth from the side and beneath the original root ball.

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Growth and Flowering of Garden Chrysanthemums Produced in Plastic or Copper-impregnated Fiber Containers

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A study was conducted with *Dendranthemum×grandiflorum* (Ramat.) Kitamura garden chrysanthemum ('Grenadine', 'Nicole', and 'Tolima') to evaluate the growth and flowering of these plants grown in 2.6-L (no. 1) black plastic containers compared to plants grown in fiber containers with $Cu(OH)_2$ impregnated into the container walls. For all three cultivars, growth indices, shoot and root dry weights, and total biomass increased for plants grown in fiber containers. Total number of flower buds per plant increased 30% to 32% for 'Grenadine' and 'Nicole' and 53% for 'Tolima' grown in fiber containers. Plants grown in $Cu(OH)_2$-impregnated fiber containers had less root coverage at the container:growing medium interface and no observable root circling in contrast to visible root circling on plants grown in black plastic containers. Foliar nutrient analysis on 'Grenadine' showed that K decreased and Fe and Cu increased when grown in $Cu(OH)_2$-impregnated fiber containers. No visible nutrient abnormalities were seen in this study.

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Container Spacing Increases Container Capture of overhead Irrigation as Application Efficiency Declines

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Ligustrum japonicum, *Rhododendron indica* 'Southern Charm' and *Viburnum odoratissimum* in 10-L containers were placed in a square grid pattern and overhead irrigated using impact sprinklers (30.3 L/min). Plants were irrigated with 12.5 mm with containers touching and, at 5 cm spacings, up to 50 cm between containers. Irrigation water reaching container surfaces (percent capture) increased for all species as container spacing increased. However, the increase in percent capture did not increase irrigation application efficiency because the percent of production area covered by the containers declined as spacing increased. Application efficiency declined with each increase in spacing to a low of 7%. The effects of intra- and inter-canopy interference are discussed.

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Effects of Fertilizer Additions on Growth of *Cotoneaster dammeri* and *Rudbeckia fulgida* in Composted Turkey Litter-amended Pine Bark Substrates

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An experiment with a factorial treatment combination in a split plot design with five single plant replications was conducted to evaluate the effects of five rates of fertilizer addition and two irrigation volumes on plant growth in a composted turkey-litter-amended pine bark substrate. Main plots were daily applications of 600 or 900 ml/3.8-L container. Subplots were either 0, 1.0, 2.0, 3.0, or 4.0 g N additions (Osmocote High H 24N–1.7P–5.8K) per container topdressed on a substrate composed of pine bark amended with 8% (by volume) composted turkey litter. No additional amendments were made to the compost amended substrates. An additional "industry control" treatment consisted of an 8 pine bark : 1 sand (by volume) substrate amended with 3.0 kg/m^3 dolomitic limestone and 0.9 kg/m^3 Micromax and topdressed with 3.5 g N (Osmocote High N) per container. After 134 days, *Cotoneaster dammeri* 'Skogholm' and *Rudbeckia fulgida* 'Goldsturm' plants were harvested and shoot and root (cotoneaster only) dry weights were determined. Cotoneaster shoot and root dry weights and rudbeckia shoot dry weight increased linearly as N rate increased from 0 to 4.0 g N. Irrigation volume did not affect cotoneaster shoot or root dry weights. Rudbeckia shoot dry weight was 18% greater with 900 ml than with 600 ml of irrigation. Rudbeckia growth in compost amended substrate was greater than in the industry control when topdressed with ≥1.0 g N. Shoot growth of cotoneaster in the industry control substrate and compost amended substrate with ≥ 3.0 g N applied was similar.

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Nitrogen Release Characteristics from Controlled-release Fertilizers

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Seven nursery grade (8- to 9-month duration), polymer-coated, controlled-release fertilizers (CRF) were topdressed or incorporated to a peat : sand : vermiculite medium to yield the same amount of N per container. The pots were uniformly irrigated with DI water every week. Leachates were collected and analyzed for N (ammonium plus nitrate) concentration. Two distinct N release (NR) patterns were observed over the 180-day experiment. Osmocote 18–6–12FS, Prokote-P 20–3–10, Osmocote 24–4–8HN, and Polyon 25–4–12 exhibited a NR pattern that closely followed changes in average daily ambient temperatures (AT) over the season. This relationship was curvilinear in nature, with NR being highly responsive to AT up to 25°C. Conversely, Osmocote 18–6–12, Nutricote 18–6–8 (270), and Woodace 20–4–12 showed a stable NR pattern over a wider range of AT, with NR rates 30% to 60% lower than those in the temperature-responsive CRF. Incorporation produced significantly higher cumulative N releases than topdressing but without effect on the actual pattern of NR over the season. Regardless of the N formulation in the CRF, >80% of the N recovered in the leachates was in the nitrate form.

150 ORAL SESSION 34 (Abstr. 243–248) Controlled Environment

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Growing Potato Tubers in Space

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Leaf cuttings from 6-week-old potato plants were planted into the Astroculture flight unit for the STS-73 shuttle flight in Oct. 1995. Tubers developed in the axils of the five leaf cuttings during the 16-days in microgravity. The flight unit had a closed growth chamber maintained at 22°C, 82% relative humidity, 150 $\mu mol \cdot m^{-2} \cdot s^{-1}$ photosynthetic photon flux, and with carbon dioxide controlled during the light period to ≈400 $\mu mol \cdot mol^{-1}$ and exceeding 4000 $\mu mol \cdot mol^{-1}$ during the dark period . A controlled delivery system using a porous tube system in arcillite medium provided water to the cuttings. A camera mounted in the top of the chamber provided video images of the plants at 2-day intervals. The cuttings maintained good vitality for the first 12 days of the flight followed by senescence of the leaves. Tubers 1.5 cm in diameter and weighing 1.7 g were produced. The shape and size of the tubers, the internal cell arrangement, and the size range of the starch grains, were similar on cuttings developed in a control experiment on the ground. Also the concentrations of starch, sucrose, fructose, glucose, and total soluble protein in the cuttings from space were similar to the cuttings developed on the ground. The challenges in scheduling experiments in a space flight and in conducting comparison control experiments on the ground are discussed. Environment control variations associated with cabin pressure changes, venting requirements, and air sampling are reviewed.

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NH_4^+: NO_3^- Optimization for Hydroponic Rice Culture in a Controlled Ecological Life-support System

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Mineral resources will be recycled in a controlled ecological life-support system (CELSS) deployed in space. N typically is supplied to crops as NO_3^- or NH_4^+ + NO_3^- mixtures. In a CELSS, NH_4^+will be abundant, but nitrification will require energetically costly chemical or biological NH_4^+ oxidization. Rice is tolerant of $NH_4^+$and preferentially absorbs NH_4^+ if provided a 1 NO_3^-: 1 NH_4^+ ratio in hydroponics. Hybrid rice absorbs more N as NH_4^+ than does inbred rice. To determine how much and in what proportion to NO_3^- rice will tolerate NH_4^+ and how varying N sources will affect grain yield, semi-dwarf hybrid rice cultivar 'Ai-Nan-Tsao' was grown hydroponically in a growth chamber. Nutrient solutions supplied 5 mM N as 40%, 60%, or 80% NH_4^+, the remainder as NO_3^-. Periodic analysis of solutions tracked mineral uptake, and solutions were modified to maintain proper concentrations. Treatment stands were harvested 84 to 86 DAP. Across all treatments, yield characteristics were similar but were highest for the border plants, presumably due to greater light absorption. Yield-efficiency rate (YER: grams of grain·per cubed meter per day·[grams inedible shoot biomass]) was 0.09 for all treatments (border) and ranged from 0.03 to 0.05 (interior), Harvest index ranged from 0.28 to 0.30 (border) and 0.26 to 0.39 (interior). Edible yield rate (EYR: grams of grain per cubed meter per day) ranged from 20.97 to 26.45 (border) and 8.52 to 14.96 (interior). The sector provided with 80% NH_4^+ had the highest YER, HI (interior), and EYR (interior), indicating that rice productivity was not limited by high percentages of N supplied as NH_4^+ . Supported by NASA grant NAGW-2329.

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Nutrient Management for pH Control in a Controlled Ecological Life-support System

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Maintaining pH to optimize nutrient availability in unbuffered nutrient solutions is important for closed spaceflight hydroponic systems and in agriculture. Total nutrient uptake is reflected by electrical conductivity (EC) measurements, while pH reflects the net imbalance of cation and anion absorption. The pH of nitrate-only (0 NH_4^+: 100 NO_3^-) nutrient solutions normally increases, whereas with equimolar (50 NH_4^+: 50 NO_3^-), solutions, pH decreases. However, when solution pH was controlled to 5.8 by a mixed N sources (25 NH_4^+: 75 NO_3^-), plant yields of semi-dwarf wheat (*Triticum aestivum* cv. 'Yecora Rojo') were equal to the control (0 NH_4^+ : 100 NO_3^-) system. When nutrient uptake was monitored at 15-min intervals, it was found that $NH_4^+$and NO_3^- were taken up simultaneously. Uptake of NH_4^+ was more rapid than NO_3^- The change in pH and EC was primarily a function of the absorption of three ions, namely NH_4^+, NO_3^- and K^+. A significant amount of the K^+ uptake was highly correlated ($P < 0.001$) to the presence of NO_3^- in solution. When the daily N requirement was supplied as a 25 NH_4^+: 75 NO_3^- mixture, comparatively little change in solution pH occurred, with reduced K^+ uptake by the plants. Thus, by knowing the daily crop N requirement from the relative growth rate, the pH fluctuations within hydroponic nutrient solutions can be reduced with daily additions of a balanced nutrient solution with a 25 NH_4^+: 75 NO_3^- mixture of N.

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Yield of Greenhouse Tomato with Constant or Intermittent Heating of the Root and Shoot

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Is intermittent heating of the root zone more beneficial than constant heating for production of greenhouse tomato (*Lycopersicon esculentum* Mill), with diurnal variation of air temperature (DIF)? Yields were compared with 14°C day/14°C night or 22°C day/6°C night minimum air temperatures, resulting in 5 and 14°C DIF. The root zone was unheated or was heated to 20°C constantly or for 6 hours in the day, or 6 hours in the night. The greenhouse tomato cultivars Buffalo and Caruso were transplanted in early and late March in 1994 and 1995. Averaged over both years and cultivars, the yield from early March planting with 14°C DIF was greater than with 5°C DIF, 6.6 and 6.1 kg/plant, respectively, due to an increase in weight per fruit and to earlier ripening. Root zone heat increased yield compared to no heat, due to a greater number of fruit. With 5°C DIF, yields with constant and intermittent root zone heat were similar. The yields were 5.4, 6.4, 6.2, and 6.2 kg/plant with none, day, night and constant heat, respectively. With 14°C DIF, there were larger differences in yield, 5.7, 7.0, 6.6, and 7.1 kg/plant with none, day, night and constant root zone heat, respectively. However, interactions between air and root heat regimes were not statistically significant. The yield from late March planting was greater with 14°C than with 5°C DIF, but root zone heat had no effect. Research supported in part by grant 93-37100-9101 from NRI Competitive grants program/USDA.

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Development of a Man–Plant Interface for Greenhouse Environmental Computers Using Generic Databases and Virtual Plants

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Currently, greenhouse environmental computers are programmed to monitor and control the macroclimate instead of directly controlling plant growth and development, which are features of more interest to growers. Our objective was to develop a generic system to represent and control the dynamic plant processes that regulate plant growth in the greenhouse. Before plant growth can be directly controlled, the dynamic interactions between the microclimate around plants and plant physiological processes must be further understood. Future computerized control systems must be able to display an intuitive, interactive software program that helps the user understand and make use of the dynamic relationships between climate controls, climate processes, and plant processes. A conceptual framework was designed for a user interface with a biological orientation. This software consists of five different elements: the information provider, the information monitor, the information browser, the growth system controller, and the system visualizer. A demonstrator application illustrating this concept was developed and connected in real time to a standard greenhouse environmental computer. Crop tissue temperature is calculated and used instead of conventional irradiance limits to control shading screens to optimize the amount of radiation absorbed by the crop. The application is based on a set of generic automatically created paradox databases. A graphical user interface on the screen displays virtual plants that are used for visualizing, understanding, and controlling the different processes governing the crop tissue temperature.

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A Survey of Planning and Adoption of Zero Runoff Systems in Greenhouse Operations

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Adopting technology to achieve environmental stewardship is a high priority among greenhouse industry members. Zero runoff crop production systems can protect surface and ground water and use water, fertilizer, and labor resources more efficiently. However, scarce capital and fear of new technology are impediments to change. Our objectives were to characterize decision making and profitability related to zero runoff systems. Managers of 80 greenhouse operations with zero runoff systems in 26 states participated in a survey designed to gather information on the costs–benefits of adoption and production changes and issues related to zero runoff systems for greenhouse operations. The survey results revealed that some adjustments of production practices were essential when adopting zero runoff systems. It also appeared that greenhouse operators believe they are achieving the intended outcomes and efficiencies from their investment. Size of the operation appeared to be closely linked to the growers' willingness to adopt this new technology. Important reasons for making the decision of adopting zero runoff systems were to improve quality of productions, cut production costs, increase production efficiency, and respond to public concern for the environment. Two thirds of the operators surveyed found that special employee training in the operation of zero runoff systems was required. Most employers found in-house training was adequate for their needs. Operators verified that a significant learning curve slows implementation of zero runoff production Adjustments of cultural practices coupled with good production management were keys to growing zero runoff successfully.

151 ORAL SESSION 35 (Abstr. 249–253) Extension–Consumer Horticulture

249

Horticulture/Gardening in Kindergarten through Fifth and Sixth Grade Education in Virginia: A Survey of Teachers

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In Spring 1995, a survey was conducted on horticulture/gardening in Virginia kindergarten through fifth and sixth grades (K–5/6). Ten questionnaires and cover letters were sent to each of 100 randomly chosen elementary schools of the 1143 elementary schools representing ≈45,000 teachers throughout Virginia. Based on a 33.7% response rate from a self-selected group of K–5/6 teachers in Virginia, there is a relatively high level of interest (87.5% of respondents were interested) regarding using horticulture/gardening in the classroom. To facilitate incorporating horticulture into the curriculum for the widest number of teachers, teaching packets containing horticulture-based lesson plans, activity ideas, posters, and AV materials should be prepared. However, it is likely that using these prepared resources alone will result in a minimum amount of integration of horticulture/gardening in the classroom. Materials should be presented to interested teachers at a local class or in-service where they can be reviewed and teachers are able to address any concerns or needs they may have. A follow-up outreach should be done in the form of monthly newsletters: one for the teachers containing new ideas on using horticulture in the classroom and one for students with horticulture-based activities and information. Additionally, the need for preservice undergraduate and postservice graduate level horticulture courses offered by Virginia Tech for teachers should be explored.

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The Effect of School Gardens on Self-Esteem, Interpersonal Relationships, Attitude toward School, and Environmental Attitude in Populations of Children

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Children develop their personalities and attitudes at an early age. With children spending 25% of each day in the classroom, schools are a major influence on self-esteem, interpersonal relationships, and environmental attitudes. Studies in human issues in horticulture have focused on how gardens affect self-esteem in nontraditional populations but have yet to research children in mainstream school districts. Our main goal was to initiate and integrate an environmental education garden program into the curriculum of several schools in the midwest and Texas. Our objectives included evaluating whether the students participating in the garden program were receiving various emotional, physical, and psychological benefits and whether they were developing positive environmental attitudes as a result of participation in the garden program. The garden program, titled "The Green Classroom," was designed to provide third- through eighth-grade teachers some basic garden activities that could be infused into their classroom lessons and would serve to reinforce curriculum in various disciplines with hands-on activities. Eight schools, ≈1000 students, took part in the study. Students participating in this study were administered a pretest before participation in the garden program and an identical posttest after its completion. The questionnaire included a psychological inventory, an environmental attitude survey, and a short biographical information section. Comparisons were made between children based on age, ethnic background, gender, and length of garden season. Results examine the relationship between the garden program and self-esteem, interpersonal relationships, attitude toward school, and environmental attitudes of children.

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Solving the Pest and Landscape Problems of Maryland Residents through an 800 Phone System

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The Home and Garden Information Center was established in 1989 to provide accurate and up-to-date environmental horticulture information to the general public. Maryland residents can speak to trained horticultural consultants 5 days per week via a toll-free number and have 24 hour per day access to pre-recorded tapes covering 23 subjects. The original automated phone system was replaced in May 1995 with a more sophisticated system. The newly designed and implemented system is the first of its kind in the United States. The AT&T Conversant Phone System includes a MAP (multi-application platform), which handles incoming calls and uses advanced speech recognition technology. Other system components include a monitor, keyboard, printer, UPS, and software. The new phone system menus were designed by the authors; the software was written by engineers at AGT International. The menus design is logical and subject-driven. Callers can move quickly through the system using a combination of touch tone and voice input. Clients can speak with a consultant at any time by pressing "0" and can access information and self-help problem diagnostic tapes by entering the four-digit tape number or by navigating menus. Subject tips are also available and are updated every 2 weeks. As of Dec. 1995, >270,000 calls were handled. More than 150,000 callers were assisted by Center staff.

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Effects of the Master Gardener Program on the Self-development of Female Inmates of a Federal Prison Camp

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More than one million people were incarcerated in U.S. prisons at the end of June 1995. Increasing emphasis has been placed on inmate rehabilitation with society's realization that 95% of those incarcerated will be released from prison and returned to society. The responsibility of undertaking the rehabilitation process lies in part with vocational programs, one of which is horticulture. In addition to developing job skills, horticulture may provide another viable means of rehabilitation in the form of horticultural therapy. The women's Federal Prison Camp in Bryan, Texas, implemented the Master Gardener program as part of its vocational training program in March 1991. The prison's Master Gardener program is sponsored by the Texas Agricultural Extension Service and constitutes a horticultural therapy program. More than 225 inmates have completed the program; however, the effectiveness in inmate rehabilitation brought about by such programs has not been extensively documented. Consequently, our objectives were to determine the effects of participation in the Master Gardener program on the locus of control, self-esteem, and life satisfaction of female inmates. About 80 inmates were administered a pretest before the Master Gardener program and an identical posttest at its conclusion. The 55-item questionnaire included a biographical section, a locus of control inventory, a self-esteem inventory, and a life satisfaction inventory. Data were analyzed using the Statistical Package for the

Social Sciences. Results examine the relationship between the Master Gardener program and the psychological well-being of the female inmates at the Federal Prison Camp in Bryan, Texas.

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Benefits of Gardening for Elderly Women

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Persons ≥60 years of age comprise a significant and growing segment of the U.S. population. More than one half of the elderly are female, and as age increases, the ratio of women to men increases as well. Gardening has long been known to be beneficial to older adults physically and psychologically. Our quantitative objective was to investigate the relationship between gardening and life satisfaction, self-esteem, and locus of control of elderly women. Our qualitative objective was to investigate the motivations to garden and the personal, self-rated benefits of gardening experienced by older women. About 45 participants were chosen from 1) volunteers in a horticultural therapy program, 2) participants in a community gardening project for older adults, and 3) participants in a community health project. During the first of two interviews, the participants completed survey instruments measuring self-esteem, locus of control, and life satisfaction. They also provided brief information about their gardening history along with demographic variables of age, ethnicity, educational background, and income level. During the second interview, the participants expanded on their experiences as gardeners, relating information such as how they became gardeners, how they learned to garden, and what factors influenced them to continue gardening. They were specifically asked to relate how they have personally benefited from gardening. Results examine the relationship between gardening and the psychological well-being of the older women.

152 ORAL SESSION 36 (Abstr. 254–261) Breeding and Genetics–Small Fruits/ Viticulture

254

Geographical Influences on Morphological Variation in *Rubus ursinus* Subsp. *macropetalus*

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Morphological variation was examined in 20 populations of *Rubus ursinus* subsp. *macropetalus* from British Columbia, Washington, and Oregon grown in a common garden. There was significant variability between and within populations for most traits studied. Principal component analyses separated populations along geographical clines for traits of horticultural significance. PC1 represented a general vigor component in all trials, and formed a negative correlation with elevation in four of five analyses ($r = 0.60, 0.58, 0.50, 0.49$; $P < 0.05$). Autumn leaf senescence tended to increase from west to east and with elevation. With higher elevation, there was a tendency for fruit weight to decrease, for later vegetative budbreak and fruit ripening, and for a shorter budbreak to first flower interval. From north to south, budbreak became somewhat earlier, cane spot susceptibility decreased, and budbreak to first flower interval increased. Characterization of this species will assist breeders to identify possible sources of cold hardiness, disease resistance, improved vigor, and acceptable fruit traits for the improvement of cultivated trailing blackberry.

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An Examination of Resistance to Blighting and Fruit Infection by *Monilinia vaccinii-corymbosi* in Highhush Blueberry

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Previous studies demonstrated a strong positive correlation between early spring shoot growth and susceptibility to the blighting phase of mummy berry. Plants with slow shoot growth derive resistance from avoidance but also may have biochemical resistance. Shoot growth of six highly resistant cultivars was artificially advanced, then plants were exposed to natural infection to assess disease response. Increased susceptibility with increasing shoot length was observed in most cultivars, although degree of response was variable. Within cultivars, there were increases in susceptibility up to shoot lengths of ≈20 mm, beyond which susceptibility decreased. Studies of fruit infection in 48 cultivars found a range of susceptibility and resistance, but little correlation between blighting and fruit infection resistance.

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Primocane Flowering in Blueberry

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Cultivated blueberries (*Vaccinium* section *Cyanococcus* species, including lowbush, highbush, and rabbiteye) normally produce flower buds at the end of the growing season; these remain dormant during the winter and give rise to flowers the following spring. However, rabbiteye and low-chill highbush cultivars that are maintained in a state of vigorous growth throughout the winter in an unheated greenhouse in Gainesville in north Florida flower and produce fruit continuously on new growth throughout December, January, and February. The regimen of cool (but not freezing) nights and short, warm days permits the plants to continue growth throughout the winter and results in rapid conversion of newly-formed axillary buds into flower buds. These do not become dormant, but sprout to produce flowers and fruit almost as quickly as they are formed. Extending the photoperiod or raising night temperatures inhibits primocane flowering by allowing the axillary buds to remain vegetative. Primocane flowering, which occurs naturally in highbush blueberry production fields south of lat. 28°N in Florida and at lat. 30°S in eastern Australia, can contribute to an extended harvest season (4 to 8 months per year) from a single cultivar.

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White Pine Blister Rust Susceptibility in *Ribes* Species

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In the late 1800s a European disease called white pine blister rust, *Cronartia ribicola* Fisher, was introduced into the United States. By 1937 this disease had naturalized and was firmly established in native *Ribes* across the country. White pine blister rust causes economic damage to white pines and infects leaves of some *Ribes* late in the summer after harvest. *Ribes* serve as obligate alternate hosts for this disease. Our objective was to determine which *Ribes* species were susceptible to white pine blister rust under field conditions in Corvallis, Ore., where inoculum is naturally present. In 1995 and 1996, 57 *Ribes* taxa from North and South America, Europe, and Asia, were evaluated in mid-August and mid-September for presence of white pine blister rust. Susceptibility was determined by the rust infection of the abaxial leaf surfaces. Rust infection was rated on a scale from 1, no infection observed, to 9, severe infection covering almost the entire surface of at least three or more leaves. Data from 1995 indicated that 22 *Ribes* taxa were susceptible to white pine blister rust, while 35 others had no infection.The 1996 data will be reported. Species without infection may offer resistance genes to breeders who wish to develop rust-resistant commercial fruit cultivars.

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Developing RAPD Markers for Grape Breeding

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The grape is an important horticultural crop that is grown worldwide. Breeding a new grape cultivar by conventional means normally will take several generations of backcross, at least 15 years. The efficiency and speed of selection can be accelerated if genetic markers are available for early screening. This project is designed to generate RAPD markers linked to viticulturally important traits, including seedlessness and pistillate genes. A F_1 population with 64 progenies of *V. vinifera* was used for the RAPD analysis. Bulked Segregant Analysis (BSA) method was used for RAPD primer screening. Three-hundred primers were screened between the two pairs of pooled DNA samples, seeded and seedlessness, pistillate and perfect flowers. At least 10 primers produced one polymorphism each between the pools. Further analysis revealed that one of these RAPDs cosegregated tightly with the seedlessness trait, while the others either had loose linkage or no linkage to the traits. To make the RAPD marker useful for breeding selection, an attempt was made to convert it into SCAR marker. The results demonstrated that the RAPD marker may be useful for grape breeding and interpreting inheritance of a particular trait in grapes.

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A History of the Ecuadorian Strawberry, Huachi (Ambato)

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Spaniards brought *Fragaria chiloensis* when they conquered Ecuador the mid-1700s. The 'Fluachi' strawberry, which was developed from these plants, became renowned in Ecuador and was eventually produced or on 500 to 800 ha in the town of Huachi Grande near Ambato. This white-fruited, long, wedge-shaped strawberry is still praised for its firmness, flavor, aroma, and shipping quality. The fruit are produced year-round on plants grown on volcanic, sandy soils in a very dry environment at an ≈3000-m elevation near the equator. The USDA germplasm explorers Paopenoe and Darrow documented the production of the 'Huachi' in the 1920s and 1950s and brought it to North America for breeding. Selections from seedling populations were determined to be red stele resistant and found their way into several Pacific Northwest cultivars, although the 'Huachi' was eventually lost in North America. Recently, we traveled to Ecuador to re-collect 'Huachi' and assess the strawberry industry there. Huachi is still grown commercially in Ecuador, although there are now only 4 to 5 ha remaining. Drought in the 1970s, "tired" soils, and the introduction of the more productive and easier to produce California cultivars have supplanted its cultivation. Ecuador now produces ≈350 ha of strawberries using California production systems. This fruit is exported fresh, primarily to the United Sates, or is frozen in a 4 + 1 sugar pack. We brought 'Huachi' back for distribution to interested breeders and to set up fertilizer trials on an established field to try to boost its productivity.

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Production of Interspecific Hybrids between Hexaploid *Fragaria moschata* and the diploid species *F. nubicola* and *F. viridis*.

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Interspecific crosses with *Fragaria moschata* (6x) have been hampered by ploidy level differences, poor seed set, and extremely poor seed germination. Modification of pollination practices, embryo rescue, and use of several genotypes has allowed over 80 synthetic tetraploids to be created from 14 cross combinations. Germplasm for the experiment consisted of eight selections of *F. moschata* (6x), two of *F. nubicola* (2x), and two of *F. viridis* (2x). Both 2x × 6x and 6x × 2x crosses were performed. Initially, negligible seed set occurred on *F. nubicola* and *F. viridis* when multiple flowers per truss were pollinated. When only one cross was performed per truss, with other flowers removed, seed set was greatly enhanced. *F. moschata* was much more tolerant of multiple crosses per truss. The crossing combination of *F. moschata* x *F. nubicola* gave the worst seed production. Other species combinations were capable of producing good seed set with noticeable differences between individual selections. When achenes were halved, only 1% appeared normal, 2% were underdeveloped or shrunken, the remainder were empty. Many of the malformed and most of the normal embryos germinated using the cut achene method. Achenes were surface-sterilized, cut in half, and placed on MS media with activated charcoal ($3g \cdot L^{-1}$), sucrose ($30g \cdot L^{-1}$), and no hormones. Germination occurred only from achenes from fully ripened fruit. Viable hybrids were obtained from 2x × 6x as well as 6x × 2x crosses. *Fragaria viridis–F. moschata* hybrids closely resembled *F. moschata* while *F. nubicola–F. moschata* hybrids were more intermediate in leaf morphology.

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Strawberry Cultivar Responses to Variations in Planting Time, Stock, and Mulches

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The cultivars Allstar, Honeoye, Kent, and Jewel yielded the most successful summer and subsequent spring crops when planted in mid-July from dormant, cold-stored, multiple-crowned, nursery mother plants. Summer fruit sizing during very high temperatures was a problem; fruit number and quality was not. In a second hot year, the same cultivars did not give satisfactory summer crops when planted after late July. The return spring crop was most successful following planting in July rather than August or September, though there was a significant cultivar × planting date interaction for a number of characters. Nursery mother plants were more productive than first daughter plants. 'Tristar' outyielded 'Seascape' on black poly-mulched beds but not on killed vetch sod beds. 'Allstar' runnered freely and produced good crops on three types of raised bed killed sod mulches and on red, blue, and silver-painted black poly raised bed mulches. Compared to the summer-planted, black, poly-mulched standard, 'Mohawk' had increased but later yields, when the poly was painted blue, red, or silver, and much later yields, when mulched with recycled paper or wood fiber. The silver and paper treatments depressed fruit size. The wood fiber mulch seems promising for deliberately delaying ripening by lowering soil temperatures under the mulch. Seedling and selection plantings have generally responded favorably to summer planting from potted or "plug" plant stocks on unfumigated soil, thus, shortening the selection and evaluation cycles, with accompanying savings in land, water, fertilizer, and pesticide use.

153 ORAL SESSION 37 (Abstr. 262–269) Sustainable Production–Vegetables

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Cucumber Yield and Soil Nutrient Changes with Poultry Litter and Synthetic Fertilizers

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Soils in eastern Oklahoma have low N and P levels. The poultry industry in the area produces large amounts of poultry litter. Horticultural producers could benefit from using the poultry litter as a fertilizer for various crops, but many horticultural crops require a fertilizer with a ratio of about 2:1:3 ($N : P_2O_5 : K_2O$). Poultry litter has an approximate ratio of 1:1:1. Poultry litter applied at a rate to supply all needed N or K will supply more P than is needed by the current crop, although low P soils can accumulate significant amounts of P before the P levels are excessive. Poultry litter at different rates and synthetic fertilizers have been applied for 3 years to a field in which cucumbers were produced. Poultry litter rates supplied N at as much as 500 $kg \cdot ha^{-1}$ and P_2O_5 at as much as 300 $kg \cdot ha^{-1}$. Cucumber yields were recorded, and soil tests were conducted three times a year for N, P, K, Ca, Mg, Mn, Cu, Pb, Zn, and Fe. Cucumber yields from plots fertilized with poultry litter were equal to or greater than yield from plots that received commercial fertilizer. There appears to be a trend toward increasing levels of soil P with all treatments. and decreasing levels of soil Zn with all treatments. After 3 years, there is no evidence of detrimental levels of any of the monitored elements.

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Characterization and Use of Nitrogen Contained in Sweet Corn Silage Waste in Cropping Systems

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Sweet corn silage waste is ≈18% dry matter and contains 1.2% N and 0.26% P on a dry-weight basis. Silage waste in rates of 0 to 448 $T \cdot ha^{-1}$ was applied to a previously harvested sweet corn field in late summer. Beginning the following spring, soil samples were periodically collected to follow the rate of N mineralization. Field corn was planted to the site the following spring as the test crop. At harvest, grain, stover, and silage yields were recorded and N removal from the system was followed through grain and tissue sampling. Additional studies were also conducted to evaluate the impact of primary tillage method on subsequent N mobilization from sweet corn silage waste and to assess the residual N release potential beyond the first year following silage waste application. Results suggest that land application of sweet corn silage waste at 224 $T \cdot ha^{-1}$ would be environmentally responsible, provided that adequate nitrogen credit from the silage waste is integrated into the total nitrogen needs of the subsequent crop. Greater mineralization is achieved when the silage waste is moldboard plowed compared to chisel plowing. Chisel plowing could result in greater residual N carryover during the year following silage waste application. Seedling emergence rates were faster and grain yield was superior in some years in moldboard-plowed plots compared to chisel-plowed plots. Further calibration of additional N fertilizer on land that received silage waste is necessary for improved production efficiency and sweet corn silage waste use in production systems.

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Utility of Shrimp Sludge from Organic Aquiculture Lagoons as a Soil Amendment for Broccoli Production

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Our objectives were to determine 1) if shrimp sludge has any value as a soil amendment in broccoli production and 2) an appropriate rate of sludge for head production. Four levels of N–P–K per 15-L pot (in grams; 2.0 N–0.07 P–1.4 K; 4.0 N–0.14 P–2.8 K; or 6.0 N–0.21 P–4.2 K; and 0.0 N–P–K) were factorially combined and replicated 10 times with four volumes of shrimp sludge (0%, 10%, 20%, and 40% v/w in 15-L pots blended with 100%, 90%, 80%, and 60% Metro Mix 300, respectively). Four-week-old 'Emerald City' broccoli transplants were planted into sludge + media–fertilizer mixtures on 12–14–95 and were grown to harvest maturity in a greenhouse. As sludge volume increased, the days to harvest, plant height, and root fresh weight : head fresh weight ratio decreased, but leaf number, fresh weight and area, head fresh weight, stem diameter, and shoot : root fresh weight ratio increased. As N–P–K rate increased, leaf number, area, and fresh weight, stem diameter, head fresh weight, and shoot : root fresh weight ratio increased, but root : head fresh weight ratio and plant height decreased. Using head fresh weight as the determinant, heaviest heads were optimized with 20% sludge and 4.0g N–0.14g P–2.8g K per 15-L pot. Sludge alone or N–P–K alone did not produce the heaviest broccoli heads as using combinations of sludge and N–P–K in a fertility program.

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Improving Garlic Using Wheat Straw Mulch

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Garlic (*Allium sativum* L.) has been cultivated in much of the world for millennia. Little scientific research, however, has focused on improving cultural conditions for production in the temperate regions of the northeastern United States, where garlic is gaining importance as a horticultural crop. To study the effectiveness of wheat straw (*Triticum aestivum*) mulch on garlic, experiments were conducted at the Cornell Univ. research facilities in East Ithaca, N.Y., during the 1993–94 (year 1) and 1994–95 (year 2) growing seasons and at the Homer C. Thompson Vegetable Research Farm, Freeville, N.Y., during the 1994–95 growing season. Two clones, one bolting and one nonbolting, were studied in year 1, and four varieties, three bolting and one non bolting, in year 2. All were fall-planted (mid-October), and mulch treatments were covered with wheat straw early in the following December. Control plots were not covered. The mulch either remained on the crop throughout the growing season or was removed early in the spring to expedite soil warming. This is the common practice among growers who use mulch only for winter protection. The presence of mulch during the winter increased the survival rate. Soil temperatures under the wheat straw were significantly lower during the summer than soil temperatures in unmulched plots, which could have contributed to the increase found in the yield and average bulb size of several of the cultivars. Maintaining the mulch through the entire growing season reduced weed pressure >30%. We found no significant increase in the amount of basal fungal infection. The results indicate that using straw mulch can improve garlic produced in the northeastern United States.

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A Strip-tillage System for Snap Beans

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Our previous research found that snap bean yields were reduced in cropping systems with cereal rye residues. Strip-tillage may overcome the yield reductions while providing the environmental advantages of high residue systems. An experiment was established at Champaign, Ill. 'Wheeler' cereal rye was seeded in September at 110 kg·ha^{-1}. The treatments were 1) conventional tillage with trifluralin, 2) rye without strips, 3) rye with fall-established strips, and 4) rye with spring-established strips. The rye was mowed 1 week before planting the snap beans. The spring strips were established in solid-seeded rye using a no-till planter, modified with extra culvers. It was difficult to maintain the fall-established strips after mowing. Weed control in the strips was problematic. Yields and insect populations were also determined.

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Effects of Cover Crops and Tillage on Production and Nitrogen Nutrition of Watermelon

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Effects of tillage, winter cover crops, and inorganic N fertilization on watermelon production were examined in a split-plot factorial experiment. Main plots received tillage or no tillage, whereas cover crops consisted of hairy vetch, winter rye, or a mix. Nitrogen treatments consisted of plus or minus addition of ammonium nitrate. Following melons not receiving inorganic N, vetch produced cover crop total N yields of ≈130 kg·ha^{-1}, which were four times greater than those obtained with rye. Melon yields and foliar N concentrations obtained without inorganic N fertilization following vetch were similar to those obtained with N fertilization following rye. Available soil N in vetch treatments remained significantly ($P < 0.05$) higher than in rye treatments for ≈70 days after melon planting and was greater in tilled treatments. Tillage significantly ($P < 0.05$) reduced melon yields by 20% and also reduced soil temperatures compared with no-till treatments. We conclude that N fixed by vetch could sustain watermelon production and no tillage may be useful when soil erosion is a problem.

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Cover Crops and N Rates Influence Sweetpotato Production

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'Jewel' sweetpotato was no-till planted into crimson clover, wheat, or winter fallow. Then N was applied at 0, 60, or 120 kg·ha^{-1} in three equal applications to a sandy loam soil. Each fall the cover crop and production crop residue were plowed into the soil, beds were formed, and cover crops were planted. Plant growth of sweetpotato and cover crops increased with N rate. For the first 2 years crimson clover did not provide enough N (90 kg·ha^{-1}) to compensate for the need for inorganic N. By year 3, crimson clover did provide sufficient N to produce yields sufficient to compensate for crop production and organic matter decomposition. Soil samples were taken to a depth of 1 m at the time of planting of the cover crop and production crop. Cover crops retained the N and reduced N movement into the subsoil.

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Gas Exchange in Tomato in a Cover Crop–Tomato Cropping System

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Our objective was to determine the effect of cover crops on the gas exchange activities of a succeeding crop of tomato. No commercial N fertilizer was applied, and the mineralization of cover crops provided the sole source of supplemental N for the tomato crop. Cover crops were planted in randomized complete blocks on 8 Sept. 1994, with treatments consisting of control (fallow), rye, hairy vetch, and crimson clover. A tomato cultivar Mountain Pride was transplanted in the field on 18 Apr. 1995. The gas exchange rate of tomato was measured at flowering (6 June), fruiting (13 July), and senescence (10 Aug.) with infrared gas analyzer using a steady-state gas exchange system. The highest stomatal conductance (g_s) and CO_2 exchange rate (CER) was obtained during flowering and fruiting, respectively. The tomato plant following a legume cover crop conducted water vapor at a significantly higher rate than those preceded by rye or fallow. The CER of tomato planted behind a legume cover crop was also higher compared to those following rye or fallow. The g_s ranged from 384 to 1146 mmol·m^{-2}·s^{-1}, and CER varied from 5.7 to 17.8 mol·m^{-2}·s^{-1} depending on the preceding cover crop and the stage of growth of the tomato plant. From the results of this study, it was apparent that, while legume cover crops increased the gas exchange activities of the ensuing tomato crop, nonlegumes had no such effect.

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Sweetpotato Genome Fingerprinting and Parental Analysis Using Microsatellites.

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Microsatellites or simple sequence repeats (SSRs) were used to characterize 20 sweetpotato genotypes and to assign paternity for offspring from crosses among them. The PCR amplifications were performed with each of the sweetpotato genotypes and primers flanking a SSR loci previously characterized with the varieties Beauregard and Excel and 20 offspring from a cross among them. The PCR reaction products were separated in nondenaturing 12% acrylamide gels run at 25 $V \cdot cm^{-1}$ for 5 hours, and DNA fragments were visualized with silver staining. Gels were scanned on a flat bed scanner and analyzed using the Pro-RFLP software package. Three primer pairs were sufficient to produce an allelic profile capable of differentiating the 20 genotypes from each other. More than seven alleles/loci were found using each of the three primer pairs assayed. Occasionally primers produced allelic products clearly localized in two or three regions of the gel. These multiple loci segregated independently in a diploid fashion. This evidence suggests that there is not total homology among the three sweetpotato genomes.

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Molecular Mapping and Tagging of Cucumber Mosaic Virus Resistance Genes in *Capsicum*

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Genetic resistance to cucumber mosaic virus (CMV) in pepper (*Capsicum* spp.) is recessive, polygenic and, therefore, has been difficult to transfer in breeding programs. Although a few varieties have been released with some resistance, in our tests, these develop severe symptoms that are eventually indistinguishable from the susceptible reactions. Furthermore, accurate and consistent screens for the disease can be relatively difficult; therefore, we report on the detection molecular markers linked to two CMV resistance genes using distributional extreme analysis to identify the relevant quantitative trait loci (QTL). The 12 most resistant and 15 most susceptible individuals were selected from a segregating F_2 population of 316 individuals that were derived from the interspecific cross (*C. annuum* 'Jupiter' x *C. frutescens* BG2814-6). A total of 132 tomato genomic, cDNA, and pepper genomic clones were hybridized to filters with DNA extracted from the distributional extremes. These clones included framework markers representing all pepper linkage groups and also selected clones from regions of the genome identified in a preliminary analysis as possibly involved with CMV resistance. Several clones from the two regions of the genome previously identified appear to be nonrandomly cosegregating with the CMV resistance phenotype in this larger population. Further analysis will be done by adding more markers in the regions and refining the positions of the resistance QTL.

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Quantitation of DNA of Propidium Iodide-stained Nuclei from Ipomoea Species and Sweetpotato Using DNA Flow Cytometry

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Sweetpotato, *Ipomoea batatas* is in the morning glory family, Convolvulaceae, genus Ipomoea, group Batatas. It has many wild *Ipomoea* relatives that serve as a reservoir of many needed pest and stress-resistance genes. A major barrier to introgression of useful genes is the ploidy gap—sweetpotato is a hexaploid and wild Ipomoeas are diploids and tetraploids. The wild species can be successfully crossed using 2n pollen or by first increasing ploidy by colchicine treatment. The ploidy of such hybrid offpsring can be determined by DNA flow cytometry. My objective was to develop a technique to determine DNA content in *Ipomoea* and values for DNA content for the major Ipomoea species using the EPIC flow cytometer with a UV detector. Nuclei were extracted and pretreated with cellulase and pectolyase before staining with propidium iodide (PI). A highly linear relationship was found between the DNA content determined by DNA flow cytometry and the ploidy of the closest sweetpotato relatives as determined by chromosome counts. These species were diploid *I. trifida*, tetraploid *I. batatas*, and hexaploid *I. batatas*. DNA content was most similar among other diploid *Ipomoea* species in the group Batatas and was significantly different in other Ipomoeas not in group Batatas.

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Screening Sweetpotato Germplasm for Field Resistance to Scab (*Sphaceloma batatas* Saw.)

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Field resistance to scab was assessed within Indonesian sweetpotato germplasm, and some of the CIP pathogen tested clones were also included. The total number of clones was 778 from Indonesia and 57 from the CIP pathogen tested list. Many of the clones tested were highly resistant under Indonesian field conditions. It was relatively easy to select resistant clones in Bogor and Lembang, West Java, Indonesia where high humidity is prevalent throughout the year. The proportion of resistant vs. susceptible accessions varied according to the geographical area of origin. The reaction to scab and the place of origin in the passport data were linked and compared for their percentage in each reaction category (e.g., HR, R, MR, S, and HS). The results indicated that there were two types of geographical provenance in terms of resistance reaction. The first group, categorized by the lower percentage (<10%) of HR clones, included West Java, Central Java, East Java, Bali, and West Sumatra. The second group, which had >15% of HR clones, included North Sumatra, Sulawesi, and Irian Jaya. When putting HR and R clones together, the first group had <30%, and the second >50%. This may be due to selection pressure exerted on the crop during the evolutionary process. Two hypotheses could be considered to explain this grouping. One is that the first group originated in areas where there has not been much natural selection pressure by the scab disease. The second hypothesis is that the grouping was enhanced by cultural practices of farmers (e.g., avoidance of cultivation during the rainy season). There are indications that most of the sweetpotatoes grown in the first group of provinces was produced on a commercial scale, while most of the crop in the second group of provinces was produced by subsistence farmers.

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Inheritance of a Mild Reaction to Lettuce Mosaic

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Resistance to lettuce mosaic (LMV) in current cultivars of lettuce is due to a single recessive gene, *momo*, in one of two allelic forms. The nature of the resistance may be described as resistance to multiplication and spread in the plant. Resistance is systemically manifested as small irregular yellowish areas on the leaf. This compares to the usual expression of susceptibility: vein clearing, followed by mottling, leaf margin recurving, and later stunting and yellowing. A cos-like stem lettuce from Egypt, 'Balady Aswan', is susceptible to LMV, but reaction to the virus is a milder one than the usual susceptible reaction. Segregating generations from crosses with normal susceptible and resistant lines were analyzed. The data suggest a single gene for reaction type, with mild dominant or partially dominant to severe. Selection of lines from crosses with the resistant type allows the breeder to select resistant and mild alleles together, which confers a higher level of resistance than *momo* alone. Plants with the combined reaction either show no symptom or show the resistant symptom very late.

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Growth Characteristics and Response to Nitrogen Fertilizer of Some Morphotypes of Jute Marlow (*Corchorus olitorius* Linn.)

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Plant growth characteristics were observed for 12 morphotypes of *Corchorus olitorius* planted in the field. Two commonly used varieties in Nigeria were subjected to increasing nitrogen fertilizer rates. Extensive variations in measured leaf, stem, and root growth confirmed genetic diversity among morphotypes. Thus, fresh shoot harvest l00 kg N/ha at 3 kg/ha seed rate for the lanceolate was 17.44 $t \cdot ha^{-1}$, the serrate-type at the same seed rate required N at 200 $kg \cdot ha^{-1}$ to produce 18.19-ha harvest.

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Effects of Broccoli Donor Genotype on Incidence of Diploids in Populations Regenerated from Anther Culture

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Broccoli (*Brassica oleracea* L. Italica group) breeders are increasingly using

anther or microspore culture to produce dihaploid (diploid), homozygous lines for use in making hybrids. During the process of anther culture and subsequent plant regeneration, wherein embryos develop from microspores and plants are regenerated from the embryos, polyploidization occurs and diploid regenerants can result. However, polyploidization may not occur at all, or it may involve a tripling or quadrupling of the chromosome complement, instead of a doubling. Thus, populations may contain haploids, triploids, or tetraploids, in addition to diploids. In two cycles (1994-95 and 1995-96) of anther culture, regenerated populations from different broccoli hybrid sources were evaluated using flow cytometry to facilitate efficient identification of diploids vs. haploids, tetraploids, or others and to determine if anther donor genotype has an effect on the frequency of different ploidy levels among regenerants. In the first cycle, five broccoli hybrids had anther-derived populations in which ≈33% were haploid, 55% diploid, 37% tetraploid, and 5% aneuploid or abherent types. The hybrid, 'Marathon', was different; it's regenerants were 78% diploid and only 15% tetraploid. In the second cycle, anther-derived populations had a significantly different makeup with a most hybrids giving 30% to 40% diploids and 50% to 60% tetraploids. However, consistent with the previous cycle, 'Marathon' gave significantly more diploids (68%) and fewer tetraploids (25%) than other hybrids. These results indicate that anther donor genotype affects ploidy frequency among regenerants. Genotypes producing a high frequency (>60%) of diploids may be relatively uncommon.

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Evaluation of Two Visual Scales to Estimate European Corn Borer Ear Feeding Damage in Sweet Corn

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The germplasm evaluation techniques in resistance breeding programs may improperly characterize insect damage. For example, the relationship between economic damage levels and biological damage levels may not be linear as some techniques assume. Most commercial sweet corn hybrids are highly susceptible to European corn borer (ECB), *Ostrinia nubilalis* Hübner, ear feeding. Genotype variation for ECB damage in our breeding program traditionally has been identified by using a 1 (no damage) to 9 visual rating scale that combines damage levels, damage site on the ear, and the economic consequences of ECB feeding for the processing industry. An alternative 1 to 5 scale based solely on a visual percentage assessment of ear feeding damage was developed and compared to the traditional scale. Seven entries, including moderately resistant and susceptible hybrids and inbred lines of the ECB ear resistance breeding program, were evaluated with both scales in 1994 and 1995 at two locations. Inbred MN3002, Hybrid MN3004, 'Apache', and 'More' had lower mean damage ratings (3.4, 3.4, 3.6, 3.8, traditional vs. 2.4, 2.2, 2.2, 2.3, alternative, respectively) than 'Jubilee', Inbred W182E, and Inbred MN3003 (5.3, 5.6, 7.3, traditional vs. 3.3, 3.0, 4.2, alternative, respectively). Thus, four entries were classified as moderately resistant (3.0 to 4.0 traditional vs. 2.0 to 3.0 alternative) and three entries were classified as susceptible (>4.0 traditional vs. >3.0 alternative). Individual entry ranks varied by scale, but this did not alter resistance classifications. Although the nine traditional ratings were based on economic consequences and the five alternative ratings were based strictly on feeding levels excluding damage location, both scales effectively identified genotypes historically classified as moderately resistant and susceptible. The value of scales is often questionable for many situations and should be considered prior to evaluation.

155 ORAL SESSION 39 (Abstr. 278–284) Nutrition–Fruits

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Optimizing Nitrogen for Improving Yield and Fruit Quality of 'Redspur Delicious' Apple

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Effects of three times and five rates of urea application on productivity, tree growth, soil nitrate movement, nutrient partitioning, and postharvest fruit quality of 'Redspur Delicious' apple on M.7 rootstock over several years were studied. Time of application did not have significant effects on most fruit quality factors or yield. However, significant differences were observed for quality and yield measurements among different quantities of N. Fruit firmness decreased with every increment in N increase. Trees with N at 0.045 kg/tree had lower yield and higher fruit firmness than those with higher quantities of N. Fruit weight and color decreased with each increment increase in the quantity of N. Trees with N at 0.045 and 0.18 kg/tree had significantly better (more red) color and lower fruit N and leaf N than those with higher quantities of N. Bud tissue nutrients were affected by quantity of N application. Fruit from trees with N at <0.18 kg/tree had lower soluble solids. High N increased fruit ethylene and respiration. Nitrogen application affected 2-methyl butyl acetate of fruit. Monitoring nitrate movement through the soil showed that application of N at >0.45 kg/tree, particularly in fall resulted in excess levels of nitrate, increasing the possibility of underground water contamination. Applying N at ≤0.32 kg/tree did not result in excess soil nitrate at 1.52-m depth.

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Fertigation of Young Apple Orchards

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Experiments conducted since 1986 indicate that multi-nutrient fertigation may be effective in improving early growth and yield of new orchards. However, the early studies did not provide information concerning the contributions of individual nutrient elements to these responses. Experiments were established in 1993 and 1994 to compare effectiveness of alternative sources, rates, and methods of applying K, Zn, and Cu through drip irrigation compared with annual soil surface applications to 'McIntosh'/M.9 and 'Empire'/M.9 trees. After 3 years, leaf K, cumulative shoot growth, and first crop year yields were increased by application of K. Differences between sources, rates, times, or methods of application generally were not significant when relatively high rates were applied. However, early results from a rate study indicate a significant K source by rate interaction. Soil surface application of K plus drip irrigation appears to be comparable to fertigation in supplying this element. After 2 years, applying EDTA chelates of Zn and Cu through fertigation increased leaf Zn and Cu, respectively, but high rates required are considered to be uneconomical when compared with foliar sprays of these elements.

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Local Soil Nitrogen Availability Affects Nitrate Uptake Capacity of Excised Peach Roots

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The interrelationships were studied between local soil N availability, tree N status, and NO_3^- uptake capacity of excised roots of mature, commercially grown 'O'Henry' peach trees. Nitrogen sufficient (+N) and deficient (–N) peach trees were established previously by differential N fertilization. High (+N) and low (–N) soil microsites were established under +N and –N trees in June 1994. Per unit root length NO_3^- uptake capacities of roots excised from +N and –N microsites were measured in late July 1994. Root excised from +N microsites exhibited higher NO_3^-uptake capacity per unit root length than roots from –N microsites irrespective of tree N status. The relationship of these data to the concept that NO_3^-uptake is a function of sink N demand will be discussed.

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Fertilization Rate and Growth of 'Hamlin' Orange Trees Related to Preplant Leaf Nitrogen Levels in the Nursery

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Our objectives were to determine if leaf N concentration in citrus nursery trees affected subsequent growth responses to fertilization for the first 2 years after planting and how N fertilizer rate affected soil nitrate-N concentration. 'Hamlin' orange [*Citrus sinensis* (L.) Osb.] trees on 'Swingle' citrumelo rootstock [*C. paradisi* Macf. x *P. trifoliata* (L.) Raf.] were purchased from commercial nurseries and grown in the greenhouse at differing N rates. Three to five months later trees were separated into three groups (low, medium, high) based on leaf N concentration and planted in the field in Oct. 1992 (Expt. 1) or Apr. 1993 (Expt. 2). Trees were fertilized with granular material (8N–2.6P–6.6K) with N at 0 to 0.34 kg/tree yearly. Soil nitrate-N levels were also determined in Expt. 2. Preplant leaf N con-

centration in the nursery varied from 1.4% to 4.1% but had no effect on trunk diameter, height, shoot growth, and number or dry weight in year 1 (Expt. 1) or years 1 and 2 (Expt. 2) in the field. Similarly, N fertilizer rate had no effect on growth during year 1 in the field. However, trunk diameter increased with increasing N rate in year 2 and reached a maximum with N at 0.17 kg/tree yearly. Shoot number during the second growth flush in year 2 was much lower for nonfertilized vs. fertilized trees. Leaf N concentrations increased during the season for trees with initially low levels even for trees receiving low fertilizer rates. Soil nitrate-N levels were highest at the 0.34-kg rate, and lowest at the 0.11-kg rate. Nitrate-N levels decreased rapidly in the root zone within 2 to 3 weeks of fertilizing.

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The Effect of Varying Cultural Practices on the Location of Mycorrhizal Infection within the Rhizosphere of Highbush Blueberry Plants

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Previous experiments in the laboratory and the field have suggested that location of mycorrhizal infection within the rhizosphere of blueberry plants may depend on cultural practices that are being used. Furthermore, we have observed that rapidly growing roots, whether in solution culture or within petri dishes, appear to be less likely to become infected when inoculated. A preliminary experiment found higher levels of mycorrhizal infection in roots growing at a 5-cm depth of soil compared to roots growing just under the mulch layer. To further test this hypothesis, an experiment was designed to evaluate the infection intensity of highbush blueberry plants (*Vaccinium corymbosum* L.) at different locations within the rhizosphere on plants growing under varying cultural practices. Cultural practices included mulching (mulch vs. no mulch) and nitrogen level (0 and 120 g ammonium sulfate/plant). Four-year-old 'Bluecrop' highbush blueberry plants subjected to these treatments were arranged in a complete factorial design with six replications at the Russell E.Larson Agricultural Research Center at Rock Springs, Pa. Mycorrhizal infection intensity was evaluated from roots sampled nondestructively using a 2.5 cm soil corer at the interface of the mulch and soil, and at soil depths of 3 and 15 cm from two locations 15 cm from the crown of each plant. Results will be discussed.

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Effect of Foliar Application of Urea and Boric Acid on Red Roomy Grapevines: I. The Effect on Behavior of Buds, Growth, and Vine Nutritional Status

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This study was performed during the 1991, 1992, and 1993 seasons to study the effect of different concentrations and number of sprays urea and/or boric acid on behavior of buds, vegetative growth, and vine nutritional status of Red Roomy grape vines. Two, three, four, or five sprays for both urea at 0.5%, 1.0%, or 1.5% and/or boric acid at 0.1%, 0.2%, 0.3% in addition to the control treatments were applied. A gradual increase was observed in the percentages of burst and fruiting buds, main branch length, leaf area, cane thickness, total chlorophyll, and total carbohydrates in the leaves and considerable depression was observed in the percentages of dormant and vegetative buds. The most pronounced effect on growth and nutritional status was detected on vines sprayed four times with urea at 1.0% plus boric acid at 0 2% during the growing season.

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Effect of Foliar Application of Urea and Boric acid on Red Roomy Grapevines: II. The Effect on Yield and Quality of the Berries

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This investigation was conducted during the 1991, 1992, and 1993 seasons to study the effect of different concentrations and number of sprays urea and/or boric acid on yield and berries quality of Red Roomy grapevines. Two, three, four, or five sprays for both urea at 0.5% 1%, or 1.5% and /or boric acid at 0.1%, 0.2%, or 0.3% in addition to the control treatment were applied. Combined sprays of urea and boric acid was preferable in increasing the number of clusters, yield per vine, berry set parentage, fertility coefficient. weight, length and shoulder of cluster, weight and dimensions of berry, total soluble solids, total sugars, and total anthocyanins in grapes and in reducing the percentages of cracked and shot berries and the total acidity compared with the single application of both. Spraying urea at 1.0% in combined with boric acid at 0.2% four times (i.e., at growth start, first bloom, immediately after berry set, and at 30 days later) is recommended for achieving high yield and fairly good berries quality in 'Red Roomy' grape vines .

143 POSTER SESSION (Abstr. 285–289) Biotechnology–Molecular Biology

285 (PS 5)

Biochemical and Molecular Characterization of a β-1,3-Endoglucanase from Valencia Orange Callus

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Inhibition of the growth of fungal pathogens has been related to levels of a β-1,3-endoglucanase (EC 3.2.1.39) (GLU) in citrus as well as other plant species. Our long-term objective is to transform *Citrus* spp. to express enhanced levels of GLU with the aim of increasing resistance to fungal pathogens. We have purified a β-1,3-endoglucanase from nonembryogenic *Citrus sinensis* (L.) Osbeck cv. Valencia callus to electrophoretic homogeneity by means of pH precipitation and ion exchange chromatography. The protein has an apparent M_r of 32.5 and a pI > 10. The enzyme hydrolyzes laminarin (*Laminaria digitata*) optimally at pH 5 and 50°C. The enzyme will hydrolyze any glucan polymer with a β-1,3 linkage whether soluble or insoluble and the rate of hydrolysis is proportional to the relative abundance of β-1,3 linkages. The enzyme does not hydrolyze cellulose or starch. Product characterization by thin-layer chromatography indicates that the enzyme is an endohydrolase. Initial attempts to sequence the protein indicated that it was N-terminally blocked. Therefore the protein was hydrolyzed using AspN, the fragments separated by SDS-PAGE, blotted onto nitrocellulose, and one of the fragments was sequenced. Amino acid sequence analysis indicated that the protein shared homology with a number of β-1,3-endoglucanases. Antibody to the purified protein was raised in rabbits and used to screen an amplified cDNA library prepared from *Citrus sinensis* (L.) Osbeck cv. Valencia callus. One of the positive clones was selected and sequence analysis indicated that the clone was homologous with other β-1,3-endoglucanases.

286 (PS 5)

Subcellular Localization of 14-3-3 Regulatory Proteins in *Arabidopsis thaliana*

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The 14-3-3 proteins were originally characterized in mammalian brains and were thought to be specifically involved in neurotransmitter production. Subsequent research has revealed that this family of proteins is ubiquitous in eucaryotic cells and is involved in a wide range of regulatory and signal transduction pathways. For instance, some 14-3-3 proteins have been associated with the signal transduction in response to fungal pathogen attack and to other environmental factors that affect transcription. In *Arabidopsis*, 10 isoforms of 14-3-3 have been isolated, raising the possibility that diversity of function may be governed by cellular and subcellular specificities of expression and localization. We have investigated the localization of certain 14-3-3 isoforms through transgenic expression of epitope-tagged 14-3-3s.

287 (PS 5)

Differential Expression of ACC Synthase Genes in Response to Stress

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Ethylene production is involved in many plant physiological processes including stress responses and is frequently associated with foliar senescence. Ethylene emission is a common plant response to many biotic and abiotic stresses. We have cloned two ACC synthase cDNAs (*OIP-1*, *PAC-1*) from the leaves of ozone treated *Solanum tuberosum L.* plants. Plants treated with ozone produced ethylene within 1 hour following treatment initiation. Levels continued to increase reaching a peak after 2 h. *PAC-1* was expressed after 1 hour reaching a maximum by 2 hours and

showed a marked decline after 4 h. *OIP-1* was first expressed after 2 hours and high levels of expression continued up to 4 hours following treatment initiation. Leaves treated with $CuCl_2$ produced high levels of ethylene within 0.5 hour after treatment initiation. Ethylene levels continued to increase reaching a peak after 2 hours with no change after 4 h. *PAC-1* was expressed after 0.5 hour reaching a peak at 1 hour and showed a progressive decline from 2 to 4 h. However, *OIP-1* expression was first detected 2 hours following treatment initiation and high levels of expression continued up 4 h. Leaves exposed to *Alternaria solani* produced increased levels of ethylene 1 day following inoculation reaching a peak after 3 days. *PAC-1* was expressed at a low level 1 day after inoculation and expression remained constant for the duration of the experiment, whereas, *OIP-1* was not expressed until day 4.

288 (PS 5)

Cloning and Characterization of an *ETR1* Homologous Gene from Carnation (*Dianthus caryophyllus* L. cv. 'White Sim') Petals

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Ethylene plays a key regulatory role in carnation flower senescence. Flower senescence is associated with a significant increase in ethylene production. Continued perception of this ethylene by the flower is necessary to sustain the climacteric rise in ethylene and the expression of senescence related genes associated with senescence. In addition, increased sensitivity by the flower to ethylene during development and senescence has been observed. In order to study the perception of ethylene at the molecular level, an ethylene receptor gene was cloned from carnation petals. The clone, *CARETR*, shows 68% homology at the nucleic acid level with the *Arabidopsis* ethylene receptor gene, *ETR1*. Northern blot analysis revealed that *CARETR* is present as a low abundant transcript in petals, styles, and ovaries. Further analysis also showed that *CARETR* is upregulated during flower senescence. Treatment with the ethylene action inhibitor norbornadiene (NBD) resulted in decreased levels of *CARETR* transcripts. These data suggest that *CARETR* plays a role in the increased sensitivity of carnation flowers to ethylene during flower development and is involved in staging the rapid and orchestrated death of the flower.

289 (PS 5)

Development of GUS Reporter Gene System for *Aphanomyces* Root Rot Screening in Pea

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Aphanomyces root rot of pea (*Pisum sativum*) in many pea-growing regions. The genetic resistance to this fungal pathogen is quantitatively inherited and confers levels of tolerance to the disease. Genetic gains in selection have been hampered by the difficulty of differentiating the highly tolerant from tolerant lines in segregating populations. Reporter gene systems have been useful in studying genetic resistance to other soil-borne pathogens. We have transformed an isolate of *Aphanomyces euteiches*, the causal pathogen, with a reporter gene β-glucuronidase (GUS) and a selectable marker gene, hygromycin phosphotransferase or neomycin phosphotransferase. The transformed lines constitutively express GUS as determined fluorimetrically by measuring the conversion of 4-methylumbelliferyl glucuronide to 4-methlyumbelliferone. The efficacy of this GUS enzyme assay will be compared with an indirect enzyme linked immunosorbant assay (ELISA) and visual disease development ratings in inoculated seedlings of three populations recombinant inbred lines of pea segregating for tolerance.

145 POSTER SESSION (Abstr. 290–294) Biotechnology–Molecular Genetics

290 (PS 7)

Early Nodulin Genes in Japanese Pagodatree (*Sophora japonica* L.) and American Yellowwood [*Cladrastis kentukea* (Dum.-Cours.) Rudd]

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Early nodulin genes, such as *ENOD2*, may be conserved and could function as molecular markers for nodulation. Many nodulating and nonnodulating legumes must be analyzed before the role of such genes in nodulation can be determined. Japanese pagodatree and American yellowwood are closely related, ornamental woody legumes. Unsubstantiated reports of nodulation in Japanese pagodatree require confirmation, and American yellowwood has not been observed to nodulate. We investigated the presence of putative *ENOD2* genes in these species, and we are studying differential and temporal expression. Genomic DNA of Japanese pagodatree and primers, derived from proline-rich pentapeptide repeats of conserved ENOD2 sequences, were used to obtain a 555-bp PCR fragment. This cloned fragment was used as a probe for Southern and Northern hybridizations. Genomes of Japanese pagodatree and American yellowwood contained sequences that are similar to *ENOD2* sequences in other legumes. Treatments with either cytokinin or an auxin transport inhibitor may induce expression of the putative *ENOD2* genes. New data on the characteristics of nodulin genes in woody legumes will clarify the nature and evolution of nodulation in legumes and may have implications for developing sustainable nursery production protocols.

291 (PS 7)

Isozyme and RAPD Analyses of Witch Hazel Cultivars

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Numerous isozyme systems were found to be polymorphic in witch hazel (*Hamamelis* spp.). However, aconitase (ACO), malate dehydrogenase, phosphoglucose isomerase (PGI), and phosphoglucomutase were most useful for identification of cultivars. From these enzyme systems, three genes were identified that control patterns of ACO (2) and PGI (1). Isozymes can be used to help verify cultivars and their simple inheritance could be useful to validate hybrids and gene flow between plants. DNA was readily extracted from young leaf tissue after grinding in liquid nitrogen and extraction in warm CTAB. DNA was amenable to amplification using polymerase chain-reaction technology. Primers (400) were screened to identify polymorphic RAPD bands. Ultimately, 19 primers were used to generate 68 RAPD markers that were reproducible. Cultivars were scored for presence or absence of the 68 markers. Genetic similarities were calculated using a Nei coefficient and clustering was conducted for more than 40 cultivars using a UPGMA program. Arbitrarily, the cultivars were assigned to seven groupings after cluster analysis. The seven classes gave one group each of *H. japonica* and *mollis*; two groups of *H. vernalis*; and three groups of *H.* ×*intermedia*. Clustering allowed some interpretation about relatedness among cultivars and genetic similarity data helped assign some cultivars to a particular taxa that were previously in question.

292 (PS 7)

Molecular Mapping of *Capsicum* and the Comparisons of Synteny with Tomato

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Pepper (*Capsicum* spp.) has the same basic chromosome number as tomato and other solanaceous plant species (2n = 2x = 24). By using the probes mostly from a tomato map, we have generated three molecular maps of pepper from interspecific F_2 crosses of *C. frutescens* BG 2814-6, *C. chinense* PI 159234 and *C. annuum* 'NuMex RNaky' with restriction fragment length polymorphisms, isozymes, random amplified polymorphic DNAs, and morphological traits. The best developed map is from *C. annuum* x *C. chinense* F_2 cross, which currently has 366 markers covered 1081 cM in 18 linkage groups. Three linkage groups were assigned to three chromosomes based on primary trisomics. Several disease resistance genes including monogenic resistance to potyviruses and quantitative trait loci for resistance to tobacco mosaic virus and cucumber mosaic virus have been mapped. The distribution of allele frequency and marker segregation ratios have been analyzed. Chi-square analyses of all clones showed more skewing of segregation ratios in *C. annuum* x *C. chinense* population than the other two populations. The skewing occurs throughout the genome and tends towards heterozygote and one of the parents. The order of markers among three pepper maps will be compared and the comparisons of synteny between pepper and tomato maps will be described. A composite of three pepper maps will be presented using JoinMap software.

293 (PS 7)

Integration of Genetic Linkage Maps of BC_1 and F_1 Populations of the Intergeneric Cross of *Citrus grandis* x *Poncirus trifoliata* Using RAPD Markers

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A greater saturation of the previously constructed genetic linkage map of *Citrus* is important in the long term goal of mapping quantitative trait loci (QTL) such as those controlling cold and salt tolerance. Segregation for cold tolerance appears to be greatly enhanced in the intergeneric F_1 population of *Citrus grandis* x *Poncirus trifoliata* as compared to the BC_1 population previously used for mapping due to the higher percentage of *P. trifoliata* genes present. This is not unexpected since *P. trifoliata* is the source of cold tolerance in this cross and is a highly heterozygous species. An integration of the maps of the two populations using about 50 random amplified polymorphic DNA (RAPD) markers common to the two populations is possible using the JoinMap computer program. This will allow the placing of approximately 100 new polymorphic RAPD markers from the F_1 population identified by screening from 42 random oligonucleotide primers onto the *Citrus* map. This saturated map will be used to locate QTL following bulk segregation analysis of cold tolerance in the F_1 population.

294 (PS 7)

Optimizing RAPD Markers for Ginseng Genomic DNA Analysis

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Random amplified polymorphic DNA (RAPD) may have utility as genetic markers facilitating selection in ginseng crop improvement. This experiment determined chemical buffer and root tissue-type combinations that yield repeatable bands. The results allow further experiments using RAPD markers for estimating the genetic distance between ginseng landraces, selection for crop improvement, and extensive fingerprinting for use in determining the origin of tissue samples. This experiment determined mean band yields for all combinations of dry, fresh, and powdered root with cetyltrimethylammonium bromide, potassium/sodium ethyl xanthogenate, and urea buffers. The buffers were applied in replication to the tissue-types with other extraction protocol factors constant. Replications were amplified four times with four different primers using constant PCR and agarose gel electrophoretic protocols. Distinct bands were counted in each replication, and the summation of the replication repeats considered an observation. Least squares means for several response variables were analyzed. The most significant difference found was between buffers. The buffers ctab and urea were productive, and the pex was not. Significant difference was found when buffers were crossed with tissue. The applications of urea to fresh root, ctab to dry root, urea to dry root, and ctab to powdered root were productive. Based on these results we conclude 1) urea and ctab are productive when applied to all tissue-types, 2) dry root, which is easily collected and stored, yields sufficient DNA for analysis, and 3) powdered root, often the form of commercial products that might be tested for genetic origin, will yield sufficient DNA for analysis.

143 POSTER SESSION (Abstr. 295–301) Biotechnology–Transgenics

295 (PS 5)

Optimization of Parameters for Particle Bombardment of Genes to Garlic

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We evaluated the efficiency of transformation in garlic for promoter activity, osmoticum effect and shaker speed using particle bombardment as the method of gene delivery. Callus was produced from root segments on a modified B-5 medium for four garlic clones. Suspension cultures were then established on a modified B-5 medium + 2,4-D using 6-month-old callus. Cells were collected by vacuum filtration and the Bio-Rad PDS-1000/He system was used to deliver genes. The activities of CaMV 35S, maize *Adh1*, and rice *Act* promoters were evaluated for transient expression using the β-glucuronidase (GUS) reporter gene. Osmotic conditioning of cells was performed by adding both mannitol and sorbitol to the medium. Osmoticum effect was evaluated for enhancement of transformation efficiency using GUS. The effect of shaker speed (120, 180 and 240 rpm) on cell type was evaluated for transformation efficiency using GUS. CaMV 35S promoter activity was much higher for garlic than either the maize *Adh1* or rice *Act* promoters. Osmoticum did not enhance promoter activity, but differences in response to osmoticum among garlic clones were observed. Shaker speed did affect cell type, and transformation efficiency was greatly increased at higher shaker speeds. Confirmation of stable transformation and regeneration are in progress.

296 (PS 5)

Genetic Transformation of Kentucky Bluegrass with the *rolC* Gene

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Coleoptile tissues excised from young seedlings of 'Touchdown' Kentucky bluegrass (*Poa pratensis* L.) were bombarded with the disarmed *Agrobacterium tumefaciens* strain EHA 101 carrying *rolC* (from *A. rhizogenes*), NPT II and GUS genes. These tissues were then cultured on Murashige and Skoog (MS) medium containing 0.2 mg·L^{-1} picloram, 0.01 mg·L^{-1} naphthaleneacetic acid (NAA), 150 mg·L^{-1} kanamycin, and 50 M acetosyringone. Calli formed on this medium within 2 weeks. The regenerated plants from these calli were analyzed for the presence of the *GUS* and *rolC* genes by histochemical GUS assay, PCR, and Southern hybridization. Only 3.7% of the regenerants were transformed when determined by the GUS assay. A similar frequency of transformation in the regenerated plants was obtained after bombarding the coleoptile tissues with the DNA isolated from the pGA-GUSGF-*rolC* plasmid. Most of the putative transformants were either albinos or variegated plants that are composed of both albino and green tissues.

297 (PS 5)

Optimization of Parameters Influencing Biolistic DNA Transformation of Common Bean (*Phaseolus vulgaris* L.)

Zhanyuan Zhang[1], A. Mitra[2,3], and D.P. Coyne[1]*, [1]Dept. of Horticulture, [2]Dept. of Plant Pathology, and [3]Center for Biotechnology, Univ. of Nebraska–Lincoln, Lincoln, NE 68583

Optimization of parameters influencing biolistic transformation is a crucial stage towards repeatable transformation of common beans. However, there has been no published study on such optimization of this crop species in a helium particle delivery system (BioRad). Using an intron-containing β-glucuronidase (GUS) gene as a reporter, we optimized several critical parameters of biolistic PDS-1000/He delivery system for common bean transformation. The target explant tissues included cotyledons, zygotic embryos, and meristemic shoot tips suitable for organogenesis. Thus, pretreatment of target tissues with osmotic medium containing 0.15–0.25 M mannitol and 0.15–0.25 M sorbitol, positioning of target tissues in 4 cm microcarrier flying distance, the use of 1.6-μm gold particle and high concentration of coating DNA, and bombardment of young immature tissues twice at 2000 psi, etc., significantly increased transformation rate and achieved the best coverage and penetration of the meristemic areas involved in direct shoot organogenesis.

298 (PS 5)

Factors Affecting *Agrobacterium*-mediated Transformation of Common Bean (*Phaseolus vulgaris* L.)

Zhanyuan Zhang[1], A. Mitra[2,3], and D.P. Coyne[1]*, [1]Dept. of Horticulture, [2]Dept. of Plant Pathology, and [3]Center for Biotechnology, Univ. of Nebraska–Lincoln, Lincoln, NE 68583

Factors influencing *Agrobacterium*–mediated DNA transfer of *P. vulgaris* were examined using an intron-containing β-glucuronidase (GUS) gene as a reporter system. Tissue culture procedures used were based on direct shoot organogenesis. Two *A. tumefaciens* strains, A2760 and EHA105, were used with more emphasis on the former due to its overall higher transformation rate. Ten bean entries including breeding lines and cultivars from both Meso-American and Andean origins were compared for compatibility with the two bacterial strains under different pre- and coculture conditions. Pinto 'Othello' was extensively used in testing different transformation conditions. Factors found to have significant effects on transformation rate included *Agrobacterium*-host interactions, explant maturity, preculture and cocultivation conditions, as well as selection schemes, based on transient expression. Some factors, such as the effect of explant maturity and dark preconditioning of explants on gene transfer, have not been reported before. The best transformation conditions included the use of susceptible genotypes and mature explants, preconditioning of explants in darkness, followed by a maximum cocultivation period in the presence of cytokinin, and the use of high selection pressure.

299 (PS 5)

Factors Affecting Transient Gene Expression in Apple Cotyledons following Particle Bombardment

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Developing an efficient gene transfer system for apple (*Malus* x *domestica* L.) remains a major objective in genetic engineering efforts of this fruit crop. Transient expression of the *uidA* gene coding for β-glucuronidase (GUS) and driven by the cauliflower mosaic virus 35S promoter (CaMV35S) has been induced in apple cotyledonary explants of mature seeds by tungsten particle bombardment using the Particle Inflow Gun (PIG). Several factors that affect transient expression of the GUS gene in apple cotyledons were investigated. The gene transfer efficiency was monitored by recording the number of blue spots observed on explants two days following bombardment. Precultivation of cotyledons for 18 hours before bombardment significantly increased the number of blue foci. Of the three different precipitation methods tested including water, 25% PEG, and 60% glycerol, the latter was the most effective for coating DNA onto tungsten particles. Washing DNA-coated tungsten particles with 70% ethanol and resuspending in 100% ethanol significantly enhanced gene delivery to cotyledons. The amount of particles used for each bombardment also influenced GUS expression. About 0.5 mg of particles per shot resulted in the highest number of blue foci. Using larger quantity of particles (i.e., 2 mg) drastically decreased GUS expression probably due to the toxicity of tungsten particles.

300 (PS 5)

Altered Morphology of *Brassica rapa* following Electroporation in the Presence of Foreign DNA

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The lengthy generation times associated with woody ornamentals has led to the exploration of alternatives to traditional breeding methods for the development of new cultivars. This report summarizes the results of experiments designed to examine the feasibility of altering plant morphology by DNA assimilation following electroporation of intact seedlings. *Brassica rapa* (a nonwoody plant) was chosen as a model plant for initial experiments due to its rapid development and short generation time. Seedlings were subjected to either one or five 300-V pulses (99 ms) in the presence or absence of foreign DNA. Foreign DNA used was *Ulmus parvarvifolia* at a concentration of 200 $\mu g \cdot mL^{-1}$. Results indicate a lower survival rate of seedlings electoporated in the presence of DNA. Data were recorded after 21 days for plant height and leaf number. No significant differences were noted for plant height. However, significantly more leaves were produced on plants electroporated (five pulses) in the presence of foreign DNA. These results suggest the possible utilization of this technique for induction of variation in other plants.

301 (PS 5)

Transformation of *Nicotiana alata* Link and Otto. with an Autoregulatory Senescence-inhibitor Gene Construct

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Leaf explants of *Nicotiana alata* Link and Otto. were surface disinfested and cultured on Murashige and Skoog (MS) medium containing 2.66 μM N6-benzyladenine (BA) to promote shoot proliferation. After 5 weeks, proliferated shoots were removed and remaining callus saved. Callus was inoculated with *Agrobacterium tumefaciens* encoding a senescence-specific promoter SAG12 cloned from *Arabidopsis thaliana* fused to a *Agrobacterium tumefaciens* gene encoding isopentenyl transferase which catalyzes cytokinin synthesis. Following inoculation, the callus was cocultivated for 6 days on BA medium. Selection for transgenics was done on BA medium plus 100 mg Kanamycin and 400 mg Ticarcillin (antibiotics) per liter. Proliferating shoots were rooted on MS medium containing antibiotics. Rooted cuttings were transplanted to soil, acclimated and flowered in the greenhouse. Transgenics were outcrossed to a commercial *N. alata* hybrid. Seed was germinated in vitro on half-strength MS medium plus antibiotics. Segregation of transgenics to nontransgenics was 1:1. Evaluation of leaf senescence on 5-month-old plants showed 2 to 14 times fewer senesced leaves on the transgenic than the nontransgenic plants.

108 POSTER SESSION (Abstr. 302–304)
Breeding and Genetics–Floriculture

302 (PS 4)

Genotype of Flowering Stems of *Antirrhinum majus* L. Influences Ethylene Evolution and Fresh Weight Changes Postharvest

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Cut flowers of a short (S)-lived (3-day) inbred, a long (L)-lived (15-day) inbred and their hybrid (F_1, 7.3 days) of *Antirrhinum majus* L. were evaluated for fresh weight and ethylene evolution change postharvest when held in deionized water. Fresh weight change of all accessions increased 1 day postharvest then declined over the remainder of postharvest life. The loss of fresh weight was most rapid for S and less rapid for F_1 and least rapid for L. Ethylene release postharvest for S and F_1 started on day 1, but for L ethylene release started on day 9. Once ethylene evolution began it continued through postharvest life. On the last day of postharvest life, ethylene release from S and F_1 were similar, but L was twice the level as S and F_1. It appears that a slower decline in fresh weight, a delay in outset of ethylene release and higher final amount of ethylene release at senescence are heritable and associated with longer keeping time of *A. majus.*

303 (PS 4)

Two-year Evaluation of Pansy Cultivars in the Florida Landscape

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Pansy cultivars were evaluated for number of days to flower, flower size, flower color, plant habit, plant dimensions, weather tolerance, floriferousness, uniformity, and overall appearance during the winters of 1994–95 and 1995–96. In 1994–95, the number of days from sowing of seed to first flower among 122 cultigens ranged from 68 days for 'Allegro Beaconsfield' to 94 days for 'Springtime New Red'. Flower diameter ranged from 4.1 cm for 'Allegro Pure Yellow' to 6.5 cm for 'Bingo Yellow with Blotch'. Plant height after 114 to 122 days from seed sowing ranged from 11.4 cm for 'Allegro Pure Orange' to 19.7 cm for 'Fama See-Me'. Subjective ratings showed few differences among the cultigens in plant uniformity and floriferousness, but differences with respect to overall appearance. In 1995–96, the number of days from seed sowing to first flower for 113 cultigens ranged from 75 days for 'Rally Light Blue with Blotch' to 97 days for 'Happy Face White'. Flower diameter ranged from 4.8 cm for 'Sprite Beaconsfield' and 'Sprite Yellow' to 7.5 cm for 'Bingo Yellow with Blotch'. Plant height at 140 to 143 days after seed sowing ranged from 12.4 cm for 'Maxim Chiffon' to 26.5 cm for 'Universal Plus White'. Subjective ratings showed no differences among the cultigens in plant uniformity or overall appearance and few differences in floriferousness or flower display.

304 (PS 4)

'Maurine Blue' and 'Florida Blue': Heat-tolerant Lisianthus [*Eustoma grandiflorum* (Raf.) Shinn.]

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Seedlings of commercial lisianthus cultivars form rosettes when grown at 25 to 28°C. Rosetted plants have a basal cluster of leaves, very short internodes typical of biennials, and do not bolt or flower for months without being exposed to 3 to 4 weeks at <15 to 18°C to reverse heat-induced rosetting. Semirosetted plants develop when seedlings are grown at a constant 22 to 25°C or at <22°C night with >28°C day. Semirosetted plants have one or more side shoots which may elongate and flower, but plants flower unpredictably and are of poor quality as cut flowers or potted plants. 'Maurine Blue' and Florida Blue' were released from the Univ. of Florida in 1995. To our knowledge, they are the first heat-tolerant lisianthus cultivars. Seedlings and plants can be grown at 28 to 31°C without rosetting. 'Maurine Blue' ranged in height from 38 cm (summer) to 67 cm (spring) during 1994 and 1995 production trials in Florida. 'Maurine Blue' has potential for use as a tall bedding plant if sold as green transplants, a flowering potted plant if grown with three plants per 15-cm-diameter pot with a growth retardant, or as a bouquet-type cut flower. 'Florida Blue' plants (38 cm) grown in an 11.5-cm square pot (0.65-L) with capillary mat irrigation were similar in height to 'Blue

Lisa' (32 cm) and taller than 'Little Belle Blue' (22 cm) and 'Mermaid Blue' (24 cm). 'Florida Blue' was designated as a semi-dwarf cultivar with an intended use as a bedding plant. Growth retardants would be useful for production in pots <10 to 12 cm in diameter. Complete descriptive information, photographs and pedigrees will be presented.

107 POSTER SESSION (Abstr. 305–315) Breeding and Genetics–Fruits/Nuts

305 (PS 3)

Heritability of Nut, Kernel, and Phenological Traits in Hazelnut

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The Oregon State Univ. breeding program is developing improved hazelnut cultivars for the kernel market. Most traits of interest are quantitative, yet there is little information available on their heritability. In this study, the heritability of 10 morphological and 4 phenological traits was estimated by regression of offspring means on midparent values. Seedlings from 35 crosses among 41 parents made in 1988 and 1989 were used. The parents represented the wide genetic diversity used in the breeding program. Estimates were all high, ranging from 0.56 for amount of kernel fiber and 0.58 for time of catkin elongation to 0.87 for percent kernel and 0.89 for nut depth.

306 (PS 3)

Advanced Evaluation System of Hazelnut Germplasm

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Based on our investigation of hazelnut germplasm and Thompson's evaluation system for European hazelnuts, an in-depth study on character description of hazelnut germplasm was conducted from 1991 to 1994. Eighty characters were evaluated for the 58 tested species. It was found that eight characters should be eliminated from Thompson's system, such as annual branch length and hair, lentical color, and serration depth. The best leaf sampling position, sample volumes for quantitative characters, and scoring standards were also determined. Therefore, an advanced evaluation system for hazelnut germplasm was developed. The advanced system is easier and simpler, and will significantly expedite systematical studies of hazelnut germplasm.

307 (PS 3)

Prunus mahaleb Seedling Populations as Improved Rootstocks for Sweet Cherry

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Seedlings of *Prunus mahaleb* are often used as rootstocks for sweet cherry (*P. avium*) scion cultivars in commercial orchards. While they are desirable based on ease of propagation and economical production of nursery stock, seedlings may be variable resulting in nonuniform compound trees, and they are susceptible to several important diseases. Seedling sources have shown substantial variability for population uniformity of plant growth, and reaction to crown gall, powdery mildew and *Phytophthora* root rot. Segregating families also vary for pollen fertility, inbreeding response and control of scion growth. Multiple screening for favorable trait combinations is underway to develop improved sources of cherry rootstocks.

308 (PS 3)

Inheritance of the Roughskin Character in Peach

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Pubescence in peach fruit is controlled by the *Gg* locus, with the homozygous recessive being the glabrous-skinned nectarine. The roughskin character in peach causes the loss of all long hairs on the epidermis of the fruit. Under a microscope short stubs are visible. The fruit is rough to the touch and appears dull rather than shiny as a nectarine would appear. A pleiotropic effect is lack of hairs on the dormant leaf and flower buds, making them noticeably shiny to the naked eye, unlike normal peaches and nectarines. The roughskin character appeared in 3 of 70 seedlings from the cross of Pekin x Durbin. The remaining seedlings all produced normal peaches. Sibling F_2 progenies segregated for peach and nectarine, and in one case, for roughskin as well, indicating the cross was valid. Results from numerous crosses and F_2 populations indicate this character is controlled by a single recessive gene, which is hereby designated *rs*. Nectarines homozygous for this gene have glabrous buds, but otherwise appear normal. The origin of the mutation is unclear. Selfed seedlings of Pekin and Durbin have not expressed the recessive form of the gene. Possibly a limb of the Pekin tree (now gone) used for the crosses had mutated to the recessive form at one or both loci. The homozygous roughskin progeny would have then been inadvertent self-pollinations rather than hybrids, since none of them segregated for nectarine.

309 (PS 3)

Analysis of S-allele Genotypes of Japanese Apple Cultivars

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Cross-incompatible combinations among the main cultivars in apple are rarely reported in Japan. Recently, however, most new Japanese cultivars are progenies of 'Ralls Janet', 'Delicious', 'Golden Delicious', 'Jonathan', and 'Indo'. Cross incompatibility in apple, therefore, will become a serious problem in the near future. Since the analysis of the S-allele genotypes were not performed, especially in Japanese apple cultivars, the fruit set percentage were examined in several combinations of 'Hatsuaki' ('Jonathan' x 'Golden Delicious') and 'Iwakami' ('Fuji' x 'Jonathan') progenies using back crossings. As a result, we found that 'Golden Delicious' and 'Jonathan' had no common S-allele, while 'Fuji' and 'Jonathan' had one common S-allele. These facts were used as basics for the S-allele genotype analysis, and fruit set percentage and seed number per fruit were investigated on a large scale. The cross seedlings between 'Delicious' and 'Jonathan', 'Ralls Janet' and 'Jonathan', 'Iwakami' and 'Golden Delicious', 'Golden Delicious' and 'Delicious', 'Hatsuaki' and 'Fuji', 'Hatsuaki' and 'Delicious', 'Hatsuaki' and 'Jonathan', and 'Hatsuaki' and 'Golden Delicious' were analyzed. In addition, incompatibility between 'Redgold' and 'Kinesei' ('Golden Delicious' x 'Ralls Janet'), 'Senshu' ('Toukou' x 'Fuji') and 'Iwakami', and progenies of 'Northern Spy' also were analyzed . As a result, we have found the existence of six alleles and 15 genotypes, and we have established S-allele standard cultivars and strains as follows: (Sa, Sb) = 'Golden Delicious'; (Sa, Sc) (4)-354, (4)-425; (Sa, Sd) = 'Toukou'; (Sa, Se) = 'Redgold', 'Kinsei'; (Sa, Sf) = 'Narihokou', (4)-4195; (Sb, Sc) = 'Hatsuaki', 'Kuifua', 'Sekaiichi'; (Sb, Sd) = 'Tsugaru', (4)-300; (Sb, Se) = (4)-150, (4)-743; (Sb, Sf) = 'Northern Spy', M.9, 'Umezawa'; (Sc, Sd) = 'Jonathan', 'Himekami'; (Sc, Sf) = 'Fuji' , 'Shinkou'; (Sd, Se) = ; (Sd, Sf) = 'Senshu', 'Iwakami'; (Se, Sf) = 'Ralls Janet'.

310 (PS 3)

Screening *Malus* Germplasm for Field Resistance to Apple Replant Disease and Root-lesion Nematodes

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Apple replant disease (ARD) is a serious problem in fruit production, and none of the major clonal rootstocks are resistant to ARD. We have screened *Malus domestica* clones and species accessions from the USDA Malus Germplasm Repository at Geneva, N.Y., including *M. angustifolia*-2375.03 (MA), *M. coronaria*-2966.01 (MC), *M. fusca*-3031.01 (MF), *M. ioensis*-3059.01 (MI), *M. sieversii*-3530.01 (MS), and *M. kirghisorum*-3578.01 (MK), for resistance to ARD and root-lesion nematodes (RLN, *Pratylenchus* spp.), in a composite soil collected from 11 New York orchards with known ARD. Plant dry mass and height, root necrosis, and nematode populations in different apple species and clones were compared after 60 days growth in steam-pasteurized (PS), RLN-inoculated (IS), and naturally infested field (FS) soils with 1200 RLN per 100 cm^3. More severe stunting, reduced plant dry mass, and root necrosis occurred in FS seedlings compared with those in PS, but *M. angustifolia* seedlings were substantially more resistant or tolerant to RLN and ARD than the other species tested. Plant dry mass ranked MK>MS>MA>MI>MF>MC, and these differences were significant at the 5% level. RLN root populations were negatively correlated with plant dry mass, and accounted for about 10% of its variation, with nematode populations in roots ranking MC>MF>MK>MI>MS>MA. Useful resistance to ARD and parasitic nematodes apparently exists within *Malus* germplasm collections, and can be identified by testing more genotypes, developing rapid resistance screening methods, and comparing RLN host preferences among *Malus* genotypes and various orchard cover crops.

311 (PS 3)

A Molecular Marker Linked to a Scab Resistance Gene (*Vf*) in Apple

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Apple scab, caused by *Venturia inaequalis* (Cke.) Wint., is the most serious disease of apple trees. Resistance to *V. inaequalis*, derived from the small-fruited species *Malus floribunda* 821, is determined by a major dominant gene *Vf*. Our major objective is to identify RAPD markers linked to the *Vf* gene. The approach in this paper is based on the introgression of the *Vf* gene from *M. floribunda* into commercial cultivars. Almost 200 random sequence decamer-primers have been used to screen a pair of bulked samples and the donor parent *M. floribunda* clone 821 for markers linked to the *Vf* gene conferring resistance to apple scab. A single primer has been identified which generated a PCR fragment, OPK16/1300, from the donor parent *M. floribunda* clone 821 and the scab-resistant selections/cultivars bulk, but not from the scab-susceptible recurrent parent bulk. Co-segregation analysis using a segregating apple progeny and polymorphism analysis of individual scab-resistant Coop selections/cultivars have confirmed that this marker is linked to the scab-resistance gene *Vf*. OPK16/1300 has since been cloned and sequenced. Sequence-specific primers of 25 oligonucleotides based on the marker have been synthesized and used to screen further *M. floribunda* clone 821, scab-susceptible apple cultivars, scab-resistant apple cultivars, and scab-resistant Coop selections. The sequence-specific primers have identified polymorphisms of OPK16/1300 based on the presence or absence of a single band.

312 (PS 3)

Utilization of Identified Simple Sequence Repeats (SSRs) in *Malus* ×*domestica* (Apple) for Germplasm Characterization

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To comprehend genetic identity and relatedness in *Malus* germplasm held in situ and ex situ, we are employing simple sequence repeat (SSR) DNA fragment information in combination with passport and horticultural data. SSRs offer certain advantages for characterizing large arrays of germplasm efficiently. They are abundantly dispersed throughout plant genomes and are exceedingly polymorphic. In addition, they can be PCR-amplified and detected by automated fluorescence-based technology. A size-fractionated DNA library of *M.* ×*domestica* cv Golden Delicious was screened to identify SSR loci . Eight loci were found to be reliably informative and were used to prepare locus-specific primer pairs. Characterization of the 75 *M.* ×*domestica* accessions included in the core subset of the USDA-ARS *Malus* germplasm collection revealed six of the eight loci were polymorphic within the array. The number of alleles per locus ranged from two to 21. Throughput was enhanced by multiplexing, allowing simultaneous use of two or three primer pairs. With improved genetic characterization of *Malus* germplasm, we intend to better develop and relate the core subset to the rest of the collection and to in situ *Malus* genetic resources. SSR markers appear to be an efficient and reliable tool to expedite this process.

313 (PS 3)

Partitioning of Isozyme Diversity in Wild Populations of *Malus sieversii* L. and Implications for Germplasm Collection

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One of the primary progenitors of the cultivated apple (*Malus* ×*domestica*) is *M. sieversii*, a species native to the forested regions of Central Asia. Despite the horticultural importance of *M. sieversii*, little is known about its genetic variation. In this study, isozyme diversity at 18 loci was determined for 259 open-pollinated offspring belonging to 31 different maternal half-sib families collected from 14 different populations in 4 regions of central Asia. Genetic diversity statistics were computed from the resulting allele and phenotype frequencies. Cluster analysis of half-sib families showed that there was some grouping based on geographic region, but 16 of the half-sib families were most closely related to half-sib families from other regions. AMOVA, the analysis of molecular variance, indicated that most of the enzyme variability (85%) was attributable to differences among half-sib families within populations, none could be assigned to populations within regions, and 15% was due to differences among regions. In addition, no alleles were found that were both fixed in a region and unique to that region. These results suggest that plants belonging to *M. sieversii* effectively form a single panmictic population. Thus, a thorough sampling of a few large populations will efficiently capture most of the genetic diversity present in wild *M. sieversii*.

314 (PS 3)

Development of in Situ and ex Situ Conservation Strategies for *Malus* Wild Germplasm in Kazakhstan

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Malus sieversii, the main progenitor of domesticated apple, is native to areas in Central Asia. To better represent *Malus* wild germplasm in the USDA–ARS germplasm collections, maintained in Geneva, N.Y., a cooperative project was initiated with the Republic if Kazakhstan to collect and assess that country's wild populations of *M. sieversii* and to develop more secure in situ reserves to complement ex situ holdings in the United States and Kazakhstan. To date, four exploration trips to the region have included participants from the United States, Kazakhstan, Canada, New Zealand, and South Africa. Four Kazkh scientists have toured USDA–ARS sites, exchanged information, and collected germplasm in the United States greenhouse screens of 1600 have revealed potentially new sources of resistance to apple scab, cedar apple rust, and fire blight. An isozyme analysis of maternal half-sib families from four regions suggests the populations of *M. sieversii* collected represent a single panmictic population, with over 85% of total genetic variation due to differences among families. The most recent collections in 1995 were directed towards more ecologically diverse regions, including a site (Tarbagatai) at the most northern limit for *M. sieversii* equivalent to northern Minnesota in the United States. Some trees in this region produced fruit nearly 70 mm in diameter with excellent aroma, firmness, and color. This germplasm is being systematically characterized for horticultural traits, pest and disease resistance, and molecular markers.

315 (PS 3)

Identification of Apple Rootstocks by Fourier Transform Infrared Spectroscopy

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Proper identification of apple rootstocks has always been a problem for nurseries and fruit growers. There needs to be a rapid, inexpensive, and repeatable protocol for identification of apple rootstocks. Fourier transform infrared spectroscopy (FTIR), an analytical chemical technique based on infrared laser characterization of molecular bonding energies for biochemical compounds, such as proteins, may provide an answer. Several rootstocks from the 1984 NC-140 apple rootstock trial were compared. Using a BioRad research spectrometer, spectra derived from 1000 scans per freeze dried sample were used to compare the rootstocks. Using Hit Quality Indices (HQI) generated by Lab Calc software, the rootstocks M.7 EMLA, B.9, and a seedling rootstock were compared with themselves, and each of the other two samples. A perfect match gives a HQI of zero. It was found that root cortex tissue could be used to separate these rootstocks from each other, but root xylem tissue was a poor tissue to use for identification.

147 POSTER SESSION (Abstr. 316–323) Breeding and Genetics–Small Fruits/ Viticulture

316 (PS 8)

Heritability of Rosette Resistance in Blackberry

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A study was conducted to determine if blackberry cultivars Humble, Rosborough, and Brazos transmit rosette (incited by *Cercosporella rubi*) resistance and to estimate heritability (h^2). Plants of parents and offspring involving these

cultivars were rated for rosette severity on a whole plant basis from 0 = no rosette to 7 = all buds infected or plant dead. An estimate of h^2 was computed by regression of cross means on parental means. The mean rosette severity rating of plants from crosses was always intermediate between the cultivar and other parents. Only 'Humble' transmitted enough rosette tolerance to be usable although 'Rosborough' crosses were more tolerant than the other parents. The h^2 estimate of 0.48 was fairly high but low variability among parents other than 'Humble' would suggest little progress from mass selection.

317 (PS 8)

Crossability of 14 *Rubus* Species with Red Raspberry and Blackberry Cultivars

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Populations of 40 *Rubus* sp., representing the Malachobatus, Idaeobatus, Eubatus, and Anoplobatus, were planted in the field in 1994. To get a preliminary idea of how successful crosses between these species and standard cultivars would be, 58 crosses were attempted between standard cultivars and randomly selected genotypes of the 14 species that produced a significant number of flowers in 1995. Diploid species were crossed with 'Tulameen' and 'Meeker' raspberry and the tetraploid species with 'Cherokee' and 'Chester' blackberry. Twenty-two crosses produced seed lots ranging from 8 to 630 seeds. Crosses were successful with *R. caesius*, *R. caucasicus*, *R. coreanus*, *R. georgicus*, *R. parvifolius*, *R. rosifolius*, and *R. sumatranus*. Crosses were not successful with *R. eustephanos*, *R. insularis*, *R. innominatus*, *R. lambertianus*, *R. sachalinensis*, *R. setchuenensis*, *R. swinhoei*, and *R. tsangorum*. In vitro seed germination was attempted with all crosses. Larger seed lots were also germinated using standard procedures for *Rubus*. There is a great deal of variability in leaf morphology of the young seedlings within a cross that suggests that some or all of the seedlings are true hybrids. Seedlings that are not true hybrids could result from contaminant pollen or, as in *R. armeniacus*, pseudogamous embryo formation. Crossing results from 1995 and 1996, including crosses attempted and seed numbers per cross, will be presented along with, for the 1995 crosses, the number of germinated seedlings and our assessment of whether they appear to be true hybrids.

318 (PS 8)

Taxonomic Relationships in *Rubus* based on RAPD and Hybridization Analysis

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RAPD analysis was performed on 44 species of *Rubus*. These species included representatives from seven of the 12 subgenera within the genus and several series within the Idaeobatus (raspberries) and Eubatus (blackberries) subgenera. For all species, up to five plants were initially analyzed by two 10-mer primers. The most heterozygous of these individuals was then analyzed using 13 additional primers. Wide band diversity exists among *Rubus* species; these differences were analyzed using the PHYLIP software program. These differences are repeatable, for example color sports of 'Heritage' red raspberry produced identical banding patterns. The genetic similarity between eastern United States blackberries (Eubatus) and numerous species was compared to the ability of these same species to act as a suitable pollen parent for eastern blackberries. These data were used to construct a dendrogram of the subgenera studied here.

319 (PS 8)

Identification of Raspberry–Blackberry Hybrid Seedlings by Isozyme Staining and Soluble Protein Banding Patterns

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Isozyme staining and SDS-PAGE of soluble proteins were performed using leaf homogenates from 6- to 8-month-old field-grown seedlings resulting from the cross of either 'Heritage' or 'Nova' raspberry with ARK-577 diploid blackberry, the latter used as the pollen-donor parent. Four enzyme systems were tested: ADH, PGM, MDH, and PGI. Of these, ADH and PGM did not show any activity; MDH was monomorphic in both raspberry and blackberry parents, with activity at the same migration distance. PGI was polymorphic in the two raspberry cultivars, showing three dimeric bands, but monomorphic in blackberry; the allele for PGI in blackberry being common to that allele coding for the most cathodal band in raspberry. This phenomenon, in addition to poor resolution of bands (due, perhaps to low enzyme activity) and evidence of accidental self-pollination in our populations, prevented us from positively identifying the hybrid offspring using isozymes. By SDS-PAGE of soluble proteins, two bands were detected that seemed to be unique to ARK-577 blackberry and were also expressed in some of the offspring, suggesting a hybrid origin of these seedlings. Morphological comparisons indicated that those seedlings possessing the two unique bands highly resemble the blackberry male parent, greatly supporting their hybrid origin. Unless additional analysis shows otherwise, SDS-PAGE can be used to identify Raspberry–Blackberry hybrids during their vegetative stage of development, and might prove applicable to other interspecific hybrids of *Rubus*.

320 (PS 8)

Isozyme Inheritance and Variation in *Actinidia*

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Isozyme inheritance and variation in *Actinidia* was investigated using 23 enzyme systems. Ten isozyme loci from six enzyme systems, Acp-2, Est, Prx-1, Prx-2, Prx-4, Prx-5, Pgi-2, Pgm-2, and Tpi, were found to be inherited as single Mendelian genes in families of two interspecific crosses. Disomic inheritance detected at ten loci in progenies of a cross between the hexaploid *A. deliciosa* x diploid *A. chinensis*, provided convincing evidence that *A. deliciosa* is an allohexaploid. Allelic segregation for tetrasomic inheritance at ten isozyme loci was demonstrated in the progenies of a cross between the tetraploid *A. chinensis* x diploid *A. eriantha*, a result suggesting the autotetraploid origin of the tetraploid *A. chinensis* which apparently originated from its diploid ancestor *A. chinensis*. A high level of isozyme variation and heterozygosity were observed in the 22 cultivars and 56 plants of 28 *Actinidia* taxa. Allozyme phenotype can be used effectively for cultivar identification.

321 (PS 8)

Prospects for Fingerprinting the USDA–ARS Cold-hardy *Vitis* Germplasm Collection using Simple Sequence Repeat (SSR) Markers

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Curators of plant genetic resources collections must preserve germplasm possessing known useful characteristics as well as material displaying general genetic diversity. In order to ensure that both types of germplasm are included in a collection, germplasm curators require three fundamental types of information about each accession: taxonomic identity, genetic identity, and genetic relationship. Because simple sequence repeat DNA fragments (SSRs) have been successfully used to determine the genetic identity of grape clones, we conducted a study to determine if SSRs would supply all three types of information for the accessions in the cold-hardy *Vitis* (grape) germplasm collection. SSR fragments were amplified at six different loci for 23 accessions of cold-hardy grape spanning the range of species diversity in the collection. The minimum number of different alleles found at a locus was 9; the maximum was 26. Heterozygosity values ranged between 0.565 and 0.783, while gene diversity values were in the range 0.785 to 0.944. Two hundred fifty-two pairs of plants out of a possible 253 could be distinguished by their SSR profiles. Nei's genetic identities were computed between all pairs of plants and used in a UPGMA cluster analysis. The relationships obtained did not correspond well to expected relationships based on geography and taxonomy. Four species of grapes were represented by two or more accessions in this study. No DNA fragments found at these six loci served to unambiguously distinguish one species from another. Thus, SSR fragments from the six loci studied were useful in determining genetic identity of accessions, but were not helpful in determining genetic relationships or taxonomic identities. We are searching for additional loci that are informative for these types of information. Meanwhile we highly recommend SSRs for determining genetic identity in germplasm resources collections.

322 (PS 8)

Evaluation of *Vitis* Species Found in Selected Locations of Texas and New Mexico

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North American *Vitis* species and hybrids thereof have been the source of rootstocks for *V. vinifera* for the last century. Collection and evaluation of native *Vitis* in north-central Texas, western Texas, and New Mexico have been made to determine their current status. Known geographical pockets of grapevines were visited, with specimens taken and identified by comparison to herbarium collections and published descriptions. In locals where more than one species existed, many natural hybrids with varying morphological characteristics have become established. In North Central Texas, two areas were visited. The first was Tarrant, Parker and Wise counties where three grapevine species (*V. mustangensis*, *V. cinerea* var. *helleri*, and *V. vulpina*) and many hybrids were observed. The second was Wilbarger County where *V. acerifolia* was found growing in the south while *V.* ×*doaniana* was found growing in the north. West Texas was primarily populated with *V. acerifolia* with the exception of the Silver Falls Canyon area in Crosby County where hybrids of *V. acerifolia*, *V. arizonica* and *V. riparia* were observed. In New Mexico, two areas were visited: San Miquel County (North Central region), where *V. acerifolia*, *V. arizonica*, and *V. riparia* were observed and Eddy County (southern New Mexico) where *V. arizonica* was observed. A rich diversity of *Vitis* germplasm appears to remain in these habitats.

323 (PS 8)

Evaluation of Grape Germplasm for Downy Mildew (*Plasmopara viticola*) Resistance as Related to Leaf Pubescence and Stomatal Density

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Plasmopara viticola infects and sporulates through stomata of susceptible grape leaves. Sporulation, chlorosis, and necrosis ratings were made in 1994 and 1995 on grape selections and cultivars and *Vitis* species grown in a fungicide-free vineyard. Cellulose-acetate impressions were made of the abaxial leaf surfaces and stomata were carefully counted within a circle 100 μm in diameter under a light microscope. Leaves were rated as either pubescent or glabrous. There were significant differences among genotypes for sporulation, chlorosis, and necrosis for 1994 and 1995, with highly significant correlations over both years. Stomatal densities were significantly different, but there were no correlations among levels of downy mildew and stomata! densities. Pubescent leaves had significantly higher sporulation, chlorosis, and necrosis ratings for downy mildew than glabrous leaves over both years.

104 POSTER SESSION (Abstr. 324–334) Breeding and Genetics–Vegetables I (Disease and Insect Resistance)

324 (PS 1)

Development of Strategies to Evaluate *Brassica oleracea* L. Vegetable Crops for Wirestem Caused by *Rhizoctonia solani*

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Wirestem, caused by *Rhizoctonia solani*, is a destructive disease of *B. oleracea* cole crops and is distributed worldwide. Effective means of wirestem control include soil fumigation and soil treatment with pentachloronitrobenzene, which are increasingly expensive and environmentally undesirable. As a consequence, alternative methods of wirestem control are needed. Thus, we conducted controlled-environment and field experiments to develop methodology to study host-plant resistance and possibly biocontrol agents as potential wirestem control alternatives. Seedlings of 12 cultivars (three each of cauliflower, broccoli, cabbage, and collard) at the four- to five-leaf stage were transplanted to trays in a growth room or into field plots and covered with soil infested with *R. solani* AG-4 sclerotia. Disease progression (percent of plants healthy, diseased, and dead) was observed every 3 days for 2 weeks in the controlled environments and for 3 weeks in field trials. At the end of two studies, plants were dug with roots intact and rated for disease using a 1 to 10 scale. In all trials, percent healthy plants stabilized at about 2 weeks after inoculation. Incidence of wirestem disease varied among experiments ranging from 70% to 100% diseased, dead plants in controlled environments, and from 51% to 88% and 33% 65% in the two respective field studies. Disease rating was always negatively and significantly correlated with percent healthy plants. Although a genotype × environment interaction was observed, some cultivars (i.e., 'Snowcone' and 'Snowcrown' cauliflowers) were always severely diseased, while others (i.e., 'Viking' broccoli and 'Blue Max' collard) were consistently among the least diseased.

325 (PS 1)

Inheritance of Resistance to Halo Blight Flower and Stem Color and Association in Common Beans

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Halo blight is one of the most important bacterial diseases of common beans (*Phaseolus vulgaris* L.). It is serious under moderate temperature and high humidity conditions. The disease is caused by a seed-borne bacterium, *Pseudomonas syringae* pv. *phaseolicola* (Burkh.) Dowson (*Psp*). The inheritance of leaf reactions to *Psp,* flower, and stem color was studied using greenhouse-grown 109 F_9 recombinant inbred lines (RI) from the *P. vulgaris* cross BelNeb 1 [resistant (R)] (USDA/NE) x A 55 [susceptible (S)] (CIAT). Two *Psp* strains, HB16 (NE) and 83-Sc2A (NE), were inoculated using the water-soaking method. A segregation ratio of 1 R :1 S RI lines were observed for disease reactions in leaves for both strains indicating major gene control. The presence of recombinants for SR, RS to the strains indicated that different genes were involved. Stem (SC) and flower (FC) color traits were each determined by two major genes. Linkages were found for reactions to the two *Psp* strains and also between FC and SC. No linkages were observed from FC and also SC with reactions to *Psp* strains.

326 (PS 1)

Resistance to Race T2 of the Bacterial Spot Pathogen in Tomato

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Thirty-three tomato (*Lycopersicon esculentum* Mill.) or *L. pimpinellifolium* (L.) Mill. accessions were inoculated with race T2 of *Xanthomonas campestris* pv. *vesicatoria* (Xcv) in a field experiment at Wooster, Ohio, in Summer 1995. These included accessions selected for race T2 resistance in greenhouse tests in Florida, and accessions from Hawaii, Brazil, and Bulgaria. One *L. esculentum* (PI 114490-1-1) and three *L. pimpinellifolium* (PI 340905-S1, PI 128216-T2, and LA 442-1-BK) accessions had no Xcv symptoms. This is the first report of resistance to Xcv race T2. Partial resistance was found in PI 271385, PI 79532-S1, PI 155372-S1, PI 195002, and PI 126428. Most of the 33 genotypes were tested for race T1 resistance in Presidente Prudente, Sao Paulo, Brazil in summer 1993. Hawaii 7983, PI 155372-S1, PI 114490, PI 114490-S1, and PI 262173 had greater resistance to T1 than the susceptible control 'Solar Set'. Comparisons with earlier experiments in which accessions were inoculated with race T1 or T3 indicated that the most consistent source of resistance to all three races was PI 114490 or selections from it.

327 (PS 1)

Evaluation of Scotch Bonnet and Habanero Peppers (*Capsicum chinense*) For Resistance to Southern Root-knot Nematodes

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Scotch Bonnet and Habanero peppers, extremely pungent cultivar classes of *Capsicum chinense,* are becoming popular in the United States. Since the southern root-knot nematode (*Meloidogyne incognita*) is a major pest of many C. *annuum* cultivars commonly grown in the United States, a series of greenhouse and field studies was conducted to determine whether Scotch Bonnet and Habanero peppers also are vulnerable to the pest. An effort was made to collect Scotch Bonnet and Habanero seeds from all available commercial and private sources. In an initial greenhouse test, a collection of 59 *C. chinense* accessions was evaluated for reaction to *M. incognita* (race 3). All accessions obtained from commer-

cial sources were moderately susceptible or susceptible. However, four accessions obtained via Seed Savers Exchange listings exhibited high levels of resistance. Three of these accessions (identified by the seed sources as Yellow Scotch Bonnet, Jamaica Scotch Bonnet, and Red Habanero) were studied in subsequent greenhouse and field plantings, and each was confirmed to have a level of resistance similar to the level of resistance exhibited by the *C. annuum* cv. Mississippi Nemaheart. Each of the resistant lines has good fruit and yield characteristics. The two Scotch Bonnet accessions produce yellow, bonnet-shaped fruit. The Red Habanero accession does not produce the lantern-shaped fruit typical of Habanero cultivars; the fruit have a bonnet shape.

328 (PS 1)

Heritability of Root-knot Nematode (*Meloidogyne* spp.) Resistance in Sweetpotatoes

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Heritabilities for resistance to root knot nematodes (*Meloidogyne javanica* and *Meloidogyne incognita* races 1, 2, 3, and 4) were studied in a population of 226 sweetpotato clones of diverse origin. For each nematode isolate tested, 128-cell speedling trays were filled with previously inoculated substrate (30000 eggs/1000 mL substrate). Sweetpotato clones suitably tagged and identified were randomly planted in the cells (one plant/cell), with a total of four plants per clone per isolate. Ninety days after inoculation, sweetpotato plants had their roots washed for substrate removal, and treated with 150 mg$\cdot$L^{-1} Phloxine B to stain nematode egg masses. The number of egg masses per root was recorded, and plants were accordingly assigned scores from 0 (highly resistant) to 5 (highly susceptible). Broad-sense heritability estimates were 0.87, 0.91, 0.81, 0.95, and 0.93 respectively for resistance to *M. javanica* and races 1, 2, 3, and 4 of *M. incognita.* The frequencies of resistant genotypes were higher for M. javanica and lower for *M. incognita* race 2. Genotypic correlations (rG) among the resistances to the various Meloidogyne isolates utilized were weak, ranging from 0.11 to 0.57, suggesting independent genetic controls. Clones could be selected, however, with high levels of resistance to all nematode isolates tested. (This work was supported by CNPq, CAPES, FAPEMIG, and FAEPE/UFLA.)

329 (PS 1)

2-Tridecanone-mediated Mechanisms of Resistance to the South American Tomato Pinworm *Scrobipalpuloides absoluta* (Meyrick, 1917) (Lepidoptera-Gelechiidae) in *Lycopersicon* spp.

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Oviposition and feeding of *Scrobipalpuloides absoluta* was studied on plants of seven different genotypes with varying 2-tridecanone (2-TD) foliage concentrations: *Lycopersicon esculentum* var. *glabratum* PI 1344417 (GLA), *L. esculentum* TSWV-547 (ESC), F1 (ESC x GLA), and four F_2 genotypes—two with high 2-TD (HI1, HI2) and two with low foliage 2-TD concentrations (LO1, LO2). GLA, HI1, and HI2 showed 2-TD concentrations above 185×10^{-12} mol$\cdot$cm^2, while ESC, LO1 and LO2 had 2-TD below 40×10^{-12} mol$\cdot$cm^2; F1 had intermediary levels of 2-TD (83.5×10^{-12} mol 2-TD/cm^2). Ovipositioning was substantially higher in the low 2-TD than on either the high 2-TD genotypes or in the F_1, especially in the upper portion of the plants. Scores for leaf lesion type (LLT), overall plant damage (OPD) and percent leaflets attacked (PLA) were substantially higher for the low 2-TD than for either the high 2-TD genotypes or the F_1. The results indicate that 2-TD mediates resistance to *Scrobipalpuloides absoluta* in the interspecific cross, and strongly suggest that 2-TD acts as both an ovipositioning and feeding deterrent for this insect.

330 (PS 1)

Initial Screening of Sweet Corn Tissues for Allelochemicals that Affect European Corn Borer Larval Development

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European corn borer (ECB), *Ostrinia nubilalis* Hübner, can severely affect sweet corn quality. Selection techniques in field experiments have improved ear feeding resistance associated with morphological features and/or allelochemicals. A laboratory bioassay was used to detect chemical resistance factors in silk and kernel tissues of 10 variously resistant sweet corn genotypes. When added to a nutritively complete diet, kernel tissue from W182E, MN275, and MN272 decreased ($P \leq 0.05$) 10-day larval weight (66.3, 61.7, and 54.5 mg, respectively) while kernel tissue from MG15, MN270, and MN3053 increased ($P \leq 0.05$) 10-day larval weight (88.3, 81.5, and 80.8 mg, respectively) compared to a cellulose control (71.0 mg). These weight differences, however, were not significant developmentally as 10-day larval maturation (fourth to fifth instar) and pupation time (13.9 to 16.3 days) were similar to the cellulose control (fifth instar and 14.8 days). Silk tissue additions to the diet decreased ($P \leq 0.05$) 10-day larval weight compared to the cellulose control (71.0 mg). Larvae exposed to diet containing silk tissue from MN3053, W182E, and 'Apache' were lightest (9.1, 8.3, and 7.8 mg, respectively). The heaviest larvae exposed to silk tissue were from diet including 'Jubilee' tissue (54.1 mg). Contrary to the instar levels found on the cellulose control, larvae feeding for 10 days on a diet containing silk tissue mainly were at third or early fourth instar excluding larvae exposed to 'Jubilee' silk (fourth to fifth instar). For all genotypes, silk additions to diet increased the pupation time compared to kernel additions. Kernel, and especially silk tissue, may contain chemical resistance factors which decrease larval weight and increase developmental time. Identifying sweet corn genotypes with chemical resistance factors may enhance ECB resistance breeding efficiency.

331 (PS 1)

Yield, Viral Reaction, and Plant Characteristics of Summer Squash Lines and Hybrids

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Culture of the Gray Zucchini (GZ) variety of summer squash in northwestern Mexico during the fall is severely affected by a viral disease, which is apparently caused by squash leaf curl virus (SLQV). Resistance to this disease was introduced from local *Cucurbita moschata* landraces and uniform GZ-type lines and hybrids (GZLH) were developed. Crosses between lines were performed during Spring 1995. In the Fall, 21 GZLH plus the commercial materials PSR-59792, Raven, and GZ (usually included as a control) were studied. The commercial materials showed a higher degree of virus infection than GZLH. Four of the materials that showed symptoms of virus infection and one free of symptoms were tested for SLCV and all were positive for this virus. Eight GZLH had higher overall and 1× yields than GZ and nine and four GZLH were better than GZ for 2× and 3× yields, respectively. Number of stems varied from one to seven and stem and internode length had values from 42 to 145 cm and from 1.2 to 4.8 cm, respectively. These results were consistent with other similar studies previously reported.

332 (PS 1)

Inheritance of Resistance to the Moroccan Watermelon Mosaic Virus in the Cucumber Line TMG-1 and its Relationship to Zucchini Yellow Mosaic Virus Resistance

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Potyviruses cause severe loss in cucurbit crops. Inbred lines derived from the Chinese cucumber cultivar, Taichung Mau Gua (TMG), have been identified to be resistant to several potyviruses including zucchini yellow mosaic virus (ZYMV), zucchini yellow fleck virus, watermelon mosaic virus, and the watermelon strain of papaya ringspot virus. Recently, an additional virus that infects cucurbits, the Moroccan watermelon mosaic virus (MWMV), has been identified to be a distinct member of the potyvirus group. In this study, we sought to determine if TMG-1 is resistant to MWMV and, if so, examine whether a relationship exists between resistance to MWMV and resistance to ZYMV. Progeny analyses show that TMG-1 is resistant to MWMV and, like resistance to ZYMV, MWMV resistance is conferred by a single recessive gene. Sequential inoculation of progeny possessing resistance to ZYMV followed by MWMV (or MWMV followed by ZYMV) suggests that both resistances are conferred by the same gene, or two tightly linked genes. Additionally, all F_3 families derived from F_2 individuals selected for resistance to ZYMV, were resistant to MWMV. A second source of resistance to ZYMV, allelic to the TMG-1 source, has been incorporated into the Dutch hybrid Dina. Progeny analyses show Dina to posses a single recessive gene for MWMV resistance. As with TMG-1, no segregation of resistances was observed when ZYMV resistant progeny were inoculated with MWMV (or MWMV followed by ZYMV). Collectively, these results suggest that a single gene, or two tightly linked genes, control resistance to the potyviruses ZYMV and MWMV.

333 (PS 1)

Examination of the Inheritance of Resistance of *Colletotrichum orbiculare* Race 2 in Cucumber

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Anthracnose of cucurbits, caused by *Colletotrichum orbiculare,* is composed of three races (race 1, 2, and 2B). The inheritance of race 1 in cucumber is reported to be controlled by a single recessive gene. Although the mode of inheritance to race 2 in cucumber has not been determined, it has been suggested that is quantitatively inherited. Four cucumber cultivars, H19 from two sources [the commercial seed (P1) and the breeders seed (P2)], Pixie (P3), and Marketer (P4), that were considered highly resistant, moderately resistant and highly susceptible, respectively, to race 2 were used as the parents in this study. Crosses between resistant x susceptible and resistant x moderately resistant were made. Some reciprocal crosses also were made. The F_1 progeny were then evaluated for resistance to race 2 in a cotyledon assay. Disease severity was assessed 8 days after inoculation using a disease rating scale of 0–7, whereby 0 = healthy plant and 7 = 100% chlorosis or necrosis. All progeny from P1 x P1 were highly resistant (disease severity 19 < 2.5); P2 x P2 and P3 x P3 were highly moderately resistant (disease severity 2.6–4.9); and all P4 x P4 progeny were highly susceptible (disease severity > 5.0) to race 2. All F_1 progeny showed a continuum of disease ratings from highly resistant to moderately resistant to race 2. The disease ratings of the F_1 progeny would indicate that resistance to race 2 is controlled by multiple genes.

334 (PS 1)

Breeding for Root-knot Nematode Resistance in Cucumber

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Root-knot caused by *Meloidogyne* spp. is the primary disease of cucumber (*Cucumis sativus* L.) in North Carolina, causing an annual yield loss of approximately 12 %. All cucumber cultivars we have tested are resistant to *M. hapla*, but none are resistant to any of the four important nematodes found on cucumber in North Carolina: *M. incognita*, *M. arenaria* races 1 and 2, and *M. javanica*. However, we are preparing to release three cucumber inbreds with resistance to four out of five of those nematodes. 'Marion' (NC-44), 'Shelby' (NC-45), and 'Lucia' (NC-46) are high yielding, monoecious pickling cucumber inbreds that have resistance to *M. arenaria* races 1 and 2, *M. javanica*, and *M. hapla*. Length : diameter ratio was 3.4, 3.0, 3.9 for 'Marion', 'Shelby', 'Lucia' ('Calypso' was 2.9 in the same trial), respectively. Thus, different length requirements for the pickling industry can be met with the three cultivars. Based on the 1995 North Carolina stage 1 pickle trial, performance (as % of 'Calypso') for 'Marion', 'Shelby', and 'Lucia' respectively was 79%, 94%, and 115% for total fruit number/ha; 71%, 96%, and 113% for marketable fruit number/ha; and 102%, 84%, and 97% for fruit quality rating. Therefore, nematode resistant cultivars are available that match the performance of the gynoecious hybrid check cultivar for the region.

106 POSTER SESSION (Abstr. 335–343) Breeding and Genetics–Vegetables II (Molecular Markers and Physiological Genetics)

335 (PS 2)

Identification of RAPD Markers Linked to Major Gene for Indeterminate Growth Habit using Bulked Segregant Analysis in Common Bean Cross

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Plant growth habit is an important trait. Our objective was to identify RAPD markers linked to major gene for indeterminate growth habit using bulked segregant analysis in an F_2 population from a bean cross Chichara (indeterminate growth habit x PC-50 (determinate growth habit). A total of 132 RAPD primers (600 RAPD primer screened) showed polymorphisms between bulked DNA derived from indeterminate and determinate plants. All markers showed coupling linkage with indeterminate growth habit. RAPD markers of A-8, A-17, C-7, C-15, D-4, D-5, F-6, F-16, G-9, H-3, H-20, and I-7 were 2.2 cM distant from the gene for indeterminate growth habit. Markers of B-7, B-16, B-17, C-8, E-1, F-1, F-20 and H-I9 primers were 4.6 cM distant from the gene for indeterminate growth habit.

336 (PS 2)

Identification of RAPD Markers Linked to Major Genes for Common Bacterial Blight (CBB) Resistance Using Bulked Segregant Analysis in a Tepary Bean Cross

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Common bacterial blight (CBB), incited by *Xanthomonas campestris* pv. *phaseoli* (*Xcp*), an important disease in common bean (*Phaseolus vulgaris* L.) Tepary bean (*P. acutifolius* A. Gray) is of interest to bean breeders because of resistance to CBB. Our objective was to identify RAPD markers linked to major genes for CBB resistance using bulked segregant analysis in an F_2 population from a tepary bean cross CIAT640005 (R) X Nebr#4B (S). A total of 57 RAPD primers (602 RAPD primers screened) showed polymorphisms between bulked DNA derived from R and S CBB plants. All markers showed coupling linkage with CBB resistance. A good fit to a 3:1 ratio of bands for presence and absence using 11 RAPD primers was observed in 77 F_2 plants. Markers of U-15 and L-7 primers were 2.4 cM distant from the gene for resistance to *Xcp* strain LB-2. RAPD markers of U-10, U-20, S-12, Y-4, F-13, P-6, Q-1, and Q-II primers were 2.4 cM distant from the gene for resistance to *Xcp* strain SC-4A. RAPD markers of IJ-15 and L-7 primers were 8.4 cM distant from the gene for resistance to *Xcp* strain EKI I.The tepary RAPD linkage group includes three molecular markers and three genes for resistance to *Xcp* strains EK-I I, LB-2, and SC-4A and spans a length of 19.2 cM. This data supports the presence of *Xcp* races.

337 (PS 2)

RAPD Linkage Map Based on an Interspecific Cross between *Solanum commersonii* and *Solanum cardiophyllum*

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To generate a linkage map for further genetic analysis of the traits involved in cold hardiness of potato, we are constructing a RAPD-based linkage map using a two-generation interspecific pedigree of *Solanum commersonii* and *S. cardiophyllum*, a hardy and non-hardy species, respectively. We initially screened 220 primers of 10-base arbitrary sequences and selected 86 to amplify a total of 577 polymorphic bands: 301 *S. commersonii*-specific and 276 *S. cardiophyllum*-specific bands. Segregation of a total of 247 markers was scored on a population of 44 F_1 individuals. From these 247 markers, we have identified 117 markers, which segregate 1:1 in the F_1 progeny following a test cross configuration. A RAPD linkage map for *S. commersonii* will be presented.

338 (PS 2)

Confirmation of QTL Associated with Common Bacterial Blight Resistance in *Phaseolus vulgaris* L.

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Common bacterial blight (CBB) incited by the bacterial pathogen *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye is an important disease of common bean. In a previous study, QTL associated with CBB resistance were described based on RAPD marker analysis of a recombinant inbred population derived from the common bean cross BAC-6 (R) x HT-7719 (S) (resistant x susceptible). The objective of this research is to confirm these previously described candidate marker locus-QTL associations using an inbred backcross PC-50 (S) x BAC-6 (R) and a recombinant inbred Venezuela 44 (S) x BAC-6 (R) population. Two markers previously found to be associated with QTL for CBB resistance in the BAC-6 x HT-7719 population were found to account for 30% of the phenotypic variation for CBB resistance in the PC-50 x BAC-6 inbred backcross population. The three most resistant BC2F3 lines based on marker locus genotypes were ranked 1, 3, and 7 (out of 64) based on phenotypic evaluation. These results provide important confirmation of marker locus-QTL associations and indicate that RAPD markers linked to loci controlling the expression of CBB resistance in common bean may be used to transfer resistance genes into susceptible breeding material.

339 (PS 2)

Tagging a Downy Mildew Resistance Gene in Cucumber Using RAPD Markers

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Downy mildew in cucumber (*Cucumis sativus* L.) is a disease caused by *Psuedoperonospora cubensis* (Berk. and Curt.). Genetic resistance is used to control this disease. However, selection for resistance to downy mildew requires considerable effort. Molecular markers that are closely linked to a gene for downy mildew resistance may be useful for increasing selection efficiency. RAPD (randomly amplified polymorphic DNA) markers are molecular markers that have several advantages including economy, abundance and high rate polymorphism. Two populations, WI 1983 x Straight 8 and ZuDM1 x Straight 8, were used to identify RAPD markers linked to a downy mildew resistance gene. The WI 1983 x Straight 8 population contained 63 F_3 families and the ZuDM1 x Straight 8 population contained 90. These F_3 families were evaluated for disease reactions in four locations—Wisconsin, South Carolina, Spain, and The Netherlands. Four replications were conducted in Wisconsin and two in the remaining locations. The ranking of susceptible and resistant families was consistent over the locations. Spearman rank coefficients between locations ranged from 0.65 to 0.84. DNA samples from individual F_2 plants in each population were combined into two bulks, one resistant and one susceptible, based on the family performance. Then, PCR analysis was performed. Over 100 polymorphic primers were screened using this bulked segregant analysis to find the resistance gene to RAPD genetic linkage.

340 (PS 2)

Genetic Analysis of Salt Tolerance during Vegetative Growth in Tomato

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Breeding for salt tolerance in tomato (*Lycopersicon esculentum* Mill.) has been restricted by insufficient knowledge of the genetic control of tolerance. The genetic basis of salt tolerance during vegetative growth was investigated by growing a salt tolerant (PI174263) and a salt sensitive tomato cultivar (UCT5) and their F_1, F_2, and backcross progeny in saline solutions with electrical conductivity of 0.5 (control) and 20 $dS \cdot m^{-1}$ (salt-stress). The relative salt tolerance of each generation was determined as the percentage of growth (i.e., dry matter production) under salt-stress relative to growth under control conditions. In all generations, shoot growth was significantly reduced by salt-stress. The reduction was largest in UCT5 (56.1%) and smallest in the F_1 (27.4%) followed by PI174263 (32.3%). Analysis of the absolute and relative growth under salt-stress indicated that genes contributing to vigor might be different from genes conferring tolerance. Generation means analyses of the absolute and relative growth indicated that the majority of the genetic variation among generations were due to simple (additive and dominance) genetic effects; nonallelic interactions, although significant, were far less important. Partitioning of the total genetic variance by weighted least square regression analysis and variance component analysis indicated that 88% or more of the variation were due to additive genetic effects. A moderate estimate of narrow sense heritability (0.49 ± 0.09) was obtained for shoot dry weight under salt-stress treatment. The results indicate that tomato salt tolerance during vegetative growth can be improved by breeding and selection.

341 (PS 2)

Genetic Basis of Physiological Traits Related to Salt Tolerance in Tomato

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Genetic relationships between salt tolerance and expression of various physiological traits during vegetative growth in tomato were investigated. Parental, F_1, F_2, and backcross progeny of a cross between a salt tolerant (PI174263) and a salt sensitive cultivar (UCT5) were evaluated in saline solutions with electrical conductivity of 0.5 (non-stress) and 20 $dS \cdot m^{-1}$ (salt-stress). Absolute growth, relative growth, tissue ion content, leaf solute potential and the rate of ethylene evolution by leaf petioles were measured. Growth of both parents were reduced under stress, however, the reduction was significantly less in PI174263 than UCT5 suggesting greater salt tolerance of the former. Under salt-stress, PI174263 accumulated in the leaf significantly less Na^+ and Cl^- and more Ca^{2+} than UCT5. The F_1 hybrid performed intermediate relative to parents and the backcross populations approached recurrent parents in both growth response and ion accumulation. In all generations, leaf solute potential decreased and the rate of ethylene evolution increased under salt-stress, however, there were little or no differences among generations under either treatment. Across generations growth under salt-stress was positively correlated with Ca^{2+} and negatively correlated with Na^+ accumulation in the leaf. In contrast, growth was not correlated with either leaf solute potential or the rate of ethylene evolution. Generation means analysis indicated that Na^+ and Ca^{2+} accumulations were genetically controlled with additivity being the major genetic components. The results indicated that the inherent genetic capabilities of PI174263 to maintain high tissue Ca^{2+} levels and to exclude Na^+ from shoot were essential features underlying its adaptation to salinity. Thus, tissue ion concentration may be a useful selection criterion when breeding for improved salt tolerance of tomato using progeny derived from PI174263.

342 (PS 2)

The Expression of Nonacclimated Freezing Tolerance and Acclimation Capacity in Progeny Derived from Somatic Hybrids of *Solanum tuberosum* and *S. commersonii*

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Tetraploid somatic hybrids between *S. tuberosum* (tbr) and *S. commersonii* (cmm) have been produced to incorporate desirable traits such as cold hardiness from cmm into cultivated potatoes. While nonacclimated freezing tolerance (NA) of these somatic hybrids were as low as tbr fusion parent, their acclimation capacity (ACC) approximated that of the parental mean. In order to further explore the potential of using these somatic hybrids in breeding programs and to examine the segregation of genes conferring NA and ACC in somatic hybrids, progenies have been developed from either selfing somatic hybrids or crossing them with a tuberosum breeding line, Wis 231. In total, 48 selfed and 6 backcross progenies were characterized for the expression of NA and ACC. The NA derived from cmm was still poorly recovered in both sets of progenies. However, ACC did show some variation ranging from the level of sensitive fusion parent to that of the selfed parent, HA 26-5. None of the progeny had ACC as high as their cmm parent. Our results suggest that the expression of NA was suppressed by the cold sensitive genome of tbr. Thus, ACC is the form of cold tolerance from cmm, which appears to be most easily accessed though these somatic hybrids.

343 (PS 2)

Inheritance and Gibberellic Acid Sensitivity of a Dwarf Red Beet Mutant

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Few genes have been identified in red beet. A spontaneously occurring dwarf mutant was identified in the late 1970s and again in 1994 in several breeding populations. Mutant plants are characterized by extreme dwarfing of both root and shoot. Young leaves are narrow, thin and strap-like while older leaves are thicker and deeply veined. The shoot axis forms a compressed rosette. Neither the shoot axis nor the root axis of field-grown plants exceeds 3 cm in height. Genetic analysis of F_2 and backcross populations revealed the dwarf phenotype is conditioned by a single recessive gene. Several experiments were conducted to determine if the dwarf phenotype was due to a lack of gibberellic acid (GA) production. Exogenous application of GA_3 at concentrations ranging from 1 to 1000 ppm on dwarf plants a) following seeding and b) during reproductive growth revealed a linear increase in plant height. Control dwarf plants receiving a water-only treatment were 18% as tall as plants receiving regular application of 1000 ppm GA_3. A wild-type phenotype during reproductive growth was recoverable following regular GA_3 application.

144 POSTER SESSION (Abstr. 344–356) Breeding and Genetics–Vegetables III

344 (PS 6)

Allelic Interaction of a Gene from *L. chmielewskii* Enhancing Soluble Solids in Tomato

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A segment from chromosome 7 of the wild tomato species, *Lycopersicon*

chmielewskii has been introgressed through backcrossing into the processing cultivar, VF145B-7879. This segment was previously shown to carry a gene or genes that increase the soluble solids content in ripe red tomato fruits. To study the allelic interaction of this gene(s) and ascertain its performance in different genetic backgrounds, this line, homozygous for the *L. chmielewskii* segment, was crossed to its isogenic parent (VF145B-7879) and three other commercial cultivars (UC204c, E6203, and ChicoIII). The recurrent parent VF145B-7879 was also crossed to the other cultivars to generate two sets of hybrids, one heterozygous for the *L. chmielewskii* segment and the other homozygous for the *L. esculentum* segment on chromosome 7. Results from two years of field study revealed that the *L. chmielewskii* fragment, when either homozygous or heterozygous in the VF145B-7879 background, comparably increased soluble solids concentration in red fruit, suggesting dominant allelic interaction. This increase ranged from 8%–10% higher soluble solids content in these lines compared to the levels found in the recurrent parent (VF145B-7879). The F_1 hybrids containing one dosage of this gene(s) showed a significant increase in the soluble solids content compared to the commercial parents. However, due to F_1 heterosis observed in all the hybrid combinations, soluble solids content in the hybrids with this gene were not significantly greater than that of the hybrids without this gene. This gene was found to exert no significant influence on fruit pH, weight, and yield.

345 (PS 6)

Sugary enhancer1 (se1) Gene Endosperm Dosage and Sweet Corn Carbohydrate Content

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Inbreds IL451b *sugary1 (su1)* and IL678a *su1* isogenic for the *sugary enhancer1 (se1)* gene mutation were used to analyze the relationship between *se1* gene dosage and endosperm sugar content . Each line was self-pollinated and reciprocal crosses were made between the isolines of each genotype to produce *se1* gene dosages of 0, 1, 2, and 3 in the triploid endosperm. Ears were harvested at 15, 18, 21, 24, 27, and 45 days after pollination (DAP). Whole kernels were freeze-dried, ground into powder, and stored at –80 °C until subsequent chemical analyses. Sucrose, glucose and fructose were analyzed using high-pressure liquid chromatography (HPLC), the results of which indicated a significant increase in kernel sugar content when the *se1* allele is homozygous.

	Sucrose content at 21 DAP (% dry wt)	
se1 dose	IL 451b	IL678a
0	9.6	10.3
1	8.0	10.7
2	11.3	10.9
3	15.8	12.2

Sucrose content at 21 DAP (typical maturity for harvesting) was observed to increase in the IL451b and IL678a backgrounds from zero to three doses of *se1* by 65% and 18% respectively, indicating that this mutation varies in its expression in different genetic backgrounds. Associations between kernel phytoglycogen and starch content and *se1* gene dosage are presented. The biochemical lesion associated with the *se1* gene product is discussed.

346 (PS 6)

Onion Umbel Tissue Induces Threefold Greater in Vitro Antiplatelet Activity than Onion Bulb Tissue

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Onion consumption promotes cardiovascular health by inhibiting platelet activity. Bulbs are the only onion plant organ thus far examined for antiplatelet activity. The inbred line W420B was grown in replicated field trials at four United States locations in 1994. At bulb maturity, samples from each plot were tested for antiplatelet activity using human blood plasma. The remaining portion of the bulbs from each plot was stored, vernalized, and planted in a breeding nursery in 1995. Umbels were excised from 20 randomly selected plants when >50% of the flowers had opened and tested for antiplatelet activity. Inducement of antiplatelet activity was 336% higher by onion umbels than by bulbs. This finding indicates onion umbels are a more potent source of antiplatelet activity than onion bulbs. In addition, these data suggest that onion umbels may be a richer source of bioactive organosulfur compounds in onion tissue.

347 (PS 6)

Heritability Estimates for Sugars, Alcohol Insoluble Solids, and Percent Dry Matter in Baked Sweetpotatoes

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Narrow-sense heritability (h^2) estimates for sugars were determined to assess the feasibility of breeding for a sweeter baked sweetpotato. Roots of parents and half-sib progeny were baked (190°C for 75 minutes) 16 weeks after harvest. Sugars from 10 gram root samples were extracted in ethanol for HPLC sugar quantification. Alcohol insoluble solid (AIS) residues (starch) were also measured from the samples. Dry matter was determined on a separate 10-g sample. Narrow-sense heritability estimates based on variance components analysis for AIS and percent dry matter were 0.20 and 0.32, respectively. Estimates for sugar data were 0.05 for sucrose, 0.52 for maltose, and 0.52 for total sugars (fructose, glucose, sucrose and maltose). These heritability estimates for maltose and total sugars imply a breeder could expect a moderate gain in sweetness over several cycles of selection.

348 (PS 6)

Unilateral Incompatibility as a Major Cause of Skewed Segregation in the Cross between *Lycopersicon esculentum* and *L. pennellii*

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Skewed segregations are frequent events in segregating populations derived from different interspecific crosses in tomato. To determine a basis for skewed segregations in the progeny of the cross between *Lycopersicon esculentum* and *L. pennellii*, monogenic segregations of 16 isozyme loci were analyzed in an F_2 and two backcross populations of this cross. In the F_2, nine loci mapping to chromosomes 1, 2, 4, 9, 10, and 12 exhibited skewed segregations and in all cases there was an excess of *L. pennellii* homozygotes. The genotypic frequencies at all but one locus were at Hardy–Weinberg equilibria. In the backcross populations, all except two loci exhibited normal Mendelian segregations. No postzygotic selection model could statistically or biologically explain the observed segregation patterns. A prezygotic selection model, assuming selective elimination of the male gametophytes during pollen function (i.e., from pollination to karyogamy) adequately explained the observed segregations in all three populations. The direction of the skewed segregations in the F_2 was consistent with that expected based on the effects of unilateral incompatibility reactions between the two species. In addition, the chromosomal locations of five of the nine markers that exhibited skewed segregations coincided with the locations of several known compatibility-related genes in tomato. Multigenic unilateral incompatibility reactions between *L. esculentum* pollen and the stigma or style of *L. pennellii* (or its hybrid derivatives) are suggested to be the major cause of the skewed segregations in the F_2 progeny of this cross.

349 (PS 6)

Analysis of Response and Correlated Response to Selection for Salt Tolerance during Germination in Tomato

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The effectiveness of directional phenotypic selection to improve tomato seed germination under salt-stress was investigated. Seed of F_2 and F_3 progeny of F_1 hybrids between a salt-tolerant and a salt-sensitive tomato cultivar were evaluated for germination response at three stress levels of 100 (low), 150 (intermediate), and 200 mM (high) synthetic sea salt (SSS). At each salt-stress level, the most tolerant individuals were selected. Selected individuals (F_2s or F_3s) were grown to maturity and self-pollinated to produce F_3 and F_4 progeny families. The selected progeny from each experiment were evaluated for germination at four treatment levels of 0 (nonstress), 100, 150, and 200 mM SSS and compared with unselected populations. The results indicated that selections were equally effective at all three stress levels and in both F_2 and F_3 generations and significantly improved progeny seed germination under both salt-stress and nonstress treatments. Estimates of realized heritability for rapid germination under the various salt-stress levels ranged from 0.67 to 0.76. Analysis of response and correlated response to selection indicated a genetic correspondence of up to 100% between germination at different salt-stress levels. Genotypic family correlations between germination at the low, intermediate, and high salt-stress levels ranged from 0.67 to 0.89 and those between nonstress and salt-stress conditions ranged from 0.25

(between 0 and 200 mM) to 0.71 (between 0 and 100 mM salt). The results indicated that similar or identical genes contributed to rapid germination response of tomato seeds at different salt-stress levels. Thus, selection at one stress level resulted in progeny with improved germination at diverse salt-stress levels.

350 (PS 6)

Recurrent Selection for Specific Combining Ability for Yield in Four Pickling Cucumber Populations

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The combining ability (hybrid performance) of breeding lines is often determined to measure selection progress for yield. Plant breeders utilize this information to develop breeding lines with higher combining ability. The objectives of this study were to measure the specific combining ability for yield traits over three selection cycles from four pickling cucumber populations with Gy 14, a popular pickling cucumber inbred; and to determine the change in specific combining ability for yield traits in four populations improved through recurrent selection. Four pickling cucumber populations, North Carolina wide base pickle (NCWBP), medium base pickle (NCMBP), elite pickle 1 (NCEP1), and hardwickii 1 (NCH1), were developed and improved through modified half-sib selection from 1983 to 1992 to improve yield per se and fruit quality in each population. Eleven families were randomly selected from each of 3 selection cycles (early, intermediate, advanced) from each populations and were hybridized to Gy 14. Plants were sprayed with Paraquat to defoliate them and to simulate once-over harvest. The experiment was a randomized complete-block design with 22 replications per population arranged in a split plot with the four populations as whole plots and the three cycles as subplots. The combining ability for fruit quality rating of NCWBP and NCMBP increased as the number of selection cycles increased. Conversely, selection for higher yield per se decreased the combining ability of the NCEP1 population for improved fruit quality. In most instances, the combining ability of each population exhibited a constant response over selection cycles for each measured yield trait.

351 (PS 6)

Genetics Cooperatives on the World Wide Web: An On-line Resource for Breeders and Geneticists

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Crop Genetics Cooperatives tend to be grassroots organizations comprised of individuals with interests in the genetics and/or breeding of a specific crop plant species, genus, or family. Activities of Genetic Cooperative often involve publishing informal research reports, compiling linkage maps, and serving as a repository for monogenic variants in the crop(s) of interest. However, information circulation is often limited to the Cooperative's membership since these organizations are rarely affiliated officially with a specific institution. Fortunately, the rapidly increasing capabilities of the World Wide Web (WWW) now allow Genetics Cooperatives to expand their outreach and provide information to anyone with Internet access. The features of WWW also allow frequent updating of information as necessary for items such as genetic maps and gene collections. The Cucurbit Genetics Cooperative (CGC) is typical of many of these organizations, and CGC is in the process of archiving back issues of the CGC Annual Report on WWW while providing current gene listings and mutant collection information to the scientific community. In addition, software such as databases and programs for analyzing genetic studies are available for downloading, and links are provided to genetic resources at other locations around the world. The process and progress of setting up the CGC website will be described, as well as plans for the future.

352 (PS 6)

Yellow-tip, a Cytoplasmically Inherited Trait in Melon (*Cucumis melo* L.)

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A new chlorophyll-deficient mutant is the first cytoplasmically inherited trait described in melon. This mutant is characterized by yellow apices with the leaves and stems progressively turning green in color as the branches mature. A protocol is proposed for naming and symbolizing cytoplasmic traits in melon. This mutation is named *yellow-tip* and symbolized *cyt-Yt*.

353 (PS 6)

'Excel', 'Early Scarlet' and 'Arkansas Blackeye #1': New Southernpea Varieties

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Southernpea (*Vigna unguiculata)* is an important crop in the southern United States. The Arkansas Agricultural Experiment Station announces the release of three varieties. 'Excel' produces a compact bush plant, from 45–60 cm tall with no basal runners. Pods are deep purple, 20–25 cm long and shell easily at the green mature stage. Flowering and fruiting are concentrated, with the pods produced at the top of the plant on medium-length peduncles. Seed has a bright pinkeye and is similar in size to pinkeye purple hull BVR but matures 3–4 days earlier. 'Early Scarlet' produces a medium sized plant, from 60–75 cm tall with no basal runners. Pods are light red, 20–25 cm long and shell easily at the green mature stage. Flowering and fruiting are concentrated at the top of the plant with pods produced on medium-length peduncles. Seed has a light pinkeye and is similar in size to 'Pinkeye Purple Hull BVR' but matures 2–3 days earlier. 'Arkansas Blackeye #1' produces a bush plant, from 50–65 cm tall with no basal runners. The pods are silver, 20–25 cm long and shell easily. Flowering and fruiting are concentrated with the pods produced in the top of the plant on medium-length peduncles.Seed has a distinct medium-sized blackeye and the seed are very similar in size, type and eye pattern to 'California #5 Blackeye'. Maturity is normally 2–3 days earlier than 'Pinkeye Purple Hull BVR'.

354 (PS 6)

Evaluation of Oriental Trellis Cucumbers in Trellis and Flat Bed Production Systems

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Suitability of commercial production of oriental trellis type cucumber (*Cucumis sativus* L.) was evaluated using 18 cultivars and breeding lines (referred to as cultigens hereafter). The cultigens (15 oriental trellis and three American slicers) were tested using two systems (trellis and flat bed production) in two seasons (spring and summer) in 1995 at Clinton, N.C. Traits evaluated included total yield, early yield, percentage culls, vine length, leaf area, gynoecious rating, fruit shape, fruit color, fruit length, seed cell size, anthracnose resistance, powdery mildew resistance, and fruit keeping ability. Highest yielding cultigens were 'Summer Top', 'Tasty Bright', and 'Sprint 440'. Those with best fruit quality were 'Sprint 440', 'Tasty Bright', 'Poinsett 76', and 'Summer Top'. Most disease resistant was 'Poinsett 76'. The best cultigens considering all traits measured were 'Sprint 440', 'Tasty Bright', and 'Summer Top'. Production of cultigens on trellis rather than flat bed resulted in an average increase in total, marketable, and fancy yield of 130%, 160%, and 140%, respectively. Oriental trellis cucumbers can be produced as a less expensive alternative to European greenhouse cucumbers, and to supply consumer demand for this particular product type.

355 (PS 6)

Varietal Effect on Some Vegetable and Reproductive Characters of Pepper (*Capsicum annum* L. and *C. frutescens*)

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Field trials of five selected cultivars each of *Capsicum annum* and *C. frutescens* were made to assess variation in yield performances. The later flowering ones *C. frutescens* grew taller, and the fruit matured late. Atawewe-9 started flowering 86 days after sowing (DAS) and fruited 103 DAS compared to Tatase-1 with 75 and 80 DAS, respectively. The plant heights for these were 36.6 and 42.7 cm, respectively. As the fruit number per plant increased the fruit size decreased within and between the two species of *Capsicum*.

356 (PS 6)

A Prospective Variety of Jute Marlow *Corchorus olitorius* Linn for Nigeria Consumers

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Five promising lines of Jute Marlow (*Corchorus olitorius* Linn.) were selected from the GeneBank of NIHORT and collections made within the last few years. A comparison of the vegetable characters and seed yields were made and NH87/CO4-1 had significantly higher shoot yields at the seedling stage of 0.31 and l.00 g per plant at 3 and 5 weeks, respectively. The highest dry-seed weight of 6.18 g/plant also makes it attractive for seed growers.

108 POSTER SESSION (Abstr. 357–361)
Breeding and Genetics–Woody Ornamentals

357 (PS 4)

Cytological and Morphological Characterization of Amphidiploids for Rose Breeding

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Several colchicine-induced amphidiploids of blackspot-resistant, wild diploid rose species were produced for interbreeding with tetraploid garden roses. Shoot-tip chromosome counts confirmed that 86-7 (*Rosa wichuraiana* Crep. x *R. rugosa rubra* Hort.) and 86-3 (*R. laevigata* Michx. x *R. banksiae* Aiton) are amphidiploids (2n = 4x = 28), and that 84-1000 (*R. roxburghii* Tratt. x *R. laevigata* Michx.) is a mixoploid with diploid (2n = 2x = 14) and hypotetraploid (2n = 4x-1 = 27) sectors. The measured volume of pollen grains and guard cells was higher in the tetraploids. Pollen stainability was higher in amphidiploids 86-3 and 86-7 than in mixoploid 84-1000. The amphidiploid 86-7 has greater pollen fertility as determined by crossing with a range of commercial tetraploid roses than 86-3 and 84-1000, but is less fertile than its parental diploid species. Leaflets of the amphidiploids are larger and more crinkled along the midrib than in their diploid parents. These three amphidiploids provide new additions to tetraploid rose germplasm.

358 (PS 4)

Use of Flow Cytometric Measurement of Nuclear DNA Content to Assess Ploidy Level in Azalea

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We evaluated flow cytometric measurement of nuclear DNA content to determine ploidy level in azalea. If ploidy level correlates with DNA content, ploidy level could be determined more readily than by direct chromosome counts and assist in planning crosses and evaluating progeny. Tested plants included azalea cultivars, materials from the azalea breeding project at the Univ. of Minnesota, and species from the Rhododendron Species Botanic Garden and the North Carolina Arboretum. Data compiled from DNA assays of practically all material analyzed fell into distinct groups consistent with their being either diploid, triploid, or tetraploid. Additionally, a known diploid plant of each of four diploid species, together with a natural or derived tetraploid plant of each of these species was obtained. Results showed that the four diploids had a similar DNA content compared to one another. DNA content of the tetraploids was also similar, and the tetraploid's DNA content was approximately twice that of the diploids, as expected. Unfortunately, success with direct chromosome counts in other material has proven elusive, currently precluding direct correlation of DNA amount with ploidy level across other species and cultivars. Although many cases exist in the literature where DNA content has a direct relationship to ploidy level, this does not always hold. Although the majority of plants tested fell into a diploid, triploid, or tetraploid grouping based on DNA content, further study is required to determine the exact relationship between ploidy level and DNA content in azalea.

359 (PS 4)

Rhododendron Root Rot Resistance

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Root rot caused by the soil-borne pathogen *Phytophthora cinnamomi* is one of the deadliest and most costly diseases in rhododendron culture. Unfortunately, the majority of cultivars appear to be susceptible to this fungus. Host resistance does occur, but it represents a tolerance of rather than immunity from the disease. A breeding program has been initiated to develop a broader array of root rot resistant cultivars and to determine the genetic basis for resistance. Greenhouse inoculations and screenings of 48 contemporary cultivars yielded seven clones with moderate to high levels of resistance to *P. cinnamomi*. Protocols for evaluation at the seedling stage were developed in order to screen large breeding populations of about 200 seedlings per cross. Root rot tolerance appears to have low-moderate heritability in these rhododendron populations. Groups of progeny with one resistant parent had a slower mortality rate and higher survivorship (avg. 10%) after 2 months of disease pressure than crosses in which both parents were susceptible (0 survivorship). A recurrent selection strategy is planned to increase the frequency of alleles for resistance in breeding populations of rhododendrons.

360 (PS 4)

Pollination Methods for *Cornus* Breeding

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Hand pollinations and honey bees were used to cross *Cornus florida* cultivars in a series of experiments investigating dogwood pollination biology from a breeding viewpoint and testing the use of insects (domestic honey bees and ladybug beetles as pollinators in dogwood breeding. Experiments were conducted to study possible incompatibility between dogwood cultivars and to determine if self-compatibility and self-fertility occur in *Cornus florida* . Since 1993, ≈200 seedlings have been produced by hand and insect-mediated pollinations. Honey bees can be used in dogwood breeding. Trees cross pollinated by ladybeetles had lower fruit set than trees cross pollinated by honey bees. Greenhouse forcing to accelerate anthesis and cold storage to delay the onset of bloom of container-grown trees can extend the dogwood breeding season effectively.

361 (PS 4)

Horticultural Research at The Holden Arboretum

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The Holden Arboretum, established in 1931, is the largest arboretum in the United States. Its mission is to promote the knowledge and appreciation of plants for personal enjoyment, inspiration, and recreation; for scientific research; and for educational and aesthetic purposes. Of the Arboretum's 3100 acres, 800 acres support collections and display gardens, while the balance comprise natural areas. The collections include nearly 8,000 accessions from 76 plant families; about 700 plant species, some rare or endangered, occupy the natural areas. The education component of the mission connects the Arboretum with the public through school programs, classes, horticultural therapy, and seasonal internships. Two research fellowships are also available. The Holden Arboretum has expanded the research emphasis. The David G. Leach Research Station, part of the Arboretum since 1986, focuses on rhododendron and magnolia breeding and research. Built in 1993, the Horticulture Science Center is a modern research and production facility able to more fully implement and support a broad range of formal horticultural research. The main objective of the research program is to develop superior woody ornamentals for the landscape through hybridization. Additional research emphasizes reproductive biology and using biochemical markers (isozymes and RAPDs) to answer basic questions about the genera under study (*Aesculus*, *Hamamelis*, *Cercis*).

108 POSTER SESSION (Abstr. 362–374)
Cell and Tissue Culture I

362 (PS 4)

Tissue Culture and Plant Regeneration of Cowpea (*Vigna unguiculata*)

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Explants (cotyledon, cotyledonary node, second node, hypocotyl, epicotyl, and leaf) of cowpea (*Vigna unguiculata*) genotypes MN13 and Pinkeye Purple Hull were cultured on Murashige and Skoog basal nutrient medium. The medium was supplemented with 1 mg·L^{-1} benzyladenine (BA) or 1 mg·L^{-1} benzyladenine plus naphthalene acetic acid (BA + NAA) or 2 mg·L^{-1} 2,4-dichlorophenoxy acetic acid (2,4-D). Cultures were maintained at 22°C for 1 month, after which they were transferred to 1 mg·L^{-1} BA + NAA. Cotyledons, hypocotyl, epicotyl, and leaf segments produced only calli after subculturing in BA + NAA. The second node and cotyledonary node explants cultured on the BA or BA + NAA followed by subculture on BA + NAA produced calli, shoots, and roots. The plants were then transplanted to promix but later died.

363 (PS 4)

Plant Regeneration of *Allium victorialis* var. *platyphyllum* Makino via Organogenesis and Somatic Embryogenesis

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This study was conducted to investigate the possibility of obtaining plantlets via somatic embryogenesis and organogenesis as means of in vitro mass propagation in *Allium victorialis* var. *platyphyllum* Makino, one of the most popular wild vegetable plants in Korea. Shoots formed directly when bulb explants of *A. victorialis* were cultured on MS medium containing 0.2 mg·L^{-1} NAA and 2.0 mg·L^{-1} zeatin under 16 hours (light)/8 hours (dark) illumination. The use of leaf and shoot tip explants was not successful, largely due to explant senescence in the present of plant growth regulators. Embryogenic calli were obtained from the bulb explants of *A. victorialis* on MS medium supplemented with 0.2 mg·L^{-1} NAA, 0.2 mg·L^{-1} BAP, and 1.0 mg·L^{-1} picloram after 4–5 weeks of culture in the dark at 27°C. Upon transfer to shoot-induced MS medium containing 0.2 mg·L^{-1} NAA and 2.0 mg·L^{-1} zeatin, embryogenic calli gave rise to numerous somatic embryos, which subsequently developed into multiple shoots after 3 months of culture under 16 hours(light)/8 hours (dark) illumination. For root induction, regenerated shoots were transferred to MS medium added with 1.0 mg·L^{-1} NAA. Regenerants with well-developed roots were potted in an artificial soil mixture of vermiculite (1) and perlite (1).

364 (PS 4)

Regeneration of *Panax ginseng* C.A. Meyer by Organogenesis and Nuclear DNA Analysis of Regenerants

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Plant regeneration ability of ginseng (*Panax ginseng*) via organogenesis was studied morphologically and anatomically. Compact callus was introduced from four different types of explants—leaf, petiole, flower stalk, and root—of in vitro-grown plantlets. Petioles were found to be the best material for callus induction. Calli induced on Murashige and Skoog (MS) medium supplemented with 2,4-dichlorophenoxyacetic acid (1.0 mg·L^{-1}) and kinetin (0.1 mg·L^{-1}) were conditioned for 2 weeks on the same medium. These calli differentiated into adventitious shoots when cultured on half-strength MS basal medium plus kinetin at 1.0 mg·L^{-1} and STS at 2.5 mg·L^{-1}. An addition of GA_3 (1.0 mg·L^{-1}) and BA (1.0 mg·L^{-1}) to MS basal medium, however, induced high-frequency in vitro flowering (86.1%) and multiple shoot budding, which affected the normal, complete development of plantlets. Plantlets with well-developed root systems were obtained 6 weeks after regenerated shoots had been transplanted to half-strength MS20 medium containing IBA at 0.25 mg·L^{-1}. Nuclear DNA content was measured to check the stability of their ploidy level. Based on DNA flow cytometric analysis, all of the regenerants were typically diploids as were the mothers plants, indicating that nuclear DNA content remained stable during cell differentiation.

365 (PS 4)

Root Growth and Organogenesis in Thidiazuron-treated Ginseng (*Panax quinquefolium* L.)

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Ginseng is an herbaceous perennial that grows in the understorey of deciduous hardwood forests and is also cultivated for its highly valued root. The primary method of propagation of ginseng is by seed which requires the breaking of dormancy by stratification, a process which takes 18–24 months. Investigation of factors controlling the growth and development of ginseng plants is a prerequisite to the development of a more efficient system of ginseng propagation. We have recently modulated the morphogenetic potential of geranium roots and stimulated *de novo* development of shoots and embryo-like structures which later formed whole plants using thidiazuron (TDZ). Our objective was to investigate the morphological changes in seedling and mature ginseng plants induced by TDZ, particularly in relation to root and shoot morphogenesis and economic yield. Applications of TDZ (0.22 and 2.20 ppm), either as foliar sprays or soil watering to greenhouse-grown seedlings over 18 weeks (2 weeks after sowing to 20 weeks when plants were harvested) induced similar effects. These responses included increased stem length and diameter, and shoot and root weight (economic yield). Single foliar applications of TDZ at 62.5 and 125 ppm to 3-year-old field-grown ginseng plants 3 months before harvest increased root biomass (economic yield) by 19% to 23%. Roots of TDZ-treated seedlings and 3-year-old field-grown plants developed thickened secondary roots on the upper part of the taproot. The root-like structure of these secondary roots was confirmed by histology. In addition, TDZ treatments induced adventitious buds on the shoulder of 3-year-old roots. These buds developed into shoots to give multi-stem plants following a period of dormancy, which was overcome with GA_3 (gibberellic acid) treatment before planting.

366 (PS 4)

In Vivo and in Vitro Propagation of Selected Cabbage (*Brassica oleracea* L. var. *capitata*) Clones

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Hybrid cabbage cultivars can be produced via seed-propagated self-incompatible (SI) inbred lines, or, alternatively, via vegetative propagation of SI clones. Cabbage clones differ in their ability to undergo vegetative propagation, a fact that appears to be related to the degree of differentiation of the axillary buds inside the head. A procedure for in vivo and in vitro propagation is described for cabbage clones known for difficulty in undergoing vegetative propagation. Cuttings from clonal families 800 (easy-to-propagate) and 007 (difficult to propagate) were immersed in indolebutyric acid (IBA—0, 5, 25, and 125 mg·L^{-1}) + boric acid (100 mg·L^{-1}) + sucrose (20 g·L^{-1}) for 15 hours and maintained in glasshouses. Induction of roots was more effective with 125 mg·L^{-1} IBA supplemented with boric acid and sucrose. This treatment showed the highest frequency of rooting and the largest number of roots per cutting. The in vitro system of propagation was performed on the basal medium of Murashige and Skoog (MS), to which triadizuron (TDZ), benzyladeninepurine (BAP), and kinetin (Kin) were added in different combinations. TDZ was more effective than BAP or Kin in the promotion of shoot regeneration.

367 (PS 4)

Regeneration and Frequency of Tetraploid Variants of *Cucumis metuliferus* are Affected by Explant Induction on Liquid/Membrane System

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Ninety-eight percent of cotyledons of *Cucumis metuliferus* (PI 482439) regenerated shoot buds in 5 weeks on MS medium with 10 μM BA. Regeneration rates on agar gelled medium and liquid/membrane system were compared after weekly transfers of tissue from liquid/membrane to agar during the 5 weeks of regeneration culture. Number of shoots and buds increased from six (on agar-gelled medium) to nine per cotyledon when explant on liquid/membrane system for 3 or 4 weeks was transferred to agar gelled medium. Shoot development, rooting, and survival in greenhouse was adequate regardless of whether regeneration was initiated on agar or liquid/membrane system. Tetraploid regenerants were found to be about 9% of the almost 400 regenerants screened. Pollen morphology was a quick and definitive screening technique for tetraploid plants. Frequency of tetraploid plants was similar after 5 weeks of induction on either agar or liquid/membrane system. This frequency decreased by a factor of 10 following transfer of explants from membrane to agar after the first week of induction. Timing of this transfer plays a critical role in eliminating tetraploid variants.

368 (PS 4)

Direct Shoot Organogenesis of *Medicago sativa*

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An efficient and reliable protocol of in vitro shoot regeneration must be first established to have a successful genetic transformation. As a member of legume family, alfalfa is very difficult for direct shoot regeneration. There is no published information on direct shoot organogenesis, although success has been well documented on embryogenesis, which must go through callus stage. Different plant growth regulators at various concentrations were evaluated for callus initiation, development, and direct shoot regeneration. Multiple shoots were produced directly from each individual explant. This will provide an efficient means for production of transgenic alfalfa plants. Therefore, genetic transformation of *Medicago* germplasm will be significantly expedited.

369 (PS 4)

Rapid Micropropagation of *xChitalpa tashkentensis*

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xChitalpa tashkentensis (*Chilopsis linearis* x *Catalpa bignonoides*) is an attractive small tree producing lavender to white orchid like flowers. Micropropagation would allow for the rapid clonal propagation of new hybrids for testing cold hardiness and landscape performance. The rapid growth response of *Chitalpa* shoot cultures also makes it an excellent subject for the study of in vitro growth parameters of woody plants. Shoot cultures were initiated from shoot tips on Anderson's rhododendron medium with MS vitamins, 3% sucrose, 1 μM BA, pH 5.6 and solidified with 0.6% phytagar. Shoot cultures stabilized rapidly. Two-node microcuttings were placed on modified MS media (200.1 μM Na_2 EDTA and 200.5 μM $FeSO_4 7H_2O$), MS vitamins, 3% sucrose, pH 5.6, 0.6% phytagar and supplemented with NAA (0 0.5, 1.5, or 3 μM) in combination with BA (0, 1, 5, 10, 15, 20, 30, or 40 μM). Cultures grown on media supplemented with 1 mM BA produced the longest shoots and the most nodes per shoot. Cultures grown on media supplemented with 10 μM BA produced the most shoots. Microshoots readily rooted on plant growth regulator free MS medium and were easily acclimated.

370 (PS 4)

Effect of Medium and Genotype on the in Vitro Growth of *Alstroemeria*

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Three *Alstroemeria* genotypes—A30, ER292, and 16-1-2— developed at the Univ. of Connecticut were grown in vitro on two media: Murashige and Skoog (MS) basal medium and *Alstroemeria* medium (ALA). Each medium had four levels of 6-benzylaminopurine (BA) added: 0, 9, 18, and 36 μM. Alstroemeria rhizomes initially containing one bud were cultured on the 24 treatments for 12 weeks with transfers onto fresh medium at 4 and 8 weeks. At each transfer and at the end of the experiment plants were scored for the number of shoots produced, number of new buds, fresh weight, and presence of roots. No difference was observed between the MS and ALA media. No interaction was found between medium and hormone concentration. BA inhibited the formation and growth of roots that were observed only in the control without BA. The control was different from 9, 18, and 36 μM BA for the number of buds produced, number of shoots and fresh weight while no differences were observed between the various concentrations of BA. ER292 gave the highest yields in number of buds, shoots and fresh weight of all the genotypes.

371 (PS 4)

Micropropagation of Chokecherry by Shoot Tip Culture

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Chokecherry (*Prunus viginiana* L.) is an important shrubby species for agroforestry planting in the northern Great Plains states. The X-disease is a serious limiting factor for its utilization. The objective of this research was to produce clonal materials for studying the host and X-disease phytoplasma interactions and for screening X-disease resistant chokecherry germplasms. Shoot tips of 1–2 cm in length were isolated from 1-year old seedling plants, sterilized, and initiated on three basal media supplemented with 5 μM BA and 5 μM IBA. After five weeks, an average of 4.8, 2.2 and 0.3 new shoots were produced on Murashige and Skoog (MS) medium, woody plant medium (WPM) and Knop's medium, respectively. The newly formed shoots were subcultured on MS medium with 5 M BA and 5 M IBA. MS and DKW media gave significantly higher proliferation rates (12–13 shoots after 4 weeks) than WPM (5.5 shoots). Microshoots rooted in half-strength MS medium supplemented with 5 and 10 μM of either IBA or NAA. The shoots were either placed on the medium for 19 days, or for 5 days then transferred to a hormone free medium for 14 days. On the media with IBA, 80% to 90% of the microshoots rooted with an average of 2.4 roots per shoot and there were no differences in rooting percentage and root number. When shoots were exposed to NAA for 5 days, 66.7% of shoots on medium with 5 μM NAA, and 83.3% on the medium with 10 M NAA formed an average of 2.2 roots per shoot; but when the shoots were exposed to NAA for 19 days, 36.4% of shoots on the medium with 5 M NAA and 30% on the medium with 10 μM of NAA formed an average of 0.53 roots per shoot. These rooted shoots are under acclimation to the ambient environment.

372 (PS 4)

Effect of Explant Size and Age on in Vitro Propagation of *Curcuma roscoeana* Wall.

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Propagation of *Curcuma roscoeana* in vitro was done successfully by culturing 0.5 × 1.0 mm shoot tips from young buds onto modified MS (1962) + 0.25 $mg \cdot L^{-1}$ kinetin. The bud-derived new plantlets could be multiplied on a new medium. Stem explants 10 mm in size, measured from base of the plantlets longitudinally cut in half, were the most suitable culture explants providing 2.8 new healthy plantlets/cultured explant. Explants from 4, 6, and 8 weeks old plantlets were more suitable than those of 2 weeks old when grown on agar or in liquid medium. From a histological study, it was found that new buds developed from preexisting meristems. The buds, like root initiation, could also occur directly from initial culture explants, not through callus. The plantlets obtained could successfully be transferred into growing pots, having a 95% survival rate.

373 (PS 4)

Thidiazuron and Benzylamino Purine Stimulation of Apple Shoot Proliferation in Vitro

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Thidiazuron (TDZ) and benzylamino purine stimulated shoot proliferation on shoot tip explants of wild apple (*Malus domestica* Borkh) when incorporated in Murashige and Skoog (MS) medium at concentrations of 1.0–10 μm. Shoot numbers obtained with TDZ were greater than the number produced when using BA in the medium but the shoots were shorter than with BA. Increasing TDZ levels increased shoot proliferation with 10 μm. Apple shoots were successfully rooted on MS medium with 2.0 $mg \cdot L^{-1}$ NAA and then transferred to a mixture of 1 peat : 1 perlite : 1 soil and acclimatized for potting.

374 (PS 4)

Adventitious Shoot and Plantlet Formation from Cultured Apple Leaf Explants

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Leaves of wild apple (*Malus domestica* Borkh) were excised from in vitro grown shoots transversely cut into halves and plated onto petri dishes containing regeneration media. Cultures were kept in the dark for three weeks before adventitious shoots were observed. Callus from leaf explants produced adventitious shoots after 3 months of in vitro culture. Callus were cultured on Nitsch and Nitsch medium supplemented with a range of BA (0.0–2.0 μm) and NAA (0.0–10 μm). BA at 10 μm combined with NAA (0.5 μm) proved most effective for stimulating shoot proliferation of cultured apple. Plantlets from tissue culture were easily transferred to the greenhouse environment.

147 POSTER SESSION (Abstr. 375–388) Cell and Tissue Culture II

375 (PS 8)

Partial Organogenesis and Somatic Embryogenesis from Petiole Explants of Field-grown Papaya (*Carica papaya* L.)

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Petiole discs from young leaves of female papaya (L-45) plants were cultured in MS or B5-based media containing 0, 2.25, 4.5, 11.25, and 22.5 μM 2,4-D. Compact embryogenic callus emerged from vascular tissue of petiole discs in about 3 weeks. In MS medium, 66% and 51% explants formed embryogenic callus with 11.25 and 22.5 μM 2,4-D, respectively. On the other hand, 79% explants formed embryogenic callus in B5-based medium with 4.50 μM 2,4-D. However, explants became necrotic in B5-based medium with 22.5 μM 2,4-D. Subculturing callus in auxin-free medium resulted in the development of roots or somatic embryos. Microscopic observations revealed that the roots were produced only by the callus that had retained its continuity with the vascular tissue. This investigation revealed that petioles from field grown papaya plants are potential

explants for somatic embryogenesis and 2-week exposure to 2,4-D is adequate for inducing morphogenesis. Additionally, an interaction between 2,4-D and the components in the MS and B5-based media was observed.

376 (PS 8)

Cultural Conditions Affecting the Frequency of Embryoid Formation in Sweetpotato (*Ipomoea batatas*)

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Somatic embryogenesis in sweetpotato is highly genotype dependent. Unfortunately, many desirable agronomic varieties do not produce embryos capable of germination when published protocols are followed. Using one responsive and three recalcitrant cultivars, we examined the effect on embryogenesis of auxin, nitrogen, and carbon; explant source; and desiccation. All cultivars formed proembryonic masses on medium supplemented with either 2,4-D or picloram; picloram favored the growth of nonembryogenic callus. Twenty mM each of ammonium and nitrate promoted the best proembryo formation in all cultivars. Ammonium was essential for embryogenesis; replacing ammonium with proline, glutamine, asparagine, glycine, or casein hydrolysate resulted in poor or no proembryo formation. More proembryos formed on medium supplemented with sucrose than with glucose, fructose, or maltose. Leaf discs from the first fully expanded leaf produced more embryos than younger leaves for all cultivars; discs taken from the lamina produced more embryos than discs including portions of the midrib. Proembryos matured and germinated only after at least 3 weeks on medium containing 5% w/v polyethylene glycol 8000, greater than 3.3 mM *myo*-inositol, and 1 or 10 μM abscisic acid. More whole plants were obtained from the responsive cultivar Jewel than from the recalcitrant genotypes.

377 (PS 8)

Histological Comparisons of Shoot-forming and Nonshoot-forming Somatic Embryo Variants of Sweetpotato (*Ipomoea batatas* (L) Lam)

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A comparison of external morphology captured via a computer vision system and a study of internal anatomy of sweetpotato somatic embryos identified five different major morphological variants among torpedo and cotyledonary stage embryos. These included 1) Perfect Type, 2) Near Perfect Type, 3) Limited/No Meristematic Activity Type, 4) Disrupted Internal Anatomy Type, 5) Proliferating Type. Perfect and Near Perfect types of somatic embryos were categorized as competent, while Limited/No Meristematic activity, Disrupted Internal Anatomy, and Proliferating types were categorized as noncompetent with respect to their conversion ability. Lack of organized shoot development in somatic embryos of sweetpotato was attributed to the following abnormalities: 1) lack of an organized apical meristem, 2) sparsity of dividing cells in the apical region, 3) flattened apical meristem, 4) multiple meristemoids and/or diffuse meristematic activity throughout the embryo. A morphological fate map of most of the torpedo and cotyledonary embryo variants was identified, which will be beneficial in synthetic seeding and transgenic research and development of sweetpotato.

378 (PS 8)

Somatic Embryogenesis Using *Cucumis sativus* (L.) Cotyledons

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To improve somatic embryogenesis of *Cucumis sativus*, two types of explants (cotyledons and stem sections) were cultured on Murashige and Skoog (MS) media supplemented with 2,4-D (2.0 $mg \cdot L^{-1}$) + kinetin (0.5 $mg \cdot L^{-1}$). After 4 weeks, the embryogenic callus was transferred for 2 weeks to MS + NAA (1.0 $mg \cdot L^{-1}$) for embryo development. Stem sections failed to develop embryos while cotyledons responded with 14% embryo formation. The embryos were transferred to MS without hormones for 4 weeks to allow for plantlet growth. These embryos developed only shoots. To improve on the successful generation of embryos with root and shoot development, the procedures used above were repeated, but the cotyledons were cut into three sections to be used as explants. Each transverse section of the cotyledon was approximately 2–3 mm wide. All sections produced callus but not all of them were embryogenic. From the first section (cotyledon base), the second (between the first and third section) and the third section (furthest from the cotyledon base), respectively, 58%, 31%, and 5% embryo development occurred. Those embryos from the basal cotyledon sections regenerated 10 plantlets, 5 with shoots and roots and 5 with only shoots. Approaches to enhance somatic embryogenesis, and shoot and root development, will be discussed.

379 (PS 8)

Axillary Shoot Proliferation from in Vitro Culture of *Pulmonaria* L. Shoots

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Actively growing shoots from *Pulmonaria* L. 'Roy Davidson' were cultured in vitro on Murashige and Skoog medium containing benzyladenine (BA) to establish proliferating cultures. BA at 0, 0.4, 0.8, 4.4, 8.8, and 44.4 μM was compared for shoot proliferation and rooting response. Shoot count was highest on 8.8 μM BA with root count highest on 0 or 0.4 μM BA. Subculture 4 weeks later of shoots to the same treatments resulted in highest shoot counts on 44.4 μM BA. Optimum level for micropropagation was 8.8 or 44.4 μM BA. Greatest rooting was at 0 or 0.4 μM BA.

380 (PS 8)

Determination of Optimum Nitrogen Ratios and Concentrations for Embryo Cultures of *Alstroemeria*

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The rates of *in ovulo* germination of embryos of three genotypes of *Alstroemeria* were observed. Ovules were harvested ten days after pollination and cultured on sixteen different treatments containing Murashige and Skoog (MS) basal medium with no plant growth regulators. The media contained four different concentrations of total nitrogen: 20, 40, 60, 80 mM. Within these concentrations were either 1:0, 1:1, 1:2, or 2:1 ratios of nitrate to ammonium. Standard MS medium, with a concentration of 60 mM total nitrogen and a ratio of 2:1 nitrate to ammonium, was used as the control. The overall rates of germination for all three genotypes were low in all treatments. The percentage of zygotic germination was low while the percentage of somatic embryos produced was high. In some situations, callus or deformed embryos were produced. Effects of the treatments on embryo development and germination will be discussed.

381 (PS 8)

Effect of Quantity and Depth of Media per Culture Container on Shoot Production of Muscadine Grape Cultured in Vitro

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Previous studies indicated that the number of shoots formed per nodal explant varied significantly depending upon the type of culture container used. Amount of media per container and amount of time that media was autoclaved were variables that differed among the containers. To determine the cause for the container effect on shoot number, a study was conducted in which autoclave time and amount of media per container were the same for all tested containers. Media was autoclaved in 500-mL batches for 30 min, then poured in 30-mL aliquots into sterile containers. Containers tested were plastic petri plates, GA-7 Magenta vessels and glass jars. Depth of the medium was 5 mm in plates, 8 mm in vessels, and 12 mm in jars. Nodes from in vitro grown shoots of 'Triumph', 'Regale', and 'Fry' were cultured on Murashige and Skoog salts and vitamins with 2 $mg \cdot L^{-1}$ BA and 8 $g \cdot L^{-1}$ agar. Results indicated that the greatest number of shoots formed in the jars. In a second study, nodes were cultured on petri plates containing 30 mL of medium (depth 5 mm) or 70 mL (depth 12 mm). Two to three times more shoots formed on the plates with the greater amount of medium. These studies indicate amount and depth of medium are factors influencing shoot number.

382 (PS 8)

A Comparison between Synthetic and Organic Iron Chelators on in Vitro Growth of *Nicotiana tabacum* Callus Cultures

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Nicotiana tabacum callus growth (fresh weight) was measured after culture in the light (16-hour photoperiod) or in darkness for four different culture media, differing in iron chelate type or concentration. All media contained MS basal medium supplemented with 30 $g \cdot L^{-1}$ sucrose, 2 $mg \cdot L^{-1}$ IAA, 0.2 $mg \cdot L^{-1}$ KIN, and 7 $g \cdot L^{-1}$ agar, pH 5.8. Three of the media contained iron-metalosate (Albion Laboratories), an organic iron chelate, at 100, 200, and 400 micromolar concentrations, and the fourth medium contained 100 μM Fe-EDTA. Twenty-five culture tubes were prepared for each of the 4 different media concentrations and 2 light

treatments (8 treatments total). A 1-cm^3 callus explant was used for each treatment and cultured for 56 days at 20°C. About 20-fold increases in callus fresh weight were observed for cultures incubated in light or in darkness. In addition, callus growth was not significantly affected by iron chelate type, suggesting the potential utility of this organic chelator in tissue culture media to alleviate potential problems of light-induced EDTA instability and subsequent IAA inactivation. These cultures are being maintained to examine the influence of iron chelate type on organogenesis.

383 (PS 8)

The Effect of Jasmonic Acid on in Vitro Nodal Culture of Three Potato Cultivars

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Jasmonates are a group of native plant bioregulators that occur widely in the plant kingdom and exert various physiological activities when applied exogenously to plants. We investigated the effect of free jasmonic acid (JA) on stem and root growth and tuberization of potato in vitro nodal culture. Nodal cuttings of three potato cultivars, Norchip, Red Pontiac, and Russet Burbank, were cultured in 2.5 × 15 cm test tubes containing either nodal culture (MS with 2% sucrose) or tuber-inducing (MS with 8% sucrose and 11.5 μM kinetin) medium. The media were supplemented with JA at 0, 0.1, 0.5 1.0, 5.0, 10.0 and 50 M. The cultures were maintained under a 16-hour photoperiod at 24°C for 6 weeks. Potato cultivars showed different sensitivities to JA in stem growth. Norchip is the most and Red Pontiac the least sensitive cultivar. On the nodal culture medium, stem length of Norchip was promoted at 0.1–5 μM, and inhibited at 10–50 μM of JA, but that of Red Pontiac was promoted by JA at all concentrations tested. The number of nodes increased significantly on media with JA than that on medium without JA. The number of adventitious roots did not, but the lateral roots increased significantly when JA was added to the medium. On tuber-inducing media, stem length and node number did not appear to be affected by addition of JA to the medium. The number of axillary shoots increased significantly on the media with low concentrations of JA (0.1–5 μM). No microtubers formed on both media from all three cultivars in 6 weeks.

384 (PS 8)

An in Vitro Potato Bioassay to Investigate Tuber Inductive Factors in Continuously Reused Hydroponic Nutrient Solutions

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An experiment was conducted in the Biomass Production Chamber (BPC) at Kennedy Space Center to examine the effects of using continuously reused nutrient solution in an NFT system to support potato growth in batch and continuous planting scenarios. Tuberization was hastened and plant growth reduced on plants grown in the aged nutrient solution. We have previously reported that the effect is removed when the aged nutrient solution is filtered through activated charcoal. In order to investigate this apparent plant growth regulator response, an in vitro bioassay has been developed that allows for repeatable, small scale, and rapid testing of the tuber-inducing response. The bioassay is a liquid culture system that employs 600-mL Berzelius beakers capped with modified Sun transparent tissue culture bags, a light shield around the root zone, and a polyurethane foam support, which holds a micropropagated potato plantlet. With this bioassay, we have observed the same plant stunting and tuber initiation effects that were previously seen with the aged nutrient solution. The bioassay appears to be sensitive to environmental factors (PPF, photoperiod, and temperature) that influence tuberization. In addition, partially purified preparations of the apparent growth regulators have elicited the tuberization response. Currently, efforts are underway to examine the role of the microbial community associated with the BPC nutrient delivery system on the tuberization response.

385 (PS 8)

$AgNO_3$ Promotes Callus Production and Regeneration of Immature Buffalograss Inflorescence Culture

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The use of buffalograss [*Buchloe dactyloides* (Nutt.) Engelm] in home lawns and golf courses has been increasing because of its drought resistance and low growth habit. In vitro regeneration of buffalograss at a high frequency may provide an effective tool to introduce new variation for breeding use. The positive effects of $AgNO_3$ on friable embryogenic callus production and regeneration efficiency is well documented in maize. In order to determine if $AgNO_3$ has the same effect on buffalograss, two vegetatively propagated cultivars, a female '609' and a male '45-3' were tested at three different concentrations of $AgNO_3$ at 5, 10, and 15 $mg \cdot L^{-1}$ using immature inflorescences as explants. Murashige and Skoog medium supplemented with 2 mg 2,4-D/L was employed as the control medium. Medium containing $AgNO_3$ significantly promoted the production of friable callus for '45-3' with the highest percentage achieved at 10 mg $AgNO_3$/L. $AgNO_3$ medium led to production of significantly larger calli than found for the control. However, no difference was detected among 5, 10, and 15 mg $AgNO_3$/L with regard to the callus formation ability and the size of callus initiated on these three treatments. Calli were then transferred to MS medium supplemented with BA at 0.1, 0.5 or 1.0 $mg \cdot L^{-1}$ to induce shoot formation. BA at 0.5 $mg \cdot L^{-1}$ gave the best differentiation response. Calli formed in the absence of $AgNO_3$ produced more shoots per callus, but more calli were produced in the presence of $AgNO_3$, and the overall regeneration efficiency was much higher with $AgNO_3$ at 10 $mg \cdot L^{-1}$. In contrast, $AgNO_3$ showed no promotive effect on callus production and regeneration for '609'.

386 (PS 8)

Performance of Virus-free and Virus-infected Plants of Mashua (*Tropaeolum tuberosum*, Ruiz & Pavon)

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Mashua, closely related to the garden nasturtium, has been cultivated by people of the Andean highlands since Incan time; however, it is disappearing from Ecuadorean markets due to decreasing yields. The main objectives of this research were to compare 1) in vitro proliferation and rooting, and reestablishment, and 2) field plant qualities such as vigor and yield between virus-infected and virus-free plant material. Virus-free material was obtained from shoot apices about 0.2 mm in size isolated from virus-infected, in vitro maintained, microcuttings of a number of mashua lines. Mashua line had an effect on proliferation, reestablishment and tuber yield. Virus infection appeared to have a detrimental effect on the general in vitro performance of all lines. There were no differences in reestablishment between the virus-infected and virus-free plants. Although there were no overall yield differences between the virus-infected and virus-free lines, virus-infected lines produced significantly more large tubers.

387 (PS 8)

Control of Bacteria and Alteration of Plant Growth in Tissue Cultures of Tansy (*Tanacetum vulgare* L.) Treated with Antibiotics

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Ten bacteria were isolated from the in vitro shoot cultures of different tansy (*Tanacetum vulgare*) genotypes. All isolates were Gram-negative. Five isolates belonged to Enterobacteriaceae, three isolates were strains of fluorescent *Pseudomonas*, and two isolates were strains of other aerobic bacteria. The combined treatment with gentamicin (50 $mg \cdot L^{-1}$) and rifampicin (25 $mg \cdot L^{-1}$) prevented the growth of all bacteria, whereas none of the antibiotics (ampicillin, cefotaxime, rifampicin, gentamicin, or streptomycin) controlled all bacteria when used alone. The antibiotics ranged based on their increasing adverse effects on shoot cultures as follows: rifampicin, cefotaxime, and gentamicin. Increased antibiotic concentration reduced the initiation and growth rates of shoots, roots and calli with some exceptions. Low concentrations of gentamicin and cefotaxime both increased the growth rate and shoot number per plant. Rifampicin stimulated the root growth of some of the biotypes tested. The growth rate of calli increased significantly in the presence of both gentamicin (25 $mg \cdot L^{-1}$) and rifampicin (25 $mg \cdot L^{-1}$) in the growth media, whereas the use of either antibiotic alone reduced the calli growth relative to the control. Viability of tansy protoplasts was enhanced by rifampicin and to a lesser extend by gentamicin and cefotaxime. The growth of bacteria isolated from tansy tissue culture can be prevented with a combined gentamicin and rifampicin treatment. The growth rate of plants decreased slightly when grown in the media supplemented with the same antibiotic combination. However, the growth retardation was not permanent, and the plants recovered and grew vigorously when transferred to antibiotic free medium.

388 (PS 8)

Screening for Root-knot Nematode Resistance in Somaclonal Variants of *Solanum quitoense* Lam.

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Solanum quitoense is a perennial herbaceous plant native to the tropical regions of Colombia and Ecuador. It has attracted the attention of the international market because of the special taste of its fruits and its being a non traditional crop. The main problem in its culture is its susceptibility to root-knot nematodes, *Meloido-gyne incognita* (Kofoid & White) Chitwood. Two cultivars of *S. quitoense* were examined, 'Baeza' and 'Dulce'. The main objective of this research was to develop protocols for proliferation, rooting and establishment, and regeneration and screening for root-knot nematode resistance. *S. quitoense* was easy to proliferate, root and reestablish without using growth regulators. Regenerants were initiated from petioles and internodal stem sections cultured on MS medium supplemented with BA 1 to 10 mg·L^{-1}. From 420 explants cultured for each cultivar, there were 226 regenerants for 'Baeza' and 279 for 'Dulce'. Screening of regenerants for root-knot nematode resistance was carried out in the greenhouse with the regenerants of 'Dulce'. Twenty-one regenerants, inoculated with 1000 eggs per plant (determined based on a previous experiment), had five or fewer galls after 5 weeks. Follow-up greenhouse and in vitro screening experiments are presently ongoing.

104 POSTER SESSION (Abstr. 389–396) Seedling Establishment

389 (PS 1)

Low-temperature Tolerance Correlates to Seed Leakage in Twenty-eight Cultivars of Chile and with the Size of Seed Company

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Twenty-eight seedlots of *Capsicum annuum* from several commercial seed companies were tested for tolerance to low temperatures. Each cultivar was tested three times at 25, 20, and 15°C in laboratory incubators. It was observed that while high germination percentages (r85%) and fast germination rates were found in several seedlots, the relationship was not strongly linked to type of chile, age of seed, or treatment temperature. Of the 28 seedlots, 14 came from companies which are in the top 10% in volume and sales. The other 14 seedlots were from smaller companies. Seventy-one percent of the seedlots with germination at r85% came from the top ten companies. Ninety-two percent of the seedlots with s85% came from small companies. To further test this finding, we randomly choose six seedlots from a small company and 6 seedlots from a small company. There was a clear delineation in germabiltiy between the small company and the large company. Our results indicate a trend that could have a negative impact on some chile seed markets. Electrical conductivity (EC) is commonly used to detect membrane leakage in seeds. Chile seed from 12 seedlots (6 from the large company and 6 from the small company) were soaked 18 hours at 25 and 5°C. There was a negative correlation ($r^2 = 0.76$) between the 15°C germination at 40 days and the EC. It is important to determine why membrane leakage varies in seedlots from different companies and whether the leakage is due to phenotypic or cultural factors, or due to management practices within the company.

390 (PS 1)

Bio-osmopriming Tomato and Cucumber Seeds for Better Stand Establishment

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Improved germination under unfavorable soil conditions is an important safeguard against yield losses in direct-seeded crops. Osmoprimed seed has been shown to provide earlier and more uniform germination as well as improve low temperature germination. These attributes combined with the reduced rates of damping-off associated with *Pseudomonas aureofaciens* AB254 creates a bio-osmopriming seed treatment that provides rapid germination under a wider range of soil temperatures while exhibiting the disease resistance and improved growth associated with bacterial coatings. The objective of this work is to combine biopriming and osmopriming into one procedure, thus creating an environment for adequate seed hydration and rapid multiplication of beneficial bacteria which will thoroughly colonize the seed surface. Processing tomato seeds (*Lycopersicon esculentum* Mill. 'OH8245') were bio-osmoprimed in aerated –0.8 MPa $NaNO_3$ at 20°C for 4 days. On the fourth day, a mixture of nutrient broth, a defoaming agent, and bacteria that have been adjusted to the same osmotic potential is added. This is done so that the removal of seeds from the tank at the end of the 7-day treatment coincides with peak populations of bacteria. *Pseudomonas aureofaciens* AB254 multiplies very rapidly in this environment, with colony forming units for tomato averaging 4×105/seed. Results will also be reported for cucumber seed (*Cucumis sativus* L. 'Score'), which were treated using a similar procedure. Bacterial populations per seed, germination characteristics and pathogen control will be discussed.

391 (PS 1)

Priming and Accelerated Aging Affect L-isoaspartyl Methyltransferase Activity in Tomato Seed

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Damage and degradation of cellular proteins is observed during seed deterioration due to aging. L-isoaspartyl methyltransferase (EC 2.1.1.77) is an enzyme hypothesized to play a role in limiting and repairing aging-induced damage of proteins. Tomato seeds (*Lycopersicon esculentum* 'New Yorker') were assayed for changes in L-isoaspartyl methyltransferase activity during accelerated aging and after osmotic priming. Accelerated aging of seeds for 1 to 4 days at 45°C and 100% humidity reduced germination from 94% to 71%, the mean time of germination (MTG) increased from 2.4 to 5.8 days and was accompanied by a correlative decrease in L-isoaspartyl methyltransferase activity $R^2 = 0.90$. Aged and untreated seeds were primed for 7 days at 20°C in darkness using aerated solutions of 3% KNO_3 or polyethylene glycol 8000 (PEG) with equivalent osmotic potential (–1.25 MPa). Priming with KNO_3 decreased the MTG but not germination percentage for untreated seeds. Priming did not affect L-isoaspartyl methyltransferase activity in untreated seeds but restored activity in aged seeds primed in KNO_3 to levels near that of untreated seeds. Priming with PEG did not effectively improve the MTG or increase L-isoaspartyl methyltransferase activity. During germination, enzyme activity remained constant for 48 hours post-imbibition and then declined suggesting the enzyme was developmentally regulated and inactivated or degraded as radicle emergence occurred.

392 (PS 1)

Effect of Humic Acid Seed Treatments on Growth and Development of Seedlings

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Seed of *Cucumis sativus* and *Pelargonium ×hortorum* were imbibed for 24 hours in solutions containing 0 (deionized water), 2500, 5000, 10,000, and 20,000 ppm humic acid. Additional treatments included seed which were imbibed in nutrient solutions corresponding to the nutrient content of each humic acid solution as well as an untreated dry control. Percent germination was reduced for geranium seed imbibed in 20,000 ppm humic acid and for cucumber seed imbibed in either 20,000 ppm humic acid or the corresponding nutrient control. Root fresh weights for untreated and water imbibed geranium seed were 0.05 g. Humic acid treatment increased root fresh weights to a maximum of 0.14 g at 5000 and 10,000 ppm. Shoot fresh weights for geranium were 0.12 and 0.10 g for untreated and water imbibed seed, respectively. Humic acid treatment increased shoot fresh weight to a maximum of 0.18 at 2500 ppm. Root fresh weights for cucumber were 0.16 and 0.18 g for untreated and water imbibed seeds, respectively. Humic acid treatment increased root fresh weight to a maximum of 0.33 g at 10,000 ppm. Shoot fresh weights for cucumber were 0.31 and 0.38 g for untreated and water imbibed seed, respectively. Humic acid treatment increased shoot fresh weight to a maximum of 0.43 at 10,000 ppm.

393 (PS 1)

Marigold Growth in Six-packs following Transplanting from Plugs at Several Stages of Development

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Root and shoot development in Marigold 'Little Devil Flame' was studied after being grown for varying lengths of time in 392-count plugs before transplanting

to six-pack cells. Seedlings were grown for 0, 5, 10, 15, 20, and 25 days before transplanting to six-packs. All plants were measured at day 25. There was no significant difference in total root length, area and dry weight per plant or in leaf area and shoot dry weight per plant for seedlings transplanted from 0 to 15 days. Both total root dry weight and total shoot dry weight of seedlings transplanted on day 20 was reduced by 32% compared to seedlings that were not transplanted. Total root dry weight of seedlings transplanted at day 25 was reduced by 60% while total shoot dry weight of seedlings was reduced by 56% from those not transplanted. In a separate experiment, the growth rate of seedlings grown in plugs was sigmoidal (r^2 = 0.98). Growth rate was significantly reduced between 20 and 25 days in the plug. These results suggest that root restriction in the plug may be a factor in the reduction of seedling growth following transplanting.

394 (PS 1)

Production of Vegetable Transplants with the Controlled Water Table Irrigation System

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Cabbage seed was germinated and grown to transplanting size in a 98-cell tray using an automatic irrigation system based on the principle of maintaining a constant water table (CWT) relative to the growing medium in transplant trays. Seedlings obtained a nutrient solution from a capillary mat with one end suspended in a trough containing the solution. The distance between the nutrient solution surface and the transplant tray bottom was regulated with a water level controller. The nutrient solution was resupplied from a larger reservoir. A polyester material on top of the capillary mat allowed solution movement to the roots but prevented root penetration into the mat. The water table placement below the tray determined the water content in the growing medium. Seedling growth was evaluated using two growing media combined with two water table placements. Excellent quality seedlings were produced; the CWT irrigation system satisfactory provided water and nutrients for the duration of the crop. The only problems observed were dry cells, less than 2%, because of no media–mat contact and algae growth on the media surface using the higher water table. The CWT irrigation system is adaptable to existing greenhouse vegetable transplant production systems. It is automatic and can provide a constant optimum amount of moisture for seedling growing. It can be adjusted for phases of seedling growing such as more water during germination and can create water stress near transplanting time to either harden off or hold plants because of unfavorable planting conditions.

395 (PS 1)

Effects of Hydrating, Boiling, Acid Scarification, and Seed Coat Removal on Emergence of *Citrus* sp., *Poncirus trifoliata*, and Citrange Seeds

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Current efforts in the study of citrus freeze hardiness including gene mapping and elucidating early induction processes require large populations of uniform seedlings. Related genera and intergeneric hybrids are often used in these studies and little is known about factors effecting their seedling emergence. We tested a total of 8 genotypes including *Poncirus trifoliata* 'Rubidoux', *Citrus grandis*, *C. sinensis* 'Pineapple', *C. jambhiri* 'Schaub', *C. paradisi* 'Duncan', *C. aurantium* (Brazilian), Carrizo citrange (*P. trifoliata* x *C. sinensis*), and Troyer citrange. A total of seven pre-planting treatments were used to evaluate seedling emergence rates. Expanding on the work of previous researchers, treatments were seed coat removal, hydrating in water (96 hours) at either 4, 25, or 35°C, acid scarification, or boiling. Generally, seed coat removal resulted in the most uniform emergence as compared to untreated controls. Presoaking at each temperature enhanced emergence in most varieties tested and 25°C was the best hydrating temperature. Acid scarification greatly delayed emergence in all genotypes tested except Troyer citrange and 'Pineapple' orange which had enhanced emergence rates as compared to controls. Preplanting treatment with 100°C water was lethal in all varieties. Pretreatment of citrus seeds can enhance uniformity of germination, although optimum treatments for individual genotypes vary.

396 (PS 1)

Morphological Development of Pawpaw [*Asimina triloba* (L.) Dunal] during Seed Germination and Seedling Emergence

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Little scientific information is available describing morphological development of pawpaw during seed germination. To provide this information, a study was designed to outline important developmental stages and describe seedling characteristics within each stage. Stratified pawpaw seeds were sown in vermiculite and germinated at 25°C in a growth chamber. Ten seedlings were randomly chosen and destructively harvested at 5-day intervals starting at radicle protrusion. Length (mm), fresh and dry weight, and percentage of total dry weight were determined for seedling components. Pawpaw seeds have a small rudimentary embryo with all food reserves stored in a ruminate endosperm. Dry weight measurements showed a dramatic reallocation of reserves from the storage tissue to developing seedling parts. Initial embryo length was less than 3 mm, but within 70 days seedlings exceeded 350 mm. Twelve days after planting, simultaneous radicle and cotyledon growth occurred (3.4 and 3.0 mm, respectively), but neither hypocotyl nor epicotyl was visible. Radicle protrusion was observed at 15 days with radicle, cotyledon and hypocotyl lengths increasing to 4.4, 4.0, and 3.2 mm, respectively. Endosperm comprised 99.1% of total dry weight at this stage. The hypocotyl hook emerged after 30 days and endosperm comprised 76.1% of total dry weight. Cotyledons reached maximum length (29.0 mm) at day 40 and the epicotyl was discernible. At 55 days, the seed coat containing cotyledons and residual endosperm abscised and the average radicle, hypocotyl and epicotyl lengths were 182.0, 61.1, and 7.3 mm, respectively. It is suggested that the cotyledons primary function is absorption of food reserves from the endosperm for transfer to the developing seedling.

104 POSTER SESSION (Abstr. 397–406)
Propagation

397 (PS 1)

Germination and Growth of Four Species of Ericaceous Plants

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The germination of ericaceous plant species is often variable and not well-defined. We have had some difficulty in obtaining good germination and significant establishment and growth after transplanting. Four different moisture regimes and two different media were used for the germination of *Kalmia latifolia, Oxydendrum arboreum, Rhododendron maximum,* and *Vaccinium corymbosum* seeds. Seeds were surface-sown on peat or peat + bark (1:4) media. Pots were then placed under either one of two different misting regimes, set in a tray of water, or set in a tray of water under a humidity tent. Germination was higher and more consistent for all species sown on peat and occurred sooner for seeds under the humidity tent. *Rhododendron* and *Kalmia* under the humidity tent grew more rapid than with other treatments. Increases in germination under the humidity tent were due more in part to higher temperatures than to the minimal increase of humidity inside the tent. Germination was poor for seeds under the high-mist treatment, presumably because there was too much moisture. Germination of *Vaccinium* and *Oxydendrum* was low for all treatments.

398 (PS 1)

Propagation of Selected Culinary and Ornamental Herbs

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Ten culinary and ornamental herbs were evaluated for time and quality of rooting of tip cuttings. The taxa included in the study were oregano (*Origanum vulgare*), lemon thyme (*Thymus ×citriodorata*), applemint *(Mentha suavolens*), Persian catnip (*Nepeta×faassenii*), lemon balm (*Melissa officinalis*), southernwood (*Artemisia abrotanum*), caraway thyme (*Thymus herba-barona*), hyssop (*Hyssopus officinalis*), 'Blue Wonder' catnip (*Nepeta* 'Blue Wonder'), pineapplemint (*Mentha suavolens* var. *variegata*). Four replicates of each species were used. The cuttings, untreated and rooting hormone treated, were placed under intermit-

tent mist, then cuttings potted when a 1- to 1.5-inch root ball had developed. Most of the stock suffered from some chlorosis during rooting; southernwood cuttings particularly displayed severe chlorosis which was overcome with 2 weeks of constant-feed fertilizer after potting. Oregano displayed the best results, rooting in seven days with or without treatment. It produced a sellable 4-inch pot in 31 days from sticking the cuttings. Lemon thyme, applemint, Persian catnip, and lemon balm all rooted in 14 days if treated. No difference was observed in days to rooting between treated and untreated lemon thyme. Untreated cuttings of lemon balm, applemint, and Persian catnip rooted in 25 to 30 days. Treated applemint cuttings not only rooted more quickly but produced a marketable 4-inch pot in significantly less time. Southernwood and caraway thyme rooted in 25 days, with no significant difference between treated and untreated cuttings. Hyssop, pineapplemint, and 'Blue Wonder' catnip took about 30 days, also with no significant difference between treated and untreated cuttings.

399 (PS 1)

Capillary Mats Modify Media Moisture Content during Mist Propagation of Chrysanthemum Cuttings

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Capillary mats were used to vary the water content in oasis blocks during mist propagation of chrysanthemum cuttings. Mats placed on the surface of the propagation bench extended over the edge of the bench and downward a distance of either 0 or 20 cm. Oasis blocks with chrysanthemum cuttings 'Boaloi' and 'Salmon Charm' were placed on mats under intermittent mist (10 seconds every 5 minutes) between 5 AM and 8 PM. Relative water content, mL of water/gram oasis, and leaf water potential were measured at noon every 5 days. After 26 days number of roots per cutting was evaluated. Water content in the oasis block was reduced by 49% (450 to 219 mL/g dry weight of oasis) by hanging the capillary mat 20 cm over the edge of the bench compared to 0 cm treatment. Cuttings showed an increase in leaf relative water content from 49% and 51% at day 1 to 65% and 71% by day 11 for 'Boaloi' and 'Salmon Charm', respectively. Following initial root formation, leaf relative water content increased to 85%. Over the course of the experiment 'Boaloi' and 'Salmon Charm' showed an average reduction in leaf water potential of 0.14 and 0.08 MPA , respectively. 'Boaloi' showed overall higher root numbers than 'Salmon Charm'; however, no difference in rooting between mat treatments was observed.

400 (PS 1)

Anatomy of Adventitious Root Formation in Stem Cuttings of *Mussaenda erythrophylla* L. 'Rosea'

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Mussaendas (*Mussaenda* spp.) are ornamental shrubs, and some cultivars are difficult to root. This study was conducted to explore how adventitious roots initiate and develop in the cultivar Rosea, and to determine if anatomical events are associated with difficulty in rooting stem cuttings. Stem cuttings were treated with 5, 10, 15 mM 1*H*-indole-3-butyric acid (IBA), or distilled water, and sampled every 2 days over 26 days to observe adventitious root formation and development. For analysis by light microscopy, the basal 1 cm of cuttings was embedded in wax and stained with safranin-fast green. Adventitious roots initiated from phloem parenchyma cells and from basal callus in nontreated cuttings. Cuttings treated with 15 mM IBA had a mean of 18 root primordia per basal 1 cm of cutting after 10 days. Root primordia were not observed in non-treated cuttings at 10 days. Root primordia that developed in non-treated cuttings lacked clear vascular connections. These results suggest that non-treated cuttings are difficult to root because few primordia are produced.

401 (PS 1)

Influence of Substrate, Auxin, and Propagation Period on Rooting of Eight Florist Azalea Cultivars

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During Spring–Summer 1995, cuttings of eight *Rhododendron simsii* cultivars 'Dorothy Gish', 'Jacinth', 'Paloma', 'White Gish', 'Friedhelm Scherrer', 'Gloria', 'Helmut Vogel', and 'Inga' were rooted using two substrates combined with or without (control) four rooting hormone treatments. The rooting substrate was composed of either pure peat moss or 80% peatmoss and 20% perlite. The basal end of cuttings were dipped into one of the four hormone treatments: IBA (Stim-Root powder) at 4000 and 8000 ppm, or IBA (liquid Stim-Root) at 5000 and 10,000 ppm. This experiment was repeated in Fall 1995 and in Winter 1996 to determine the effect of seasonal period on rooting. Spring is the optimal period for rooting the cultivars used in this study. Highest percentage of rooting was obtained with cultivars 'Helmut Vogel', 'Inga', 'Jacinth', and 'Paloma'. Dry mass of cultivars propagated using liquid formulation was significantly increased during this period. Substrates did not significantly effect rooting percentage and quality and dry root mass.

402 (PS 1)

Effect of IBA Concentration on Rooting of Sugar Maple

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Softwood cuttings of 'Commemoration' and two selections of Caddo maple (83-NR3 and 90-7185) were collected on 24 May 1995 from specimen trees located at the Wichita Horticultural Research Center. Uniform cuttings 14–19 cm long containing 4–5 leaves were dipped in selected IBA hormone solutions for 10 seconds and stuck in a rooting mix consisting of 30% Canadian sphagnum peat and 70% perlite (v/v). The experiment was conducted in a greenhouse located at Kansas State Univ. To achieve a high relative humidity around the cuttings, a fog generator (Humidifan, turbo XE 1000) was installed and operated for 12 hours per day. The experiment was a factorial design with 3 maple selections, 4 hormone concentrations and 3 replications. After 10 weeks cuttings were evaluated for rooting using a visual rating scale of 1–5. There was a significant difference between the maple cultivars and the IBA levels tested. 'Commemoration' cuttings rooted the best among the maple cultivars with all of the IBA treatments. The best rooting of Caddo maple selection (83-NR3) took place with 10,000 ppm IBA. None of the cuttings of the other Caddo maple selection (90-7185) rooted regardless of the hormone concentration. The rooted cuttings were potted in 15 cm plastic containers filled with Metro Mix 702 for future production.

403 (PS 1)

The Effects of Combinations of Three Scions and Three Rootstocks on Yield and Quality of Iranian Pistachio Nuts

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Rootstocks in various species have been shown to significantly influence vigor of scion growth, yield, fruit size, maturity, quality, and other phenomena. This research studied the effects of combinations of three scions and three rootstocks of Iranian pistachio on characteristics of fruit. A split-plot design was laid out at Rafsanjan/Iran in 1993 and results for a period of 2 years from 1994 to 1995 are presented. Diameter of trunk 5 cm above and below the graft area, weight of nuts with hull, weight of nuts without hull, weight of in-shell nuts, weight of blank, percent of shell splitting and total yield weight were measured. Almost all the treatment differences in the experiment were associated with rootstock effects and not scions. Statistical analysis indicated that different scions had no effect on any of the measured characteristics except the diameter of trunk 5 cm below the graft area. Rootstocks, however, had large and significant effects on all the characters except percent shell splitting. Interactions between scion and rootstock were important such that the combination of the scion 'Kalehghochi' with the rootstock 'Ahli' gave substantially higher yields than any other combination.

404 (PS 1)

Study and Comparison of Different Methods of Nonsexual Propagation of $F_{12/1}$ and Colt Rootstocks of Cherry

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This research work was carried out for 2 years at Kelardasht-Mazandaran and Mardabad-Karaj Agricultural Research Stations to evaluate the rooting of selected and hybrid $F_{12/1}$ and Colt rootstocks under climatic conditions of Iran. Young $F_{12/1}$ and colt rootstocks (semi-hard wood and summer cuttings) available in Kelardasht Agricultural Research Station were used These rootstocks were also used for layering. Summer cuttings were taken in early July and, after wounding, were treated with IBA with 1000, 2000, and 3000 ppm and then put under mist. Three months later the rooted cuttings were evaluated on the basis of rooting percentage, number and the length of the main and the lateral roots and the length of the rooted section. The hardwood cuttings were prepared in two intervals (early Dec. and late March) and, when wounded, were treated with IBA with the same concentrations. Finally, the experiments were completed by horizontal layering of several

rootstocks and covering them with soil. The results were used in a completely randomized block design in four treatments, and the averages were compared by Duncan test. The results indicate that the summer cuttings treated with 1000 ppm IBA have the highest rooting percentage in both rootstocks, while those treated with 2000 ppm gave the best results with regard to number and the length of the main root. The best result on the number and the length of the lateral roots are achieved in cuttings treated with 2000 ppm IBA. Number and the length of lateral roots in Colt and $F_{12/l}$ rootstocks are, respectively, high in cuttings treated with 2000 and 3000 ppm. IBA. In semi-hardwood cuttings, different concentrations of IBA were effective on callus formation and budbreak. Thus, there were more callus formation in high concentration and the number of budbreaks was reduced. Study on the layering method indicates that there are 6.1 and 3 rooted cuttings in every Colt and $F_{12/l}$ layered rootstocks respectively. The rooting percentage in the said rootstocks is 100% and 73.3%, respectively.

405 (PS 1)

Study of the Effect of Different Media Beds, Time, and Wounding Factors on the Rooting of Semi-hard Cuttings of Olive [*Olea europaea* (Roghani & Zard Zeitoun C.V.)] under Mist Conditions

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To determine the most proper bed, time, and wounding factors on the rooting of semi-hard cuttings of olive (*Olea europaea*), cuttings were selected and research was conducted at the Faculty of Agriculture of the Tehran Univ. in Karaj. The required cuttings were taken from healthy and similar mother trees at the Roodbar Research Station. Then, semi-hard cuttings of 15 cm in length and 3 to 5 mm in diameter with four terminal leaves were prepared. Then those prepared cuttings were treated with IBA at 4000 ppm and Captan fungicide at 3000 ppm before planting. This experiment was designed in a factorial with a randomized complete block, with four media bed factors for rooting in seven levels (peatmoss + perlite, sawdust + sand, peatmoss + sand, and perlite, sand, and perlite + sand), the time factor for cutting preparation in four levels (May, August, September, and March), cultivars at two levels (Roghani and Zard Zeitoun), and wounding treatment at two levels (unwounded and wounded); there were three replications (20 cuttings per replicate per each unit). The results indicate that, among the selected beds, perlite with 53% of rooting average yield has the highest and peatmoss + perlite with a rooting average of 43.8% has the lowest. As far as time is concerned, those cuttings prepared in March show the highest rooting average of 69.3%, while those prepared in August show the lowest average of 12.7%. The comparison between the two cultivars shows that Roghani, with 60.4% rooting yield, is preferred to Zard Zeitoun, with 48.2% rooting average. There were no significant differences between wounded and unwounded cuttings with regard to rooting.

406 (PS 1)

Propagation of Pistachio Trees Using Epicotyl Grafts

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Methods to shorten the required fruiting period for pistachio may reduce production costs. Therefore, grafting is recommended. We examined three grafting methods : fabble, cleft, and side. Fabble grafts had 66% success and therefore a higher efficiency than the other two types of grafts examined. BA or ascorbic acid did not have a considerable positive effect on graft healing and there may have been some negative effects. The results of microscopic dissection show that healing between rootstock and scion, i.e., formation of callus, xylem, and phloem tissues in the epicotyl stage, are similar and the plants propagated by epicotyl grafts enjoy maturity signs from ontogeny points of view in two growing seasons.

145 POSTER SESSION (Abstr. 407–411) Postharvest Physiology–Cross-commodity

407 (PS 7)

Effects of Sprouting Inhibitors and Reconditioning Conditions on Tuber Quality of Processing Potato

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This study was conducted to find out the effect of sprouting inhibitors under different storage temperatures and reconditioning conditions on the processing quality of potato tubers produced in the alpine area of Korea. A higher sprouting ratio was observed in potatoes stored at 15°C than those at 5°C. In particular, 1% CIPC, was effective in the inhibition of sprouting, keeping the sprouted shoots in less than 2 mm, while rosette-shaped shoots, 12–17 mm, were observed in the CMH (100%) treatment. Atlantic was, in general, lower in reducing sugar contents compared to Superior. Reducing sugar contents in potatoes stored at 15°C were not increased, while potatoes stored at 5°C showed a 1% increase in reducing sugar contents for 180 days after storage. As far as chip color "L" value was concerned, no difference was detected among potato cultivars and sprout inhibitor treatments. Potato chip color was found to be the best from potatoes stored at 15°C for 180 days of storage. However, potatoes stored at 5°C gave rise to poor quality of potato chips with browning and bitter taste. Reconditioning had different effects on potato cultivars in that Atlantic potatoes produced more sprouts when they were reconditioned compared to the control of 15°C potato storage. In terms of the effect of reconditioning on reducing sugar contents, Atlantic sugar contents was reduced reconditioning went on. Sugar contents of Superior, however, was increased after undergoing the decrease for some time. Changes in potato chip color as influenced by reconditioning were in accordance with changes in reducing sugar. Atlantic was much better in chip color than Superior, showing a chip color "L" value of more than 50 in all treatments.

408 (PS 7)

Stress-induced Ethanol Production in Fresh Fruit and Vegetables

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Fresh fruits and vegetables produce ethanol when they are held in atmospheres containing low concentrations of oxygen. Ethanol concentrations in the headspace of fresh *Brassica* vegetables held 24 hours in nitrogen at 20°C ranged from 5 to 110 $mmol \cdot m^{-3}$. The absence of oxygen induced anaerobic respiration and the production of ethanol in these vegetables. However, other stresses, including heat and high concentrations of carbon dioxide, can also stimulate the production of ethanol in fresh fruits and vegetables held in aerobic atmospheres. Fresh heads of broccoli dipped in 52°C water had increased concentrations of headspace ethanol 2 hours after treatment when held at 20°C in air. Concentrations were 6, 160, and 490 times greater in broccoli treated for 1, 2, or 3 minutes than in nontreated controls, respectively. Fruit of three highbush blueberry cultivars held in 25% carbon dioxide for 6 weeks at 0°C had 80 to 190 times more ethanol than fruit held in air. The 25% carbon dioxide atmosphere also induced blueberries to soften and develop off-flavors. Ethanol may be a fast and easy-to-measure indicator of physiological stress in stored fresh fruits and vegetables. Monitoring induced ethanol production could identify injurious storage environments or postharvest treatments. Possible mechanisms of stress-induced ethanol production will be discussed.

409 (PS 7)

Effects of Anaerobic Atmosphere on the Metabolism of Sulfur Volatile Compounds Produced by Broccoli

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Objectionable off-odors are produced by broccoli (*Brassica oleracea*, L.) when it is held under anaerobic conditions. These off-odors were attributed to sulfur volatile compounds mainly methanethiol (MT) and hydrogen sulfide. The present study was undertaken to investigate the effects of anaerobic conditions on the metabolism and emission of sulfur volatiles by broccoli. Inhibition assays using aminooxyacetic acid (AOA)—a potential inhibitor of pyridoxal-phosphate-dependent enzymes- confirmed the enzymatic origin of these volatiles. However, anaerobic atmosphere had no inducible effect on the enzymes cystine lyase, cysteine desulfhydrases and S-alkylcysteine lyase. These pyridoxal-phosphate-dependent enzymes thought to catalyze the respective degradation of cystine, cysteine and S-methyl-L-cysteine to sulfur volatiles showed no significant activity increase. Storage of sterile broccoli seedlings under anaerobic atmosphere resulted in an important increase of the content of sulfur amino acids that corresponded to an increased emission of sulfur volatiles. Cysteine and methionine content increased particularly at 24 hours and decreased later. Whereas, S-methyl-L-cysteine content increase was more obvious after 48 hours. The results suggest a possible involvement of the pathways for synthesis and breakdown of sulfur amino acids via methionine.

410 (PS 7)

Rapid Analysis of Volatile Flavor Compounds in Horticultural Produce Using Solid-phase Microextraction and Gas Chromatography–Time-of-flight Mass Spectrometry

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Aroma analysis of horticultural produce is an emerging field in which both flavor producing and malodorous compounds are detected from within a complex sample matrix. Qualitative and quantitative information is desired to monitor produce ripeness and provide quality control over processed products such as juices, preserves and canned products. Conventional analysis methods such as purge and trap and gas chromatography–mass spectrometry provide much of this information but are laborious and time consuming. Faster techniques are required when large numbers of samples are being analyzed and when rapid feedback to the produce harvester is required. Solid-phase microextraction (SPME) has recently been shown to significantly reduce the sampling times required by more conventional methods. The use of fast gas chromatographic techniques along with the recently commercialized time-of-flight mass spectrometer has also significantly reduced the separation and analysis times. We have combined SPME with gas chromatography–time-of-flight mass spectrometry as a rapid and quantitative tool for the analysis of flavor volatiles in apples and tomatoes. The sampling and analysis processes provide significant improvements to sample throughput, with analysis times taking only 2–6 minutes. The linear response of this system to butylacetate, ethyl-2-methylbutanoate and hexylacetate ranges from ppb to ppm levels, and the identification of unknown flavor compounds is possible even in the presence of other co-eluting compounds. The SPME technique is able to investigate volatiles changes in apple cuticle and tissues, which open the new possibility for flavor biochemistry research.

411 (PS 7)

Photocatalysis of Ethylene in Air: Reactor Design and Performance Evaluations

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The performance of a reactor designed to convert volatile hydrocarbons to carbon dioxide and water by a combination of surface chemistry and UV radiation was tested under conditions relevant to horticulture. Air containing 65 to 1100 $nL \cdot L^{-1}$ ethylene gas passed through a bed of catalyst crystals at a rate of 0.1 to 2.0 $L \cdot min^{-1}$. The catalyst bed consisted of 14 g of zirconia-titania particles, 0.50 to 0.75 mm in size, that occupied the space between a 4-W UV lamp and a stainless-steel housing. Dew-point temperatures of the air passing through the reactor ranged from 5 to 22°C and internal reactor temperatures ranged from 20 to 80°C. Increasing internal reactor temperature, ethylene concentration, or air flow resulted in increasing ethylene photocatalysis by the reactor. Increasing dewpoint temperature of the air stream resulted in decreasing ethylene photocatalysis by the reactor. Operation of the reactor over a 120-day period showed that reactor design and catalyst performance were stable and robust during continuous duty. Our results demonstrate that the reactor performed well over a wide range of conditions and may be useful for applications in horticulture. This research was, in part, NASA sponsored, and a reactor similar in design to that used in our studies has been used for plant growth in space.

412 (PS 7)

Postharvest Stability of Guayule Natural Rubber and Resin during Long-term Cold Storage

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Guayule shrub (*Parthenium argentatum* Gray) is a source of natural rubber resin and latex. Because guayule does not produce natural antioxidants, considerable amounts of rubber and resin are lost after harvest. The effect of long (2–7 years) cold storage on postharvest stability of rubber and resin contents in selected dryland guayule breeding lines were compared. While most genotypes tested showed significant decline in rubber and/or resin content during the storage, few genotypes consistently maintained or increased the amounts of rubber or resin content during storage. The mechanisms of postharvest degradation or synthesis of rubber and resin in harvested guayule plant materials need to be studied further.

108 POSTER SESSION (Abstr. 413–418) Postharvest Physiology–Floriculture

413 (PS 4)

Analysis of MADS Box Gene Expression during Ethylene-insensitive Flower Senescence using Quatitative RT-PCR

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The metabolic pathway and function of ethylene during the senescence of many fruits and flowers have been extensively studied, the molecular basis of ethylene-insensitive flower senescence remains unknown. The ephemeral flowers of daylily (Hemerocallis) were used as a model system for the examination of ethylene-insensitive senescence. Senescence-associated cDNA clones were isolated from a cDNA library constructed from mRNA expressed in senescing tepals of daylily flowers. Up-regulated cDNA clones were identified by differentially screening the cDNA library. Sequence analysis of one of the clones, designated as SEN12, indicates that it contains a MADS box domain and an associated leucine-zipper K-box region and may be a transcription factor similar to floral homeotic genes. Northern analysis indicates that SEN12 encodes for a rare message. Therefore, reverse transcriptase polymerase chain reaction (RT-PCR) assays were used to quantitate the abundance of SEN12 transcripts during floral senescence. RT-PCR assays demonstrated that SEN12 transcripts significantly increase in abundance during the earliest stages of flower senescence and continue to increase until the end of senescence. We propose that SEN12 may be involved in controlling senescence in ethylene-insensitive flowers and we are continuing to investigate this hypothesis.

414 (PS 4)

Postharvest Handling of Cut Inflorescences of *Ebenus cretica* L.

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Ebenus cretica, Leguminosae, is a perennial bush endemic to the island of Crete, and produces attractive pinky red or purple flowers on 15-cm long racemes. To study the possibility of its use as a cut flower, cut inflorescences on 40-cm-long spikes were taken from plants grown outdoors in the farm of the Technological Educati Institute and used to determine the postharvest characteristics of *Ebenus* flowers. Without any postharvest treatments, the inflorescences held in water had an average life of about 7 days. A solution of 100 ppm 8-hydroxyquinone sulfate (HQS) in DI water, supplemented with 5% $Ca(NO)_3$ increased vase life for 2 days and improved the water potential without affecting transpiration, whereas the addition of 2% or 5% sucrose decreased vase life by 1 or 2 days respectively. Pulsing with 0.2 mM STS for 2 h improved flower quality and vase life. Addition of 6-BAP (2 ppm) or GA_3 (3 ppm) in the preservative solution did not affect flower quality or vase life compared to control. These results indicate that inflorescences of *Ebenus cretica* may be used as cut flowers; however, further research is required to determine their sensitivity to ethylene as well as its storage capabilities.

415 (PS 4)

Prolonging the Vase Life of Snapdragons and Carnations with a Natural Lipid, Lysophosphatidylethanolamine (LPE)

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Freshly cut snapdragon (*Antirrhinum majus* L) spikes or carnation (*Dianthus caryophyllus* L cv. White Sim) stems were put in LPE (10 ppm for carnation, 25 ppm for snapdragon) solution for 24 hours and then transferred to deionized water. Parallel controls were kept continuously in deionized water. Snapdragon spikes were harvested when they had one-third of the florets opened which is a standard commercial practice. The carnations used in the experiment were harvested at three different stages of flower development starting from open brush bud stage (Stage IV) to fully opened (Stage VII, petals 45(to the stem) flower. LPE treatment delayed senescence in snapdragon by four days. Furthermore, it enhanced the opening of floral buds and opened all the florets on every spike. LPE treatment also significantly delayed loss in fresh weight of spikes associated with

senescence, lowered the endogenous ethylene production and reduced ion leakage from florets. LPE had a similar effect on fresh weight and ion leakage from carnations if it was applied at an early stage of flower opening. Older carnations (Stage VII) were found unresponsive to LPE. In conclusion, LPE has the potential in enhancing the vase life of snapdragons and carnations. Carnations must be harvested at the open brush bud stage for effective LPE application. Our results suggest that LPE is prolonging vase life of cut flowers by reducing ethylene production and maintaining membrane integrity.

416 (PS 4)

Physiological, Biochemical, and Molecular Changes in *Pelargonium* Cuttings Subjected to Short-term Storage Conditions

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The purpose of this study was to evaluate physiological, biochemical and molecular changes which occur in unrooted *Pelargonium* ×*hortorum* cuttings during storage. *Pelargonium* cuttings of 'Sincerity' (good shipper), 'Wendy Ann' (moderate shipper), and 'Snowmass' (poor shipper) were stored at 25°C and evaluated over a 5-day period. Following removal from storage, cuttings exhibited progressive declines in photosynthesis, respiration, carbohydrate, starch and protein over time which was significant in all three cultivars, however there was little difference among the cultivars. Ethylene levels produced by 'Sincerity' and 'Wendy Ann' began to increase 3 days following the initiation of storage, whereas 'Snowmass' showed an increase after one day reaching a peak at 3 days and was followed by a sharp decline. When unrooted cuttings of 'Snowmass' were stored for a 5-day period at temperatures from 4 to 25°C, it was observed that those stored at 4°C had a significantly higher visual rating, chlorophyll content, root and shoot weight than at higher temperatures tested. The decline in quality progressively became greater from 10 to 25°C. Changes in gene expression of two ACC synthases and an ACC oxidase were evaluated in 'Snowmass' cuttings which were stored at 4 and 25°C. Correlations between ethylene and ACC levels with gene expression were observed.

417 (PS 4)

Postharvest Evaluation of Fresh Cut Sunflower Cultivars

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Specialty cut flowers are gaining a greater market share of the floral industry. One species that seems to be losing its fad status and again becoming a market mainstay are sunflowers. In response to that demand seed companies are introducing new sunflower cultivars. Little work has been done to evaluate and compare the postharvest life of these new cultivars. A study was conducted Summer 1995 to determine the postharvest life of several cultivars using both water and floral preservatives. Less than half of the cultivars evaluated had an acceptable commercial postharvest life when only water was used. When fresh flower preservatives were used only three of the cultivars evaluated had an unacceptable postharvest life. The addition of floral preservatives significantly increased the postharvest life of more than a third of the cultivars evaluated, but only two thirds of those had their postharvest life increased into the acceptable range. Cultivars found to have an acceptable postharvest life include a wide variety of colors, plant heights and pollenless flowers, giving the grower a wide choice of cultivars for commercial production.

418 (PS 4)

Evaluation of Stem and Flower Strength of Different Freeze-dried Peony Cultivars

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The floral industry is always trying to identify new products for consumers. Dried/preserved products have gained in popularity because they have a long vase life and offer a wide range of forms, textures and shapes. Among these new dried/preserved products are freeze dried flowers. Freeze drying preserves flower color and shape better than air and matrix drying. From a grower's standpoint, they need to know which plants and which of their cultivars will freeze dry better than others, especially if the plant is a perennial that takes time to come into production. Peonies are a good example. Fragility of the flowers after freeze drying is one of the most important factors determining the suitability of a plant and its cultivars. The objective of this study was to evaluate the flower and stem strength of freeze dried peony flowers of several cultivars to be able to recommend to growers which cultivars freeze dried better than others. Flowers from different red, pink and white herbaceous peony cultivars were freeze dried using commercial equipment and protocols. Stem and flower strengths were determined by compression tests via an Instron Universal Testing Machine. There were no differences in flower strength among the white cultivars evaluated. Flowers of the red cultivars, 'Shawnee Chief', 'David Harum', 'Kansas', and 'Monsieur Martin Cahuzac', were stronger than most of the other reds evaluated. 'James Pillow' flowers were stronger than most other pinks. There were no differences in flower strength among the other pink cultivars. Lack of differences in flower and stem strength provides growers with a wider selection of suitable cultivars.

143 POSTER SESSION (Abstr. 419–426) Postharvest Physiology–Subtropical/ Tropical Fruits

419 (PS 5)

Alleviation of Grapefruit Peel Injury after Exposure to Irradiation and Storage

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Low-dose irradiation (0.15 kGy) of grapefruit is reportedly a viable quarantine treatment for pests such as Caribbean fruit fly larvae, and is expected to be approved soon for use by the U.S. citrus industry. For the application of ionizing gamma irradiation to be efficacious for all fruit treated on commercial pallet units, fruit will likely require doses 3 to 4 times the required minimum dosage. Grapefruit peel is known to be slightly injured at 0.3 kGy, and can be seriously injured at 0.6 kGy but no peel injury is allowed for U.S. #1 grade fruit. A forced-air vapor-heat treatment at 38°C for 2 hours reduced the severity and incidence of grapefruit peel injury by irradiation at doses to 1.0 kGy. The heat treatment reduced the incidence of peel injury at 0.5 and 1.0 kGy by about 50% and 21%, respectively. No other quality or condition attribute was affected by the combination treatment of heat and irradiation. Peel injury was not reduced however by pretreatment with thiabendazole (TBZ) at 1000 ppm or 4000 ppm, or a combination of 1000 ppm each of TBZ and imazalil. A combination treatment of heat before irradiation may allow for doses higher than attainable without heat during the application of irradiation as a quarantine treatment of grapefruit.

420 (PS 5)

Tolerance of Grapefruit and Mexican Fruit Fly Larvae to High-temperature Controlled Atmospheres

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The objective of this research was to investigate whether a controlled atmosphere established inside a high temperature forced air chamber could enhance the mortality of the most heat-resistant life stage of Mexican fruit fly larvae (*Anastrepha ludens* Loew) and thereby reduce the amount of time grapefruit (*Citrus paradisi* Macf.) harvested from Mexican fruit fly-infested regions must be exposed to high-temperature forced air to achieve quarantine security. The mortality of third instar larvae treated on diet was significantly higher after exposure to 1% oxygen or 1% oxygen enriched with 20% carbon dioxide than it was in either air or air enriched with 20% oxygen. Reducing the amount of oxygen in air from 21% to 1% during forced air heating at 46°C, reduced the exposure time required for 100% kill of larvae inside artificially infested grapefruit from 5 hours to 3.5 hours. Inconsistent fruit quality results warrant further study to optimize controlled atmosphere conditions during heating. Based upon relative levels of carbon dioxide inside the grapefruit during heating, fruit respiration during heating in 1% oxygen was lower than during heating in air. Results from this research suggest that reducing the amount of oxygen in a high temperature forced air chamber during heating can reduce the amount of time fruit must be exposed to heat for quarantine security against Mexican fruit fly.

421 (PS 5)

Effectiveness of Methyl Jasmonate on Reducing Chilling Injury in Grapefruit

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Freshly harvested unwaxed 'Marsh Ruby' grapefruit (*Citrus paradisi* Macfad.)

were obtained from Wabasso, Fla. The fruit were treated with methyl jasmonate by dipping, pressure infiltration (82.7 kPa for 3 minutes), or vapor fumigation. Control fruit were similarly treated with distilled water. All fruit were then stored at 1°C. Samples from all treatments were transferred to 20°C for 3 days after 4 and 10 weeks of storage at 1°C for evaluation of chilling injury. Symptoms of chilling injury were negligible in all treatments after 4 weeks of storage. However, after 10 weeks of storage, moderate to severe pitting occurred in the control fruit but the severity of chilling injury was significantly reduced by methyl jasmonate treatments. The most effective treatments were either pressure infiltration using a 0.1 mM emulsion or fumigation with vapor at saturation.

422 (PS 5)

The Effect of Ethylene during Controlled-atmosphere Storage of Bananas

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Banana fruit respiration rates and quality parameters such as peel color, pulp pH and soluble solids content were examined at 14°C under a number of controlled atmosphere (CA) environments. CA conditions were 1%, 2%, 4%, or 8% oxygen with or without 5% carbon dioxide. Each treatment combination was also done with or without 50 $\mu L \cdot L^{-1}$ ethylene added to the atmospheres. Green banana fruit were either gassed with ethylene (triggered) or ungassed. One percent oxygen was too low to consistently give undamaged bananas. The addition of 5% carbon dioxide to the controlled atmosphere increased fruit respiration rate whereas air plus 5% carbon dioxide showed decreased respiration when compared to air control fruits. Green, triggered fruit partially ripened under the CA conditions. Pulp pH and soluble solids content changed in a normal ripening pattern, however peel color was poor. Addition of ethylene to the atmospheres advanced fruit ripening somewhat in all fruit. When green, ungassed bananas were placed under CA, the presence of ethylene in the atmosphere did not cause the bananas to turn yellow, although some changes in pH and soluble solids were detectable. In triggered fruit the presence of ethylene in the storage advanced ripening with higher oxygen concentrations promoting faster ripening. Bananas that have ripened under CA conditions are not as high quality as those ripened in air in terms of visual appearance.

423 (PS 5)

Interactions between the Timing of the Application of Hypoxia and Rate of Sugar Accumulation and Activities of Invertase, Sucrose Synthase, and Sucrose Phosphate Synthase

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Previous research has shown that subjecting bananas to low O_2 treatment during the climacteric rise decreases the rate of sugar accumulation but the fruits eventually ripen. In the present study we applied low O_2 in fruits whose ripening had been initiated by exogenous C_2H_4 and in preclimacteric ones. In preclimacteric fruits low O_2 suppressed the climacteric rise during the duration of the experiment (20 days). It completely inhibited the increase in sugars, invertase and sucrose phosphate synthase (SPS) activities while there was a sharp increase in sucrose synthase (SS). In control fruits the increase in sugar content coincides with a sharp increase in invertase, and SPS and a decline in SS. Hypoxia inhibited the increase in invertase and SPS while it induced an increase in SS. Nevertheless, the activities of invertase and SPS in the climacteric hypoxic fruits was higher than in hypoxic preclimacteric ones. The results, thus, indicate that the imposition of low O_2 at the preclimacteric stage is much more efficient in delaying banana ripening than when it is applied after the initiation of ripening.

424 (PS 5)

Response of Mango Fruit to Potassium Permanganate as an Ethylene Absorbent during Storage

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Mango fruit of 'Palmer' and 'Keitt' were harvested at the preclimacteric stage. An inexpensive ethylene absorbent was made by mixing aqueous $KMnO_4$ with vermiculite and silicagel as support material. Fruits were treated with the mixture of vermiculite–$KMnO_4$ and silicagel–$KMnO_4$ as ethylene absorbents and stored at 10 and 15°C for 18 days. Fruits were evaluated for skin and pulp color, total soluble solids, titratable acidity and weight loss at interval of 3 days. Ethylene absorbents had no significant effect on skin color parameters (lightness, hue, and chroma). However differences due to ethylene absorbents and temperature storage were evident on pulp color parameters. Soluble solids content and titratable acidity were affected by ethylene absorbent and temperature storage. The percent of weight loss increased with temperature and with duration of storage.

425 (PS 5)

Mango Tolerance to Reduced Oxygen Levels in Controlled-atmosphere Storage

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Exposure to hypoxic O_2 levels has been reported to result in better epidermal color, higher titratable acidity and soluble solids levels, delayed softening and reduced ethylene production and respiratory activity in many fruit species. Mangoes have been shown to tolerate short term (4 days) exposures to O_2 concentrations below 0.5% with beneficial effects on firmness retention and maintenance of ground color. In the present work, 'Haden' mangoes were stored for 14 days at 15°C with O_2 levels ranging from 2% to 5% and compared to an air control and an atmosphere of 25% CO_2 in air. 'Tommy Atkins' mangoes were stored under the same treatments at 12°C for 21 days. After storage at 12 or 15°C the mangoes were transferred to air at 20°C for 5 days. Ethanol production rates during controlled atmosphere (CA) storage were significantly higher at O_2 levels of 4% and below. Respiration (CO_2 production) rates were reduced during CA storage but did not differ from the control after transfer to air. There were no differences in ethylene production as well as in flesh firmness, titratable acidity and total sugars. The ground color of mangoes kept under the lowest O_2 concentration and under 25% CO_2 was greener, as indicated by higher hue angles, than in the other treatments upon transfer to air at 20°C. However, only the mangoes stored under high CO_2 maintained higher hue angles during the subsequent 5 days at 20°C.

426 (PS 5)

Study on Canning Methods of Date (Mozafati and Karout Varieties)

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Research was conducted in the laboratory of Horticulture Dept. of Seeds and Plants Improvement Research Inst. in Karaj to review the possibility of canning soft and nectariferous 'Mozafati' and 'Karout' dates from Bam and Zahedan cities. According to the existing information, there are large amounts of postharvest spoilages on this fruit because of their storage in carton boxes or other packing materials and due to a large amount of nectar. Thus, there are physical and chemical changes particularly during ripening (date), and, as a result, there is always a severe effect on the quality of the product. It seems that canning of date under proper conditions could maintain the characteristics of the proposed variety and also the physical and chemical properties of the fruit for a longer time and it could be easily transported to all parts of the world. The samples for this experiment were collected in tamer stage because there are a lot of changes in the ripening stage of these varieties, which lead to severe fruit drop. The proposed samples were randomly collected from 10 date palms. The specifications and characteristics of the collected samples were recorded after the preliminary test procedures, washing, and disinfection. In this experiment a complete randomized design with four treatments were used. The experimented factors were variety and treatment. The experimented varieties were Mozafati and Karout and the proposed treatments were control tree–date syrup, sugar syrup, sugar beet molasses, and vacuum conditions. This experiment was repeated for four times for all treatments, and the best canning method was determined. The results indicate that vacuum conditions are the best canning method for Mozafati, while canning with sugar beet molasses is the best method for Karout.

104 POSTER SESSION (Abstr. 427–440) Postharvest Physiology–Temperate Fruit

427 (PS 1)

Volatile Emissions and Quality of Bagged 'Fuji' Apples

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Enclosing apple fruit in bags during development is widely practiced in Japan. Bags create a barrier that reduces damage from insects and fungal patho-

gens as well as treatments to control these problems. Bags also reduce the incidence of sunburn and change fruit appearance by altering peel pigmentation composition, two features that have prompted northwestern United States producers to bag 'Fuji' apples. Fruit maturity and quality of bagged and nonbagged Fuji apples grown in Washington state were evaluated at harvest and after refrigerated storage in air or controlled atmosphere. Bagged fruit had less watercore and lower ethylene production at harvest compared to non-bagged fruit with similar starch ratings. Bagged fruit had lower soluble solids content, titratable acidity and firmness at harvest and during storage. Emission of ester and alcohol volatiles was consistently lower for bagged fruit. Postharvest volatile emissions were negatively correlated with bagging duration during development. Bagged fruit had no incidence of a peel disorder with similarity to delayed sunscald.

428 (PS 1)

Aroma Volatiles of 'GoldRush' and 'Golden Delicious' Apples

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The aroma volatiles of ripe fresh 'GoldRush' and 'Golden Delicious' apples (*Malus ×domestica* Borkh) were examined using dynamic headspace to capture the volatiles and gas chromatography (GC)–GC–mass spectroscopy (MS) analysis for compound identification. A total of 21 aroma volatiles were identified, with 16 being common to both cultivars: toluene, butyl acetate, hexyl formate, 2-methylbutyl acetate, xylene, butyl propionate, pentyl acetate, s-butyl butanoate, hexyl acetate, iso-butyl 2-methylbutanoate, hexyl propionate, hexyl butanoate, hexyl 2-methylbutanoate, hexyl hexanoate, a-farnesene, and ethyl phthalate. Three volatiles [dipropyl disulfide, pentyl 2-methylpropionate, and 2,6-bis(1,1-dimethylethyl)-2,5-cyclohexadiene-1,4-dione] were unique to 'Golden Delicious'; two compounds (nonanal and nerolidol) were unique to 'GoldRush'. Most identified compounds were esters. Hexyl acetate (18.39%) was the major volatile in 'Golden Delicious', while butyl acetate (13.40%) was the highest in 'GoldRush'.

429 (PS 1)

Sorting Fruit by Quality: What Chloroplast Fluorescence Can Tell Us

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Chloroplast fluorescence as a nondestructive tool for assessing 'Red Delicious', 'Golden Delicious' and 'Law Rome' apple fruit quality was examined after approximately 4.5 months storage. Fluorometry parameters of minimal fluorescence (Fo), maximal fluorescence (Fm) and quantum yield (Fm-Fo)/Fm (otherwise denoted as Fv/Fm) were determined. All fluorescence parameters declined with time as apple fruit were maintained at 22°C in air. Fv/Fm was found to correlate well with firmness for 'Red Delicious' fruit. A decline in Fo with time correlated very well with the development of yellow coloration of 'Golden Delicious' fruit. The Fv/Fm value was consistently higher for controlled-atmosphere (CA) stored fruit than for regular-air (RA) stored fruit. When CA and RA stored 'Law Rome' fruit were combined and a Fv/Fm value of 0.685 was used to resegregate fruit from the two storage regimes. Resegregation was achieved with 75% accuracy, with only 5% RA-stored fruit incorrectly identified as CA-stored. The accuracy, speed of assessment and light-based nature of fluorometry suggest it may have some practical use as a tool for sorting apple and other chlorophyll-containing fruit on commercial packinglines.

430 (PS 1)

Carbon Dioxide Injury of 'Empire' Apples

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Occasional occurrence of a superficial skin injury associated with CA storage can cause severe commercial loss in the 'Empire' cultivar in the northeast. To develop industry strategies to prevent losses due to the disorder, we have examined a number of factors related to its occurrence. 1) Fruit from six orchards were stored with 2% or 5% CO_2 (with 2% O_2) at 0.5 or 3°C for 6 or 9 months. Orchard variation in susceptibility was high. Preharvest factors such as maturity or mineral levels in the fruit did not account for these differences. Incidence of the disorder was much higher at 5% than at 2% CO_2. However, temperature did not affect the extent of injury. 2) Exposure of fruit stored at 2% CO_2/2% O_2 to 5% CO_2 at 4-week intervals from harvest until 20 weeks indicated that fruit were most susceptible to injury between 0 and 8 weeks. 3) A postharvest treatment with diphenylamine (DPA) prevented occurrence of the disorder, ethanol reduced it, but ascorbic acid had little effect. 4) Fruit were held at storage temperatures for up to 10 days before exposure to either 2% or 5% CO_2. Injury was highest in fruit exposed one day after harvest and negligible when exposed after 10 days. Collectively the results indicate that rapid CA can aggravate the disorder if care is not taken to maintain low CO_2 concentrations in the storage atmosphere but that use of DPA for control of superficial scald will prevent its occurrence.

431 (PS 1)

Storage Potential for 'Ginger Gold' and 'Nittany' Apples

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High-quality processing and fresh market cultivars are critical to the Mid-Atlantic apple industry. Dual purpose cultivars such as 'Ginger Gold' and 'Nittany' are of particular interest. 'Ginger Gold' is an early cultivar harvested in mid to late August and is of interest to processors in the area. Early cultivars typically do not store well. The at-harvest quality is high and we have initiated studies to determine if quality of 'Ginger Gold' can be maintained in storage for an acceptable length of time. Apples harvested 25 Aug. were placed in three storage atmospheres: air, 3% O_2 + <2% CO_2, or 0.7% O_2 + 1% CO_2, all at 0°C. At harvest the firmness was 85 N with soluble solids concentration (SSC) of 12.6. After 4 months of storage both CA treatments maintained firmness better than the air control treatment. SSC and decay were not different among storage treatments (SS = 13.5 and % decay = 5%–8%). Data indicate that 'Ginger Gold' can be stored for some time in CA and that low-oxygen storage may be beneficial. 'Nittany' apples harvested 6 Oct. were placed in 2 storage atmospheres - 3% O_2 + <2% CO_2 or 0.7% O_2 + 1% CO_2. At harvest the firmness was 85 N and the SSC was 12.7. After 6 months in storage the fruit in low O_2 were firmer than in standard CA. The SSC was 14.5 and decay 6% for all samples.

432 (PS 1)

Effects of Low O_2 on the Timing of the Onset of the C_2H_4 Climacteric and Subsequent Ripening of 'Gala' Apples at 1°C

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We have investigated the effects of different O_2 concentrations on the onset of the climacteric rise in C_2H_4 evolution and subsequent ripening of 'Gala' apples. The data show that the effect of low O_2 on the timing of the onset of the C_2H_4 climacteric is saturable in that for low O_2 to retard the onset of the rise in C_2H_4 evolution its concentration must be decreased below 8%. Further, the results suggest that the retarding effects of low O_2 on the onset of ripening cannot be ascribed to the inhibitory effects of low O_2 on the action of the low levels of C_2H_4 evolution by preclimacteric apples. The results concerning the rate of C_2H_4 evolution and accumulation of the ACC-oxidase protein show that application of low O_2 after the initiation of the climacteric rise in C_2H_4 is not as effective in delaying senescence as when it is imposed early, i.e., at the preclimacteric stage.

433 (PS 1)

Ethanol Vapor Controls Superficial Scald of Apples during Storage: A New Alternative Approach

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We are investigating alternative strategies to control scald on apples. Ethanol vapors were applied to 'Law Rome' and 'Red Delicious' apples in the storage chambers by ventilating air through aqueous solutions of ethanol at different concentrations, and in modified atmosphere packages by adding various initial concentrations of ethanol vapor. Fruits in storage chambers treated with ethanol vapor at 1600 ppm for about 2 months showed no scald when stored for an additional period in air storage whereas the scald index in control was up to 2.33 (the highest is 3). The similar results in the modified atmosphere experiments confirmed that ethanol vapor could prevent apple scald. Ethanol vapor treatment was also correlated with a reduction of α-farnesene production by the fruits. α-farnesene is an isoprenoid metabolite in the pathway to carotenoid synthesis that has been implicated indirectly as a factor in scald development. Evidence for this based on diphenylamine (DPA) reducing the level of a conjugated terpene product of α-farnesene oxidation. Our results suggested that the control of scald by ethanol vapor treatment may be related to the reduction of α-farnesene production and its subsequent oxidation. Ethanol vapor treatment resulted in accumulation of ethanol in the fruits in direct proportion to the ethanol concentration administered and reduced the rate of ethylene production, and the internal ethanol levels dropped rapidly when fruits were returned to air without ethanol vapor.

434 (PS 1)

Farnesene and Trienes in Apple Peel Quantified by HPLC

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Farnesene and its conjugated triene oxidation products in apple peel are positively correlated with, and thought to be involved in, the storage disorder superficial scald. Levels of these compounds are often estimated by dipping fruit in hexane and measuring the absorbance of the crude extracts at 232 nm (farnesene) and 269 or 281 minus 290 nm (trienes). We have devised a C18 HPLC method with UV detection at 232 and 269 nm that allows the simultaneous quantitation of 80 ng of farnesene and trienes. Using this method we have confirmed the recent report that one conjugated trien-6-ol comprises 90% of the stable oxidation products of farnesene. It was also found that crude hexane extracts of apple peel can give spuriously high values for farnesene and/or trienes when levels of these compounds are low and other UV-absorbing components are present. A group of compounds unrelated to farnesene, with an absorbance maximum at ≈259 nm, were noted in the peel of cv. Gala apples, which produced little farnesene or trienol. This may explain the report that fruit with a high ratio of A_{258nm}/A_{281nm} in peel extracts have a low incidence of scald. The new HPLC method will be applied in subsequent studies of postharvest factors involved in regulation of farnesene synthesis and oxidation.

435 (PS 1)

Surfactants Augment Postharvest Pressure Infiltration of Calcium into 'Golden Delicious' Apples

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The effects of organosilicone and more conventional hydrocarbon surfactants on postharvest radiolabeled calcium (Ca) and on Ca solution infiltration into 'Golden Delicious' apples were examined to provide a direct and more efficient pressure infiltration technique to increase fruit Ca concentration. Both radiolabeled Ca infiltration and the proportional increase in fruit Ca estimated by fruit weight gain from Ca solutions of known concentration were significantly enhanced by a range of surfactants having differing chemical structures. Two organosilicone surfactants, Silwet L-77 and Silwet L-7604, known for their greater capacity to lower the surface tension of solutions than conventional hydrocarbon surfactants, were the best among the surfactants tested at augmenting Ca infiltration. Applications of surfactants to fruit were as effective or more effective when used as a pretreatment rather than by mixing with Ca solutions. The applied atmospheric pressure necessary to infiltrate Ca to levels considered sufficient to maintain fruit firmness and resist decay during storage could be lowered in fruit treated with organosilicone surfactants. Postharvest surfactant and Ca treatments may offer a practical means of increasing the Ca concentration of apple fruit.

436 (PS 1)

Changes in Hemicellulose-associated Pectin during Softening of Peach Fruit

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Softening to a normal melting flesh texture in peaches involves a combined participation between polymers located in the middle lamella and primary cell wall. Pectins located in the primary cell wall polysaccharide matrix which cosolubilize when hemicellulose is extracted with KOH have received less attention than the chelator or sodium carbonate soluble pectin likely to be associated with the middle lamella. We conducted a series of extractions for cell walls prepared from softening peach fruit (47, 30, and 15 N firmness) using 0.5 M imidazole, sodium carbonate and a graded series of KOH. Hemicellulose-associated pectin was a substantial proportion of most KOH extracts (30 to 50 mole percent) and fractionated on size exclusion chromatography as a high apparent molecular weight peak which became more prominent as fruit softened and could be separated from two lower apparent molecular weight peaks by anion exchange chromatography. The nature of a hemicellulose-pectin interaction in peach was apparently by physical entrapment, versus covalent cross-linking. Softening related changes in hemicellulose-associated pectin will be addressed.

437 (PS 1)

Volatile Compounds for Control of *Botrytis* on Strawberry: Duration of Treatment and Use of Polymer Film

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A number of natural volatile compounds exhibit promise as postharvest fumigants for control of *Botrytis* on strawberry fruit. Because some of compounds may cause apparent phytotoxic responses by the fruit, short duration treatment is desirable. The compounds have been evaluated in single fruit bioassays with passively established modified atmospheres using a polymer film. The compound source was removed after 3 hours, 1, 3, or 7 days, or remained in the containers for the 10 day duration of the study. At levels which inhibited Botrytis in closed containers without film, E-2-hexenal was effective with a 1-day treatment, diethyl acetal was increasingly effective as treatment period increased, and 2-nonanone and methyl salicylate were not effective with continuous treatment. The levels of both the source compound and its metabolites were different using the film than without it. The film, used to allow gas diffusion and exchange with the surrounding environment, may allow diffusion of the volatile compounds and their metabolites. Thus, successful use of the compounds in modified atmosphere storage may require knowledge of their diffusion through the films to establish the appropriate levels for effective fumigation of the fruit and avoid adverse quality effects.

438 (PS 1)

Estimation of Anthocyanin Concentration from Colorimeter Measurements of Raspberry Fruit.

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Measuring intact fruit with a colorimeter could be a quick way to estimate anthocyanin concentration and reduce waste disposal. Five fresh fruit from each of 134 plots were measured with a Minolta tristimulus colorimeter in 1994. Samples were frozen and anthocyanins extracted with acidified ethanol and measured with a spectrophotometer. The hue angle and anthocyanin concentration had $r^2 = 0.51$. L*, a*, b* and C* were significantly correlated with anthocyanin concentration with $r^2 = 0.31$, 0.32, 0.42, and 0.34, respectively. In 1995, five fruit from each of 20 plots were measured as before. In 1995, the hue angle and anthocyanin concentration had $r^2 = 35$. A regression equation with hue angle, b* and a* estimated anthocyanin concentration with $R^2 = 0.62$. In 1995, the same 20 samples were also measured with a colorimeter immediately after thawing. The hue angle and anthocyanin concentration had $r^2 = 0.55$. A regression equation with hue angle, b* and L* estimated anthocyanin concentration with $R^2 = 0.76$. It may be possible to estimate anthocyanin concentration by measuring intact fruit with a colorimeter after freezing and thawing the samples.

439 (PS 1)

Cultivar and Conditioning Treatment Affect Development of Red Drupe in Blackberry Fruit

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Blackberry fruit often exhibit an unattractive discoloration following harvest and storage. This redness appears at random on the berry and has been associated with sunburn or high temperature damage, or with fruit harvested less than fully ripe. We began a study to separate and identify causes of red drupe. Black (fully ripe) berries, free of sunburn, of six blackberry cultivars were harvested in the morning and subjected to conditioning treatments of 20 hours at 2 or at 20°C, followed by 7 days storage at 2°C. Strong cultivar differences and effects of conditioning treatment were found. 'Navaho', 'Arapaho' and 'Chester' had little or no red drupe, regardless of conditioning treatment. As much as 50% of 'Shawnee' and 'Choctaw' berries exhibited red drupe, with more appearing in fruit conditioned at 2°C. Development of red drupe in berries conditioned at 2°C was quadratically related to total anthocyanin and juice pH, while that of fruit conditioned at 20°C was quadratically related to percent titratable acidity. The red drupe disorder in blackberries is exacerbated by low temperature storage and may be due to decreased cellular pH and subsequent anthocyanin glycosylation in individual drupelets.

440 (PS 1)

Applanation Tonometry for Fruit Firmness Measurements

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The eyecare industry has used various instruments and methods for determining intraocular pressure. Some of the methods may be applicable for measurement of fruit firmness in the horticultural industry. We determined fruit firmness with an applanation tonometer, currently one of the most popular instruments in the eyecare industry. We then measured firmness of the same sample using a penetrometer with an 8-mm probe. Kiwi, mango, peach, strawberry, tomatillo, and tomato fruit were included in the study. With the exception of mango, tonometer and penetrometer measurements within a species were significantly correlated. The contact area of the tonometer probe was 1.5 mm^2, which was less than 3% of the contact area of the penetrometer probe. The heterogeneous nature of mango mesocarp due to fibers and this large difference in contact area between the two instruments may have caused the lack of correlation for that species. The data indicate that tonometry may be useful for determining firmness of fruit, and further development may lead to a nondestructive method of obtaining these data.

107 POSTER SESSION (Abstr. 441–448) Postharvest Physiology–Tomatoes

441 (PS 3)

Nondestructive Quality Screening of Green Tomatoes Using Ethylene Gas

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The effects of prolonged ethylene exposure on external and internal quality parameters of tomato fruits were studied in order to explore the feasibility of its use as a nondestructive technique for screening immature and inferior quality fruit. 'Agriset' and 'CPT-5' tomatoes were hand harvested at Stage 1 (green) and held at 20°C and 50 ppm ethylene for 1-7 days. Each 24 hours, fruits reaching Stage 2 (breaker) were removed from C_2H_4 and transferred to 20°C air for subsequent ripening. Tomatoes were considered at edible maturity upon reaching full red-ripe stage and 4 mm deformation and final quality parameters were determined. For both cultivars, fruits which required prolonged C_2H_4 exposure to reach Stage 2 had lower overall visual appearance. 'Agriset' tomatoes which required short exposure times to C_2H_4 (1 to 3 days) had somewhat higher quality than those requiring prolonged times (4 or 5 days). Days to reach edible maturity were 9.5 and 7.7, respectively. For the short exposure times, peel color was more intense (higher chroma value), while soluble solids content and total sugars were significantly higher (P = 0.05). Quality of 'CPT-5' tomatoes was not adversely affected until requiring 6 or 7 days exposure to C_2H_4. Days to reach edible maturity decreased from an average of 12.5 to 11.0 for 1 to 5 or for 6 to 7 days exposure, respectively. For fruits requiring 7 days exposure, soluble solids content, total sugars and pH were significantly higher than for those reaching Stage 2 in fewer days. There were no significant differences in titratable acidity or ascorbic acid content for either cultivar.

442 (PS 3)

Physiological Response of Tomato Fruit to Ethylene at High Temperature

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Mature green fruit of 'Agriset 761', 'Colonial', 'Sunny' and 'Sunbeam' tomatoes were exposed to 100 ppm ethylene at 20, 25, 30, 35, or 40°C around 95% relative humidity (RH) for 24, 48, or 72 hours, then transferred to air at 20°C and 95% RH for ripening. There were few differences in ripening behavior in tomatoes exposed to ethylene at high temperatures (>30°C) for 24 hours compared to those treated at lower temperatures. However, increasing the duration of ethylene treatment at 35 or 40°C to 48 or 72 hours inhibited subsequent red color development, but prior exposure to ethylene at 30°C stimulated red color development. Ethylene production was inhibited after 48 or 72 hours at 40°C, but was stimulated by exposure to lower temperatures in the order shown: 35 > 30 > 25. During ripening, conversion of ACC to ethylene increased in fruit exposed to ethylene at 20 or 25°C but did not change in fruit from 30 or 35°C. ACC oxidase activity was lowest after exposure to 40°C. Untreated fruit ripened slowly and nonuniformly compared to those previously treated with 100 ppm ethylene. Increasing the ethylene treatment concentration to 1000 ppm did not alter the responses to high temperatures described above.

443 (PS 3)

Glutamic Acid and 5-Aminolevulinic Acid May Function as Precursors of System II Ethylene in Ripening Tomato Fruit

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The ethylene biosynthetic pathway has been established as methionine (MET) to S-adenosylmethionine to 1-aminocyclopropane-1-carboxylic acid (ACC) to ethylene, and this pathway has been labeled System I. Another pathway to ethylene may exist during synthesis of massive amounts of ethylene, and this system has been labeled System II. Our objective was to evaluate the efficacy of several compounds as possible precursors of System II ethylene in ripening tomato fruit tissue. Discs of 'Rutgers' tomato pericarp tissue at the mature green, pink, and red ripe stages were incubated continuously in 10, 25, or 40 mM solutions of MET, ACC, 5-aminolevulinic acid (ALA), homocysteine, glutamic acid (GLU), alpha-ketoglutarate, or citrate buffer (control). The ethylene production rate at 8-hour intervals during a 32-hour incubation period and free and conjugated ACC content at the end of the incubation period were quantified. Fruit discs at the mature green stage treated with MET and ACC exhibited increased ethylene production and increased free ACC content. These results confirmed the role of MET and ACC as the predominant precursors of ethylene during the early stages of fruit development in tomato (System I). At the pink stage (System II); however, ALA increased ethylene production by 75% and free ACC content by 46% over the control, and MET increased ethylene by 27% and free ACC content by 57% over the control. At the red ripe stage, ALA caused a 35% increase and GLU caused a 31% increase in ethylene production over the control. These results suggest that ALA and GLU may be metabolized to ethylene via an unknown pathway during tomato fruit ripening (System II).

444 (PS 3)

Polygalacturonase Levels Influence Electrolyte Efflux in Tomato Fruit

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Tomato fruit transformed with the PG-antisense gene have been shown to exhibit persistent structural competence and extended shelf-life compared with normal, PG-containing lines. In this study, PG-antisense and nontransformed, wild-type fruit were examined for electrolyte efflux trends during ripening and following extended storage at the full-ripe stage. Pericarp disks from PG-antisense fruit showed minimal differences in net electrolyte efflux compared with the normal, wild-type fruit at the mature-green through ripe stages of development. Following extended storage (14 days) of ripe fruit, or in response to storage at chilling (1°C) temperatures, significantly higher (25%–33%) values for proportional electrolyte efflux were observed for wild-type fruit. Additionally, ripe wild-type fruit following extended storage or in response to chilling injury exhibited increased (15%–20%) total soluble electrolytes, particularly in tissues subjected to freeze-thaw versus thermal-disruption. Although PG-antisense fruit do exhibit increases in net electrolyte efflux during ripening, the enhanced efflux and electrolyte generation from wild-type ripe fruit during extended storage was due, in part, to the release of polyelectrolytes originating from pectin hydrolysis. These data may explain the divergence in postharvest performance and structural integrity of PG-antisense and normal, wild-type fruit during post-ripe storage and also suggest that modification of the apoplastic environment resulting from developmental increases in electrolyte efflux can enhance the catalytic activity of PG in vivo.

445 (PS 3)

Polygalacturonase Isozyme 2 Binding and Catalysis in Cell Walls From Tomato Fruit: Control and *B*-subunit Effects

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The high catalytic potential of PG evident in reactions with soluble pectic polymers is typically not expressed in vivo. In this study, the binding and catalytic properties of PG isozyme 2, and the influence of the *B*-subunit protein, were investigated using cell walls prepared from tomato fruit expressing the *B*-subunit antisense gene. Cell walls were prepared from mature-green fruit and treated to remove/inactivate

endogenous enzymes. Walls were then preloaded with rate-limiting quantities of purified PG 2, and incubated under catalysis-promoting conditions over the range of pH from 4.5 to 6.0. Cell walls of both *B*-subunit antisense and wild-type fruit retained comparable quantities of loaded PG 2. The enzymic release of pectin from PG-loaded walls was proportional to the quantity of wall-bound PG 2. In walls lacking the *B*-subunit protein, the quantity of pectin released by a given dose of wall-associated PG was as much as 2-fold higher than from wild-type walls. The *B*-subunit protein also influenced the extent of pectin depolymerization during ripening. The release of pectin from cell walls during periods of catalysis was not the sole indicator of the range of pectins hydrolyzed. Treating postcatalytic loaded cell walls to inactivate PG, and subsequent extraction of residual wall pectins using 50 mM CDTA solutions solubilized polymers of significantly lower mol mass compared with pectins solubilized directly from nonloaded cell walls.

446 (PS 3)

Quality of Tomatoes Stored at Chilling Temperatures following Prestorage Heat Treatments and Partial Ripening

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Mature green 'Sunbeam' tomato fruit (*Lycopersicon esculentum* Mill.), were treated in varying order with C_2H_4, 42°C water for 60 minutes, 38°C air for 48 hours, partial ripening for 48 hours at 20°C, or not treated, and then stored at 2°C for 14 days before ripening at 20°C. Heat treated fruit stored at 2°C and transferred to 20°C ripened normally while 63% of nonheated fruit decayed before reaching red ripe. More chilling injury (CI) developed when C_2H_4 was applied following heat treatment rather than before. There was more CI in fruit that were 42°C water treated compared with the 38°C air treatment. Less CI developed on fruit that were partially ripened for 2 days at 20°C before a 42°C water treatment rather than following it. At red ripe, nonchilled fruit were firmer than chilled heat treated fruit. Fruit treated in 42°C water were firmer when the heat treatment was applied before the C_2H_4 treatment rather than following it. Chlorophyll and lycopene content and internal quality characteristics of fruit were similar at the red ripe stage irrespective of C_2H_4 or heat treatment. Chilling and heat treatments reduced some of the 15 flavor volatiles analyzed. Volatile levels were lower in fruit treated with C_2H_4 before heat treatment compared with fruit treated with C_2H_4 following heat treatment. Prestorage heat treatments could allow for storage of mature green tomatoes at low temperatures with little loss in their ability to ripen normally.

447 (PS 3)

Intermittent Warming Reduces Tomato Fruit Quality Deterioration during Cold Storage

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Mature green tomatoes (cv. Vibelco) were stored at 2°C for 2, 3, and 4 weeks. Intermittent warming treatments for 12, 24, and 36 hours at 24°C were applied at the end of every week. Control Fruit were held continuously at 2°C. All fruit were subjected to poststorage ripening at 24°C for 7 days. Fruit decay, chlorophyll and lycopene content, fruit firmness, pH, TSS and TA were detected after storage or 7 days after transfer to 24°C. Results were compared between control and intermittently warmed fruit when stored at 2°C for 2, 3, and 4 weeks. Compared to fruit kept continuously at 2°C, intermittent warming at 24°C for 12, 24, and 36 hours reduced decay, increased chlorophyll disappearance, lycopene synthesis, and fruit firmness, enhanced pH and TSS, and declined TA. Fruit intermittently warmed for 36 hours/week showed the least decay, higher chlorophyll disappearance, and lycopene synthesis; retention of fruit firmness, pH, and TSS; and lower TA than fruit intermittently warmed for 12 and 24 hours/week. Decay percentage, lycopene content, pH, and TSS were increased from 2 to 4 weeks, but chlorophyll content, fruit firmness, and TA were declined.

448 (PS 3)

Resistance of Tomato Fruit (*rin* and *nor* Type) to Postharvest Diseases Depends on Stage of Maturity

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On Sinaloa State, tomato growers test new varieties every year looking high yield, better quality and long shelf life. However, few studies are done to know the resistance to postharvest diseases. The objective was to identify postharvest pathogens that infect this new tomato varieties with characteristics *rin*, *nor* or normals (BR84, S211, S69, and S121). Fruits in two stages of maturity (pink and red) were harvested and stored under simulated marketing conditions (20°C and 80% RH). Pathogens found were aisled on PDA and identified under microscope. Different chemicals were tested to control pathogens [NaOCl; $Ca(OCl)_2$; Supersana; iodine; Citrucidal; Captan; and water]. Six fungus species—*Alternaria alternata*, *Fusarium oxysporium*, *Rhizopus stolonifer*, *Colletotrichum* sp., *Rhyzoctonia* sp, and *Phomopsis* sp—were found on all varieties. BR84 fruit (*rin* type) harvested on pink stage were more resistant than red ones. S69 fruit (nor type) were more susceptible at the pink than at the red stage. S121 fruits (normal type) were equally susceptible at both stages of maturity. Least resistant variety to fungus infection at both stages of maturity was S211 (*rin* type). Citrucidal and $Ca(OCl)_2$ gave the best control.

144 POSTER SESSION (Abstr. 449–456) Postharvest Physiology–Vegetables

449 (PS 6)

Carbohydrate Contents of Xylem and Cortex Tissues of Carrot Roots

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The relative concentrations of sucrose, glucose, and starch in the xylem and cortex tissues of carrot (*Daucus carota*) roots were evaluated after harvest and during storage. For the three cultivars (Apache, Bolero, Danvers 126) tested, the cortex tissue contained 76.6, 49.1, and 33.6 $mg \cdot g^{-1}$ dry weight of sucrose, glucose, and starch, respectively. In comparison, the average contents of sucrose, glucose, and starch in xylem tissues were 57.4, 52.4, and 11.6 $mg \cdot g^{-1}$ dry weight, respectively. In general, cortex tissue contained higher concentrations of sucrose and starch than the xylem tissues. The glucose concentrations in cortex and xylem were similar. In 'Apache', for example, the cortex tissue contained 40% and 57% higher concentrations of sucrose and starch, respectively, than the xylem tissues, whereas glucose content of the cortex was only 7.5% higher than that of the xylem. Since sweetness is largely influenced by sucrose, the relative volume of cortex to xylem must be considered in evaluating carrot cultivars for sweet taste.

450 (PS 6)

Respiration of Fresh-cut Carrots Stored in Low Oxygen or High Carbon Dioxide Atmosphere at Various Temperatures

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Respiration of carrot slices, sticks, and shreds was monitored during storage in air, low O_2 (0.5%, 1%, and 2%) or high CO_2 (3%, 6%, and 10%) atmospheres at 0, 5, and 10°C. The respiration pattern differed with temperature and type of cuts. At 10°C, the rates of all cuts decreased with time. At the lower temperatures, the rate of sticks and shreds increased with the increase being greater at 5°C. Carbon dioxide production and O_2 consumption of all cuts were lower when stored in either reduced O_2 or elevated CO_2 relative to those in air. Reduction was the greatest with cuts held in 0.5% O_2 or 10% CO_2 at 0°C. Low O_2 was more effective than high CO_2 atmosphere in reducing the rate at 10°C, but not at other temperatures. Respiratory quotient (RQ) of shreds were higher when held in low O_2 and lower when held in high CO_2 relative to those in air. RQ of other cuts were affected, but not consistently. The Q_{10} of all cuts ranged from 1.9 to 7.4 in the 0 to 10°C range and was lower with cuts in low O_2 and greater with cuts in high CO_2.

451 (PS 6)

Ethanolic Fermentation of Carrot Root Shreds under Low Oxygen

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Although a number of studies have been conducted to evaluate the effect of control and modified atmosphere on the quality and storability of carrot roots (*Daucus carota* L.) under low O_2 atmosphere, little is known about the underling biochemical changes in particular changes in anaerobic respiration. Carrot root shreds were stored under a continuous flow of 0.5% and 2% O_2 (balance N_2), or air for 7 days at 5 and 15°C to study the regulation of glycolysis and the accumulation of glycolytic end products, such as ethanol and/or lactic acid. Low O_2 atmosphere caused

increases in the concentrations of ethanol and acetaldehyde and the activities of alcohol dehydrogenase (ADH) and pyruvate decarboxylase (PDC). By day 3, ethanol increased 38-, 25-, 13-, and 9.5-fold, acetaldehyde increased 20-, 13-, 7.7-, and 5.6-fold, ADH increased 7.6-, 6.3-, 3.8-, and 2.7-fold, and PDC increased 4.2-, 3.9-, 2.3-, and 2.2-fold for 0.5% O_2 at 15 and 5°C, 2% O_2 at 15 and 5°C, respectively, compared with corresponding air control. These results shows that the production of ethanol was higher in 0.5% O_2 than in 2% O_2 at both temperatures. The enhancement of the glycolytic flux under 0.5% O_2 indicates that under these conditions the mitochondrial terminal oxydases were restricted, hence, the enhancement of ethanol synthesis, to compensate partly for the decrease in ATP production.

452 (PS 6)

Potassium Nutrition and Shelf Life of Carrots (*Daucus carota* L.)

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The effect of potassium (K) nutrition on the shelf life of carrots was studied using a hydroponics system involving rockwool slabs as support. Carrots were grown for 192 days under greenhouse conditions and supplied with 0, 0.1, 1.0, 10, and 15 mM of K. Increase in K concentration in the nutrient medium decreased postharvest weight loss. Carrot weight and tissue K content increased and water potential, osmotic potential, and relative solute leakage decreased with increasing K concentration in the nutrient feed. Differences in postharvest weight loss were mainly associated to root weight and relative solute leakage. Root weight correlated negatively and relative solute leakage correlated positively to water loss. Water and osmotic potential also correlated to water loss, but not as strongly as root weight and relative solute leakage. These results suggest that K nutrition influences postharvest weight loss by influencing carrot size and membrane integrity. Effects on cell water and osmotic potential are also important in this regard but to a lesser extent.

453 (PS 6)

Influence of Preharvest Water Stress on Postharvest Weight Loss of Carrots (*Daucus carota* L.)

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To understand the relationship between preharvest water stress and postharvest weight loss, carrot cultivars Eagle and Paramount were grown in muck soil in 6-L pots (eight carrots per pot) in a greenhouse at the Univ. of British Columbia. The plants were watered to field capacity every second day for 4 months before receiving 100, 75, 50, and 25% field capacity water stress treatments, henceforth referred to as low, medium, high, and severe water stress, respectively. Postharvest weight loss of carrots was monitored at 13°C and 32% relative humidity. Carrot weight loss increased with duration of storage in all treatments. It was low in the low-water-stressed and high in severely water-stressed carrots for both cultivars. Root crown diameter, weight, water, and osmotic potential decreased, and specific surface area and relative solute leakage increased with increasing preharvest water stress. Water potential followed by relative solute leakage were the variables that affected weight loss the most. The results show that carrots adjust to water stress by lowering water and osmotic potential. Preharvest water stress lowers membrane integrity of carrot roots making them lose more moisture during storage.

454 (PS 6)

Postharvest Evaluation of Eastern Muskmelon Cultivars

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Several leading Eastern muskmelon varieties were evaluated for their postharvest characteristics. The varieties evaluated were 'All Star', 'Athena', 'Eclipse', 'Legend', 'Quasar', 'Starship', and 'Superstar'. The fruit were harvested in multiple harvests from 1 July through 10 Aug. 1996. Postharvest measurements taken included soluble solids (%), firmness, rind and flesh color, respiration, flavor quality, damage after drop tests, storage life, and shipping ability. The fruit of each cultivar were harvested at "half-slip" and "full-slip" and fully evaluated at each level of maturity. Most of the cultivars had similar postharvest characteristics, except 'Superstar', which had the lowest overall ratings. Firmness ratings were highest for 'All-Star', 'Athena', and 'Legend' and were lowest for 'Superstar'. The flavor quality was similar for most cultivars and lowest for 'Superstar' fruit. This trial will be repeated in 1996 and promising cultivars will be recommended for midwestern Unites States production.

455 (PS 6)

Quality Parameters in Four Melon Hybrids Stored at Different Temperatures

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Melon fruit (*Cucumis melo* L.) from Chando, Concorde, Explorer, and Durango hybrids, collected from a Sante Ines farmer from Rio Tocuyo, were stored at 5, 10, and 18°C and room temperature for 7, 14, and 21 days with the objective of getting the response of melon hybrids in relation to quality characteristics. The soluble solids content and dry matter were not significant in the studied hybrids, titratable acidity was higher at 5°C, Chando had the highest values. Explorer had the highest pH values and soluble solids : titratable acid ratio at room temperature. Reducing and total sugars had the lowest values at 18°C and room temperature, Chando had the highest values. Concorde had the highest values for fresh weight loss at room temperature during 21 days of storage.

456 (PS 6)

Volatile Constituents of Muskmelon (*Cucumis melo* cv. Mission)

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The volatiles of muskmelon (*Cucumis melo* L. *reticulatis* cv. Mission) were sampled by dichloromethane extraction and dynamic headspace methods and analyzed by gas chromatography (GC) and GC–mass spectroscopy (MS). A total of 34 constituents were identified, with esters contributing 8%–92% of the total volatiles. Butyl propionate, ethyl 3-methylpentanoate, hexadecanoic acid, methyl (methylthio)acetate, propyl butyrate, phenylpropyl alcohol, and vanillin, were recovered only by solvent extraction, while hexanal was only detected using dynamic headspace sampling. Methyl butyrate 35.2%, ethyl acetate 17.1%, butyl acetate 11.6%, ethyl propionate 8.3%, and 3-methylbutyl acetate 6.3% were the major constituents by solvent extraction sampling method. Butyl acetate 35.5%, 3-methylbutyl acetate 20.9%, ethyl acetate 7.3%, 2-butyl acetate 5.6%, and hexyl acetate 3.8% were the major constituents recovered by headspace sampling. Fruit tissue was also separated into five layers (exocarp, outer mesocarp, middle mesocarp, inner mesocarp, and seed cavity) and the volatile constituents differed significantly in content and composition by tissue.

143 POSTER SESSION (Abstr. 457–464) Food Science

457 (PS 5)

Overcoming Gas Sampling Problems: Analysis of Volatiles Using Capillary Column Needles

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Sampling factors that could affect gas chromatograph (GC) response for volatile analysis such as syringe pumping time, injection volume, needle length, temperature, and the type of volatile were investigated. Capillary GC column segments (steel and glass) were installed in gas-tight syringes and used as needles for volatile analysis. Standard stainless-steel needles were also used. Hexylacetate, ethyl-2-methylbutyrate, 6-methyl-5-hepten-2-one, and butanol standard were measured. The number of pumps required to maximize GC response for each needle–volatile combination was determined. Maximal GC response for hexylacetate using standard stainless steel, capillary glass, and capillary steel needles required 10, 20 and 30 pumps, respectively. However, for butanol measurement, the optimal syringe pump number was 5 to 10 for all needle types. The use of a capillary needle resulted in an increase in GC response in the range of 3- to 15-fold relative to a standard stainless steel needle. Injection volume affected GC response in a needle-and volatile-dependent manner. In no case did injection volume vs. GC response extrapolate through origin. The GC response for capillary column needles increased as temperature decreased. Capillary column needles may be useful tools for analysis of volatiles that readily partition into the column coating.

458 (PS 5)

Development of a Sensory Descriptive Profile for 'Gala' Apple

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'Gala' is an early maturing apple variety that has a distinctive aroma and flavor. Its storage season is short and flavor volatile production is reduced following controlled atmosphere (CA) storage. The aroma and flavor characters of 'Gala' apples were identified by 10 trained panelists. A vocabulary of 13 descriptors for the aroma of whole and cut fruit and 16 descriptors for flavor were used to characterize the changes of apples stored in CA and/or regular atmosphere (RA) during five months. When compared to RA storage, intensity of fruity (pear, banana and strawberry) and floral characters decreased after 2.5 months in CA for whole and cut fruit aroma and flavor. During the entire storage period under CA, aroma of cut apples retained high vegetative and citrus characters but had a less intense anise aroma. Sourness, starchiness and astringency were significantly higher, however, sweetness was significantly lower. A musty note was perceived in whole apples stored in CA for 5 months. Differences in fruitiness of whole fruit and sourness only were found between fruit stored for 4 months in CA followed by 1 month in RA and fruit stored 5 months in CA. Relationships between panel ratings of specific characters and corresponding quantitative analysis will be discussed.

459 (PS 5)

Comparison of Nutritional Composition of Two Edible Species of *Cnidoscolus* (Tree Spinach)

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The tree spinach (*Cnidoscolus* spp., Euphorbiaceae), called chaya in south Texas, is popular in Mexico and Central America and has been introduced into the United States (mainly Texas and Florida) for potential uses as a leafy vegetable plant. Nutritional composition of raw and cooked leaves of two chaya species (*C. chayamansa* and *C. aconitifolius*) were determined and compared with nutritional composition of spinach (*Spinicia oleraceae*). While the two chaya species contained substantially greater amounts of mineral nutrients and vitamins than spinach, no significant differences were found in the amounts of mineral nutrients and vitamins, except in relative compositions of fatty acids and amino acids, among the chaya species. Cooking slightly reduced nutritional composition of both chaya and spinach leaves. Because of the presence of toxic hydrocyanic glycosides in chaya leaves, cooking, which inactivates the toxic compound, is essential.

460 (PS 5)

Bioavailability of Calcium from Common Vegetables Assessed in Teenagers

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Calcium is an essential human nutrient that is important in bone growth and metabolism. While dairy products in reasonable quantity can supply minimum daily requirements of calcium, the current decline in the consumption of dairy products, especially among teenagers, implies that dietary requirements must be met from other sources. Green beans, spinach and broccoli contain high concentrations of calcium, but the bioavailability of calcium from these food sources has not been determined in children. To provide accurate dietary recommendations for these foods, we have developed a recirculating hydroponic system for the growth and intrinsic labeling of plants with stable isotopes. Plants were maintained on a non-labeled nutrient solution until an appropriate developmental age and were then presented with nutrient solution containing 42-Ca. Labeled green bean pods and spinach were harvested at the proper commercial age, and were cooked, pureed and frozen until use. Thirteen teenage subjects seven girls, six boys) were recruited for a 2-week stay in the Metabolic Research Unit, and were fed 42-Ca-labeled vegetables along with 48-Ca-enriched milk; an intravenous dose of 46-Ca was also administered. Blood, urine and fecal samples were collected during the 2-week study. Calcium bioavailability and kinetics were determined using a multi-compartment model. The bioavailability of calcium averaged 28% from green beans, which was comparable to that of milk calcium. Calcium bioavailability from spinach averaged only 3%, due probably to the high oxalate content of spinach. Our results suggest that low-oxalate containing vegetables such as green beans can serve as good dietary sources of calcium. This research was funded in part by USDA-ARS Coop. Agr. No. 58-6250-1-003 and USDA-CRS Grant No. 94-347200-0605.

461 (PS 5)

Sugars and Acids Influence Flavor Properties of Mango (*Mangifera indica* L.)

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Fruit flavor is a function of sensory perception of taste, aromatic and chemical feeling factor components in the mouth. The specific role of sugars and acids in potentiating flavor perception of volatile compounds and chemical feeling factors is not well known for many fruits. This study was conducted to determine the effects of selected levels of sugars and acids on perception of 3 taste (sweet, sour, bitter), 6 aromatic (banana, grassy, orange peel, peach, pine/turpentine, sweet potato), and 2 chemical feeling factor (astringent, biting) flavor notes in diluted, fresh mango homogenate using a trained descriptive panel. Perception of all flavor descriptors except sour were enhanced by increasing the sugar concentration. An increase in acid concentration enhanced perception of sweet, sour and biting notes while lowering perception of the astringent, peach and pine/turpentine notes. Brix-to-acid ratio (BAR) was found to be an effective chemical indicator for perception of sourness but was not effective for perception of sweetness. These results provide insight into optimum balances of sugars and acids as they influence mango flavor perception specifically in preparation of juice blends, selection of cultivars for specific fresh markets, or determination of optimum ripeness in the marketplace.

462 (PS 5)

Effect of Thermal Blanch Treatment on the Quality of Frozen Chinese Chestnuts

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Chinese chestnuts (*Castanea molissima* Blume) are very susceptible to spoilage, and require artificial storage means to maintain fresh nuts. Frozen shelled nuts would offer the consumer a convenient product with no waste or spoilage, however chestnuts have traditionally been cured and held in storage to develop a desirable texture and conversion of starch to sugars. This research was initiated to determine the effect of thermal blanch treatment (water vs. syrups) on the texture, color and acceptability cured and uncured frozen, shelled Chinese chestnuts. After frozen storage nuts blanched in syrup had better color and firmer textures than water-blanched nuts. Uncured nuts were firmer than cured nuts, and were ranked above cured nuts by sensory panelists.

463 (PS 5)

Effect of Prestorage Thermal Treatments, Vacuum Infused Mycostatic Treatments, and Storage Relative Humidity on the Stability of Chinese Chestnuts

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Chinese chestnuts (*Castanea molissima* Blume) are a highly perishable commodity which requires artificial storage means and is easily spoiled by fungi. This investigation was designed to develop processes and adapt equipment for more efficient processing and storage of Chinese chestnuts, establish parameters for optimum fresh storage, and to compare the yields and qualities of the chestnuts processed by the test methods. Chinese chestnuts were prepared for fresh storage by vacuum infusing mycostatic solutions and modified starch coatings inside the shells. Vacuum treatment facilitated perfect contact of these solutions with the surfaces of the kernels, and was a more rapid method than atmospheric or pressure soaking methods. Vacuum infused pretreatments limited desiccation, minimized spoilage, reduced storage weight losses, and yielded products with better color and texture than conventional storage. Thermal treatments for surface pasteurization were defined. A storage relative humidity of 87% was found to be optimal.

464 (PS 5)

Applied Research for Citrus and Tropical Fruit Ingredient and Raw Materials Development for Juice Processing

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The National Horticultural Research Institute coordinates many projects designed to boost and improve the use of various fruits and vegetables around Nigeria.To achieve the set goals for fruit processing, projects are undertaken in

cooperation with selected laboratories. Based on the depth of work required for transforming research results into patented products, university and industry were involved in a collaborative assignment in sweet orange concentrate research and development. The work covered engineering and product testing, packaging, and sensory experiments in which materials and resources were shared at the participating center. This presentation focuses on guidelines for overcoming the problems associated with collaborative studies in developing countries and suggestions on funding components.

107 POSTER SESSION (Abstr. 465–478) Stress–Cold Temperatures

465 (PS 3)

Chilling Stress Protection in Cucumber: A Role for Antioxidants?

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To examine the role of endogenous antioxidants in providing chilling stress protection, field-grown cucumber (*Cucumis sativus* L. cv. Eureka) fruit were stored in the dark and evaluated throughout storage. Storage treatments included continuous chilling (C) (5°C), continuous tempering (T) (12°C), intermittent warming (IW) (1 day at 12°C every 4 days) for 1, 2, 3, or 4 cycles, and preconditioning (PC) (12°C for 4 or 8 days) before chilling. Fruit exposed to in-field chilling (FC) were also stored under continuous chilling at 5°C. Samples were evaluated visually for tissue damage (lack of exudate, water-soaked appearance), and ascorbic acid (Asc) and reduced (GSH) and oxidized (GSSG) glutathione levels and glutathione reductase (GtR) and ascorbate free radical reductase (AFRR) activities were determined. Each 4 days of PC extended storage life by 7 days relative to C. FC or 1–2 IW cycles also extended storage life relative to C. With all treatments, Asc depletion preceded visual tissue damage, whereas GSH, GtR, and AFRR were not depleted before such damage. GSSG levels remained low throughout storage. GtR activity was elevated by FC and IW. AFRR activity was elevated by all treatments. Asc levels were elevated initially by all treatments, with this elevation lasting longer with PC and T. These results suggest that Asc levels decline during stress in the absence of an obvious lesion in the Asc regeneration scheme.

466 (PS 3)

Oxidative Stress and Chilling Tolerance in Tomato Seedlings

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Diurnal variation in the chilling sensitivity of tomato seedlings was examined. Sensitivity to chilling in tomato seedlings is a response to light and not under the control of a circadian rhythm. Chilling sensitivity is highest in seedlings chilled at the end of the dark period, and these seedlings become more resistant to chilling injury upon exposure to the light. Diurnal variation in chilling sensitivity was associated with changes in catalase and superoxide dismutase activities. The results show an increase in catalase and superoxide dismutase activities at the end of the light period. The recovery of the net photosynthesis rate following chilling was faster in seedlings chilled at the end of the light period. It is suggested that an increase in catalase and superoxide dismutase activities at the end of light period before the chilling plays a role in the resistance to chilling stress in tomato seedlings. Forty-eight hours of 14°C acclimation or hydrogen peroxide pretreatment conferred chilling tolerance to tomato seedlings and were correlated with elevated catalase activity. Acclimated seedlings still exhibited diurnal variation in chilling sensitivity while hydrogen peroxide treated seedlings showed little evidence of a diurnal variation in chilling sensitivity. Transgenic tomato plants expressing an antisense catalase gene were generated. A several-fold decrease in total catalase has been detected in the leaf extracts of transformants. Preliminary analysis of these plants indicated that modification of reactive oxygen species scavenging in plant system can lead to change in oxidative stress tolerance.

467 (PS 3)

Development of Indexes to Evaluate Hardiness of Rose Germplasm

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Physiological, biochemical and anatomical indexes were investigated for rose hardiness. It was found that bound/free water ratio, proline accumulation, photosynthetic rate, palisade/spongy tissue ratio, and lignification of winter-acclimated stems were heavily influenced by the temperature causing stem browning. Spongy cell volume and stem tenderness were inversely related to winter hardiness. Data generated from this research demonstrated that catalase stability, TTC reduction rate at 0°C, total photosynthetic rate, stem pith ray number, and leaf wax thickness are good indicators for rose hardiness to freezing temperatures. Two compound indexes were developed through the main component analysis. Based on the results obtained from 12 tested cultivars, these indexes are ideal to quantify hardiness of rose germplasm.

468 (PS 3)

Indexing Cold Tolerance/Resistance of Hazelnut

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Cold tolerance/resistance of 41 hazelnut hybrid strains was investigated by evaluating electrolyte seepage velocity, recovering growth, and tissue browning for the tested cold temperatures. Results demonstrated that electrolyte seepage velocity of all tested strains was faster as temperatures dropped down. The S curve relationship was found between seepage velocity and temperature. Turning point temperature used as the half deadly injured index (LT_{50}) was developed using a logistic equation. The mean LT_{50} and temperature causing tissue browning were excellent indexes to predict cold tolerance/resistance. After treated at –30 or –35 °C and then evaluated for their recovering growth, 10 cold-resistant hybrid hazelnut strains were developed. These hybrids are being tested for regional adoption and will be released as commercial cultivars.

469 (PS 3)

Temperature Response of *Fragaria* Species

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Plants of a diverse collection of *Fragaria* clones from a range of native habitats representing *F. chiloensis*, *F. virginiana*, *F. virginiana glauca*, and *F. vesca*, were grown in a controlled environment at one of three day/night temperatures, 15/15, 23/15, or 31/15°C. Relative growth rate (RGR) and net assimilation rate (NAR) were estimated from plant leaf areas and total dry weights. At 23/15°C, the species mean RGR and NAR values were comparable although clones within species exhibited significant variation. At 15/15 and 31/15°C, RGR and NAR for species were lower than at 23/15°C. At 31/15°C, chiloensis and vesca mean values were reduced more than the others, to less than 50% the 23/15°C values. Also, NAR declined most for chiloensis, to 45% the 23/15°C value. At 15/15°C, virginiana had much higher RGR and NAR values than the other species, and its NAR mean value was greater than at 23/15°C. Although the species means would suggest that there are interspecific differences in temperature response, intraspecific variability was also large. Thus, classifying *Fragaria* species by temperature response may be an over-generalization.

470 (PS 3)

Cryopreservation of Dormant Vegetative Buds from Sour Cherry

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The dormant vegetative bud method for cryopreservation has been successfully applied to many lines of apple. We examined this method for five cultivars (Kentish, Montmorency, Meteor, North Star, Schatten Morelle) of sour cherry (*Prunus cerasus* L.) with the aim of developing long-term storage at NSSL. Single-bud nodal sections (35 cm) were desiccated to 25%, 30%, or 35% moisture before cooling at 1°C/hour to –30°C and holding for 24 hours. Sections were then directly placed in storage in the vapor phase above liquid nitrogen (about –160°C). Warmed samples were rehydrated and patch budded at Geneva to assess viability. Sections that were either undried, dried but unfrozen, or dried and cooled to –30°C survived very well. For samples then cooled to –160°C, highest viabilities for each line occurred with the 25% moisture level, although fairly high viabilities also were observed at 30% and 35% moistures. Cryopreserved buds from four lines directly developed into a single shoot; buds from Montmorency formed a shoot from a lateral within the bud, suggesting that the terminal meristem died but that axillary meristems within the bud survived and formed a shoot or multiple shoots. Nineteen lines were harvested in January 1996 for long term storage of sour cherry germplasm under cryogenic conditions.

471 (PS 3)

Desiccation Tolerance of Dormant Grape Buds from Germplasm Accessions in the Cold-Hardy *Vitis* Core Subset Collection

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The USDA–ARS germplasm collection of cold-hardy *Vitis* held at the Plant Genetic Resources Unit, Geneva, N.Y., has over 1300 clonal accessions maintained as field-grown vines. Security back-up using field-grown or potted vines at remote sites or via in vitro methods is costly. Cryopreservation offers a safe, cost-effective alternative. While we routinely employ cryogenic storage of dormant buds of *Malus*, dormant buds of *Vitis* generally do not appear to tolerate the desiccation levels required by our current cryopreservation protocol. Since tolerance to desiccation and cold appear to be correlated in *Vitis*, we tested desiccation tolerance of 60 germplasm accessions selected from the core subset to represent a range of cold hardiness. Budwood was collected in December 1995 in Geneva, stored at –4°C in sealed bags, and systematically desiccated to 30% and 20% moisture. In some treatments, additional desiccation was imposed by slow freezing to –25°C. Microscopic examination of rehydrated buds indicated 60% of accessions tolerated desiccation as low as 20% moisture. Freeze-desiccation at –25°C after desiccation at –4°C neither increased nor decreased viability in these accessions. Only slight modification so current protocols should be necessary for cryopreservation of this class. Of the remaining accessions, 25% tolerated desiccation to 30% moisture, but 15% were intolerant to any desiccation level tested. Techniques must be developed to successfully cryopreserve both these classes of accessions.

472 (PS 3)

Cooperative Cryopreservation of Dormant Apple Buds from the Canadian Clonal Gene Bank

Philip L. Forsline[1], Margie Luffman[2], John Warner[2], and Leigh E. Towill[3]*, [1]USDA-ARS Plant Genetic Resources Unit, Cornell Univ., Geneva, NY 14456-0462, [2]Canadian Clonal Genebank, Agriculture and Agri-Food Canada, Trenton, Ont., Canada K8V 5R5, [3]USDA-ARS National Seed Storage Laboratory, Ft. Collins, CO 80523

Based on protocols developed by the Plant Genetic Resources Unit (PGRU), Geneva, NY and the National Seed Storage Laboratory, Fort Collins, Colo., nearly 40% of the 2500-accession USDA–ARS *Malus* germplasm collection has been preserved cryogenically. Recent program changes require the entire Canadian *Malus* collection of 700 accessions at the Canadian Clonal Genebank, Trenton, Ont., be moved to a new location in Harrow, Ont., by the end of 1996. This provided an opportunity to utilize cryogenic storage during repropagation and reestablishment to develop a security backup for the collection. In a cooperative experiment, dormant buds of four Canadian *Malus* accessions were collected in Trenton and cryopreserved in Geneva in February 1995. Field-level moisture of dormant buds ranged from 45% to 50%. Three levels of bud desiccation were tested: 25%, 30% (current standard), and 35%. The desiccated buds were containerized and slowly frozen to –30°C, plunged into liquid nitrogen, and held for one month at Geneva prior to recovery testing by bud-grafting at Geneva and Trenton. Results were identical at both sites. We obtained 60% recovery at 30% and 35% moisture levels and 80% recovery at 25% moisture across all four accessions. Further studies on a broader range of germplasm will determine if desiccation to the 25% level is superior to the 30% level. Meanwhile, we have initiated a cooperative project to cryopreserve 350 accessions unique to the Canadian collection at Ft. Collins.

473 (PS 3)

Optimizing Bud Harvest Time and Duration of Temporary Cold Storage for Cryopreservation of Dormant Apple Buds

Philip L. Forsline, James R. McFerson, and Warren F. Lamboy,* USDA–ARS Plant Genetic Resources Unit, Cornell Univ., Geneva, NY 14456-0462

The USDA–ARS active collection of *Malus* includes over 2500 accessions maintained as field-grown trees at the Plant Genetic Resources Unit (PGRU), Geneva, N.Y. Nearly 30% of this collection is presently cryopreserved as dormant buds at the National Seed Storage Laboratory, Fort Collins, Colo., as a backup security collection. Successful bud-grafting recovery rates (≥40%) after one to four years of cryogenic storage have been documented for over 675 of 750 accessions tested. However, current protocols dictate budwood collection at PGRU from late December through early March, when buds are thought to be optimally acclimated for desiccation and slow freezing to –30°C, our pretreatment for cryopreservation. This causes a processing bottleneck. Our observations suggest temporary storage of budwood at –4°C after field harvest is possible, but we had not tested this directly. Therefore, we collected budwood from four accessions representing different levels of cold tolerance on six dates from January to March, 1995. Dormant buds were processed for cryopreservation monthly after storage in sealed bags at –4°C for 1 to 6 months. Recovery rates ranged from 55% to 100%. Neither collection date nor length of storage at –4°C affected rate of recovery. These results suggest we can significantly increase the throughput and efficiency of our cryopreservation efforts, thereby enhancing management and security of the *Malus* collection.

474 (PS 3)

Hardiness and Aesthetic Quality of Boxwood Cultivars as Affected by Landscape Exposure

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Five cultivars of boxwood (*Buxus microphylla*)—'Winter Gem', *B. microphylla* var. *japonica* 'Green Beauty', 'Green Velvet', 'Green Mountain' and 'Glencoe'—were planted in twelve different exposures at Manhattan and Wichita, Kan., representing USDA hardiness zones 5 and 6 respectively. The 1995–96 winter was one of great extremes. Lows of –25°C for Manhattan and -23°C for Wichita were recorded, along with sharp 24-hour temperature drops of 31–32°C in January and March. Differences in cultivar performance were noted between the sites. At the Wichita site best winter color was exhibited by 'Green Velvet' and 'Glencoe', whereas 'Green Mountain' sustained some bronzing of foliage due to winter sun. At Manhattan only 'Glencoe' in protected locations exhibited good winter color. All other surviving cultivars showed considerable bronzing. In addition, 'Green Beauty' was severely damaged at Manhattan, sustaining bark splitting due to low temperatures, although most plants survived at Wichita. Shaded locations on north, northeast and northwest produced best plant quality of all cultivars; whereas, the poorest plant performance occurred on south and southeast exposures.

475 (PS 3)

Lowest Survival Temperature Estimation in 45 Magnolia Varieties by Controlled Freezing

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Lowest survival temperature (LST) estimations for 45 varieties of Magnolia from Delaware were obtained over 4 testing dates with some varieties tested on fewer dates due to a shortage of material. Terminal stem cuttings were subjected to a controlled freezing regime, incubated at 100% humidity for 10–14 days and evaluated for injury by visual observation. LSTs were estimated as the lowest temperature at which 100% survival was observed. LSTs were difficult to estimate due to a lack of consistency caused by fungal pathogens. Incubation in moist towels and aluminum foil, post-freeze addition of moist towels following prefreeze sodium hypochloride dip, and dry incubation were employed to eliminate fungal pathogenicity as a source of post-freeze damage. Results show varieties with *M.* ×*loebneri* heritage to be the most consistently cold tolerant. Varieties such as *M.* 'Raspberry Ice' and *M.* 'Merril' rated as inconsistent with no definite LST estimated. Direct comparisons of incubation method, date of test, fungal pathogenicity and varietal consistencies will be discussed.

476 (PS 3)

Influence of Fluctuating Temperatures on the Cold Hardiness of Container-grown Nursery Stock

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The loss of container-grown nursery stock during winter months may be due to lack of root hardiness when exposed to cold temperatures. After *Euonymus alatus* 'Compactus', *Weigela florida* 'Java Red', and *Hibiscus syriacus* 'Paeonyflora' reached midwinter hardiness, replicates of each cultivar were subjected to 12 hours of 21°C followed by 12 hours of 0°C each 24-hour period for up to 16 days. Controlled temperature freezing was conducted after each 48-hour period, with temperatures ranging from –6 to –27°C to determine the level of root hardiness. Plants were placed in a greenhouse environment to observe post-stress performance. *Weigela* was the most cold hardy, followed *by Euonymus* and *Hibiscus.* In general, the early accumulation of warming temperatures decreased root hardiness and delayed budbreak, with a noticeable loss of vigor. Results of this research will be presented.

477 (PS 3)

Characterization of a 23-kDa Protein from the Wood of *Cornus sericea,* whose Accumulation is Associated with Seasonal Changes in Cold Hardiness

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Deciduous trees vary in their ability to survive low winter temperatures. Among species studied, two distinct responses to freezing have been described: deep supercooling and extracellular freezing. The tissue characteristics that account for these different responses have not been identified, but it has been proposed that properties of the cell wall distinguish species that supercool from those that do not. Our present objective was to analyze proteins from the cell walls of *Cornus sericea*, an extremely freeze-tolerant species that does not supercool. Twigs were collected throughout the year. The bark was removed, and the remaining wood was frozen in LN_2, freeze dried, and ground into a fine powder. Modifications of published protocols were used for the isolation of total proteins and cell wall proteins. The proteins in the cell wall fraction constituted only a small portion of the total proteins in wood ((<2%). SDS gel electrophoresis established at a single band corresponding to a 23-kDa protein was the predominant component in an extract from twigs in winter. The quantity of 23-kDa protein within the cell wall fraction varied with season. Levels were highest in winter, were reduced in spring, not detectable in summer, and increased in fall. Further analysis, using 2D gel electrophoresis, has shown that the 23-kDa band contains several proteins having similar MW and basic PI These proteins are glycosylated, and a partial amino acid sequence of one protein has been obtained.

478 (PS 3)

Seasonal Fluctuations in Cold Hardiness and Protein Profiles of Five Rhododendron Cultivars

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A time-course study was conducted to characterize seasonal patterns of cold hardiness (CH) and protein profiles in the leaf tissue of five Rhododendron cultivars ('Grumpy Yellow', 'Vulcan's Flame', 'Autumn Gold', 'Chionoides', and 'Roseum Elegans'). Leaf samples were collected monthly (starting in mid September) and leaf discs were subjected to controlled freezing and thawing regimes. CH (LT_{50} defined as temperature causing 50% injury) was assessed by electrolyte leakage and visual observations. Data indicate that cultivars varied in their CH in nonacclimated state and in their ability to cold acclimate. Results obtained in September showed 'Grumpy Yellow' to be least hardy (about –3°C) and 'Roseum Elegans' to be most hardy (about –7°C). All cultivars exhibited successive increases in CH during fall and winter. Maximum CH in all cultivars occurred by December/January with 'Chionoides' being most hardy (about –31°C) while 'Grumpy Yellow' was least hardy (about –20°C). LT_{50} based on electrolyte leakage was highly correlated with visual rating. Seasonal changes of protein profiles and relationship of specific stress proteins to cultivars' CH and cold acclimation ability are discussed.

145 POSTER SESSION (Abstr. 479–486) Water Stress

479 (PS 7)

Drought Responses of Mycorrhizal and Nonmycorrhizal Neem Plants of Comparable Size and Tissue Nutrition

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Mycorrhizal (VAM) and phosphorus (P)-supplemented nonmycorrhizal neem plants (non-VAM) of comparable size and tissue nutrition were subjected to a slowly developing drought. VAM and non-VAM plants responded to drought similarly. However, mycorrhiza compensated for low P supply, allowing VAM plants to have comparable growth, tissue P, and other physiological parameters as non-VAM plants, which received higher P supply. Drought decreased growth, transpiration (E), photosynthetic rate (*A*), stomatal conductance (g_s), and plant water status. Osmotic adjustment did not occur, but the relatively low osmotic potential of this species helped maintain turgor during drought. Plant water relations and *A* of stressed plants fully recovered in 24 hours after rehydration, while g_s and E partially recovered. Instantaneous water use efficiency (*A*/E) increased during drought and recovery, except for a decrease at peak stress due to very low *A*. Carbon isotope discrimination (D) values of mature leaves remained constant regardless of mycorrhiza or drought. However, D decreased in expanding leaves that developed during a drought period, indicating an increased long-term water use efficiency of these leaves.

480 (PS 7)

Effect of Mycorrhiza on Growth Recovery of Neem Plants after Drought Exposure

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Growth recovery of mycorrhizal (VAM) and nonmycorrhizal (non-VAM) neem plants after drought exposure were followed under low phosphorus conditions. Drought significantly decreased plant growth regardless of mycorrhiza. Relative growth rate of droughted plants was greater than nondroughted plants during the growth recovery period, and compensated the loss of growth during the previous drought. VAM increased plant growth and improved regeneration of new roots outside the original root balls, particularly in plants previously exposed to drought. New roots of VAM plants were readily colonized by the VAM fungi, while those of non-VAM plants remained uncolonized. VAM growth enhancement after drought exposure was associated with greater uptake of phosphorus and other nutrients, and improved root regeneration.

481 (PS 7)

Mycorrhizal Influence on Transpiration Rates of Detached Leaves of Cowpea, Rose, and Geranium Exposed to Varying Levels of Abscisic Acid (ABA), pH, Calcium, and Phosphorus

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Mycorrhizal colonization can alter stomatal behavior of host leaves during drought. This may be related to an altered production or reception of a chemical signal of soil drying. We tested whether intact root systems were required to observe a mycorrhizal effect on leaf transpiration (*E*), or whether some residual mycorrhizal influence on leaves could affect *E* of foliage detached from root systems. Transpiration assays were performed in the presence of several possible candidates for a chemical signal of soil drying. In detached leaves of *Vigna unguiculata* (cowpea), colonization interacted significantly with ABA and pH in regulating transpiration. Colonization affected *E* of detached *Rosa hybrida* (rose) leaves but had no effect on *E* of detached leaves of *Pelargonium hortorum* (geranium). In each species tested, increasing the ABA concentration decreased *E*. In cowpea, calcium appeared to alter stomatal sensitivity to ABA, as well as regulate stomatal activity directly. The pH of the feeding solution affected *E* in rose, but did not change *E* independently in cowpea or geranium. Adding phosphorus to the feeding solution did not alter *E* or the apparent sensitivity of stomata to ABA in any of the test species. Colonization of roots by mycorrhizal fungi can result in residual effects in detached leaves, that can alter the stomatal reception of chemical signals in both rose and cowpea.

482 (PS 7)

Effects of Short-term Water Stress, Hydrophilic Polymer Amendment, and Antitranspirant on Stomatal Status, Transpiration, Water Loss, and Growth in 'Better Boy' Tomato Plants

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Seedling plugs of 'Better Boy' tomato plants (*Lycopersicon esculentum* Mill.) were potted in processed fiber:perlite (60:40% by volume) media amended or nonamended with either crystalline or powdered hydrophilic polymer (2.4 $kg \cdot m^{-3}$), and treated with one of the several concentrations (0, 2.5, 5, 7.5, and 10%) of antitranspirant GLK-8924, at the four true-leaf stage. Plants were either well-irrigated or subjected to short-term water stress, water withholding for 3 days, after antitranspirant GLK-8924 application. Leaf stomatal conductance, transpiration rate, whole plant transpirational water loss, and growth were depressed by short-term water stress and antitranspirant GLK-8924. In contrast, hydrophilic polymer amendment increased plant growth, resulting in higher transpirational water loss.

The depression of stomatal conductance and transpiration rate by short-term water stress was reversed completely in 2 days after rewatering while the reduction of plant growth rate diminished immediately. The effects of antitranspirant GLK-8924 were nearly proportional to its concentration and lasted 8 days on stomatal conductance and transpiration rate, 4 days on plant growth rate, and throughout the experimental period on plant height and transpirational water loss. Plant growth was reduced by antitranspirant GLK-8924 possibly by closing leaf stomata. In contrast, hydrophilic polymer amendment resulted in larger plants by factors other than influences attributed to stomatal status. Hydrophilic polymer amendment did not interact with antitranspirant GLK-8924 on all variables measured. The application of antitranspirant GLK-8924 was demonstrated to be useful for regulating plant water status, plant growth and protecting plants from short-term water stress.

483 (PS 7)

Effects of Antitranspirant and Leaching on Medium Solution Osmotic Potential, Leaf Gas Exchange, Abscisic Acid Content, and Growth of 'Early Girl' Tomato Plants

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'Early Girl' tomato plants (*Lycopersicon esculentum* Mill.) were grown in a medium containing peatmoss and perlite (60%:40% by volume). The medium was drenched with 0% or 5% GLK-8924 antitranspirant. Half of the plants were flushed daily with 250 mL water (leaching), and the other half were subirrigated by capillarity. The solution osmotic potential of the medium was reduced significantly by 5% GLK 8924 treatment, then recovered gradually to the control level after 3 days with leaching or 10 days without leaching. Leaf stomatal conductance, transpiration rate, and plant growth were depressed by the antitranspirant application, and the depression was alleviated by leaching. Neither antitranspirant GLK-8924 treatment nor leaching influenced leaf abscisic acid (ABA) content. The effect of the antitranspirant on leaf gas exchange and plant growth was highly related to the reduction in the solution osmotic potential of the medium, but not to leaf ABA content. Younger leaves had higher stomatal conductance and transpiration rate but lower ABA content than older leaves in general.

484 (PS 7)

Gas Exchange, Stem Water Potential, and Leaf Orientation of *Rubus idaeus* L. Are Influenced by Drought Stress

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Rubus idaeus L. cv. Heritage raspberries were placed in controlled environment chambers (25°C, 14-hour photoperiod, 2.0 kPa vapor pressure deficit, CO_2 concentration of 380 mol$\cdot m^{-2}\cdot s^{-1}$) to study the effects of drought stress on leaf gas exchange and stem water potential. Whole-plant photosynthesis (Pn) and transpiration were sensitive to drought stress and gradually decreased from the second day of the study until rehydration. Stomatal aperture feed-back regulation was present during the initial 48 hours of the study with transpiration rates dropping in response to a decrease in stem water potential. Spatial differences were also present with leaf Pn, and stomatal and CO_2 conductance values of the younger, distal (i.e., closer to the apex) leaves decreasing at a faster rate than the older, proximal leaves (i.e., close to crown). Evidence of increased mesophyll resistance to drought stress was apparent with c_i either remaining constant or increasing, while Pn and carboxylation efficiency simultaneously decreased. Protection of the underlying photochemistry was evident with parahelionastic leaf movements which resulted in a reduction in the effective leaf area and subsequent heat load. Therefore, an optimum balance between water loss and c_i existed, and an alteration in these rates represented a stomatal conductance adjustment to match the intrinsic photosynthetic capacity rather than just a causal relationship.

485 (PS 7)

Effect of Wind and Soil Moisture on the Growth of 'Bluecrop' (*Vaccinium corymbosum* L.)

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This study was conducted in the greenhouse by running two experiments at different temperature regimes (22°C day and 13°C night and 33°C day and 22°C night). One-year-old tissue culture propagated plants were irrigated at three different soil moisture tension levels (5, 15, and 30 cnbars) and either exposed to moving or still air. The moving air treatment was created by two 51-cm-diameter fans running at either low (5.6 mph) or medium (8.2 mph) speed. Each experiment included, forty-eight plants arranged in a randomized complete block design. Each block consisted of a greenhouse bench containing two fans, a plastic dividing wall and two plant replications for each treatment. Canopy volume measurements were taken at the beginning, middle and end of each experiment to estimate growth rate. At the end of each experiment, total leaf area and leaf, stem and root dry weight data were collected. In the moderate temperature experiment, the still air treated plants had the highest canopy volume and leaf weight ratio while the moving air treated plants had the highest stem weight ratio. The only difference for the moisture treatments was the 5-cnbar treatment had the highest canopy volume. In the high temperature experiment, the still air treated plants had the highest canopy volume, total leaf area, leaf dry weight, shoot/root ratio, leaf weight ratio and leaf area duration while the moving air treated plants had the highest root weight ratio. The 5-cnbar treatment had the highest canopy volume and biomass accumulations. The 30-cnbar treatment had the highest root weight ratio.

486 (PS 7)

Gas Exchange and Vine Water Relations are Crop Load Dependent

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The effect of shoot density and crop level on gas exchange and water relations of filed-grown Sauvignon blanc was studied. Ten and 44 shoots/vine and one and two clusters per shoot treatments were examined in a factorial design. The two-cluster treatments had higher stem water potential (Y_{stem}), assimilation rate, and stomatal (g_s) and nonstomatal (g_m) conductance. A quantitative analysis suggests that capacitance cannot account for the simultaneous increase in g_s and Y_{stem} in the two clusters treatment. The two-cluster treatment had higher Y_{stem} for similar transpiration rates (similar g_s) compared to the one-cluster treatment. The similar transpiration rate and lower stem to root water potential difference in the two-cluster treatment was explained by increased root permeability in the two-cluster treatment. The similar g_s–g_m, in spite of a meaningful decrease of gs with decreasing Ystem, suggests that g_s and g_m synchronize themselves to perturbations of g_m due to sink effect and g_s due to water stress.

108 POSTER SESSION (Abstr. 487–492) Water Stress–Woody Ornamentals/ Landscape/Turf

487 (PS 4)

Foliar Dehydration Tolerance of Twelve Deciduous Tree Species

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We compared the potential for foliar dehydration tolerance and maximum capacity for osmotic adjustment in twelve temperate, deciduous tree species, under standardized soil and atmospheric conditions. Dehydration tolerance was operationally defined as lethal leaf water potential (Ψ): the Ψ of the last remaining leaves surviving a continuous, lethal soil drying episode. *Nyssa sylvatica* and *Liriodendron tulipifera* were most sensitive to dehydration, having lethal leaf Ψ of –2.04 and –2.38 MPa, respectively. *Chionanthus virginiana, Quercus prinus*, *Acer saccharum*, and *Quercus acutissima* withstood the most dehydration, with leaves not dying until leaf psi dropped to –5.63 MPa or below. Lethal leaf Ψ (in MPa) of other, intermediate species were: *Quercus rubra* (–3.34), *Oxydendrum arboreum* (–3.98), *Halesia carolina* (–4.11), *Acer rubrum* (–4.43*), Quercus alba* (–4.60), and *Cornus florida* (–4.88). Decreasing lethal leaf Ψ was significantly correlated with increasing capacity for osmotic adjustment. *Chionanthus virginiana* and *Q. acutissima* showed the most osmotic adjustment during the lethal soil drying episode, with osmotic potential at full turgor declining by 1.73 and 1.44 MPa, respectively. Other species having declines in osmotic potential at full turgor exceeding 0.50 MPa were *Q. prinus* (0.89), *A. saccharum* (0.71), *Q. alba* (0.68), *H. carolina* (0.67), *Q. rubra* (0.60), and *C. florida* (0.52). Lethal leaf Ψ was loosely correlated with lethal soil water contents and not correlated with lethal leaf relative water content.

488 (PS 4)

Leaf Conductance and Xylem Water Potential of Ecotypes and Cultivars of *Acer saccharum* and *A. nigrum*

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This study examined physical factors and physiological responses of five different ecotypes and cultivars of *Acer saccharum* and *A.nigrum*. The objective was to determine variations in leaf conductance and xylem water potential and correlations associated with their natural geographic distribution. Compared were two ecotypes of sugar maple, Caddo and Wichita Mountains, native to Oklahoma with cultivars Green Mountain and Legacy, plus black maple seedlings from Iowa. Measurements taken included leaf conductance, xylem water potential and soil water potential in a replicated block of 15-year-old trees. The two ecotypes had consistently higher photosynthetic rates, stomatal conductance and transpiration rates than other selections. Xylem water potentials were significantly higher for Caddo maples than Green Mountain, Legacy and Acer nigrum in both predawn and midday samples. This difference in water availability can be associated with a tendency for Caddo to vary its stomatal conductance. The other tree types maintained stable stomatal conductances.

489 (PS 4)

Ethylene Production as a Drought Stress Response in *Cassia corymbosa*

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Landscapes in the desert Southwest must be water efficient and utilize drought tolerant plants. Therefore, plants with landscape potential must be evaluated for their level of drought tolerance and drought tolerance mechanisms. Drought tolerance, for some plant species, may be related to the plants ability to produce ethylene as a mechanism for defoliation, thus reducing water use. *Cassia corymbosa* has potential as a woody shrub for southwestern landscapes because of its dark green foliage and bright yellow flowers. Studies were conducted to determine the effect of leaf dehydration and drought stress on ethylene production in Cassia. Leaf dehydration was examined by excising leaves and placing them at 20, 25, or 30 °C. The time course of ethylene production depended on the temperature (rate of dehydration), but the peak occurred at 18% to 25% fresh weight loss, regardless of dehydration temperature. The effect of irrigation rate was determined by supplying plants with 0%, 40%, 60% and 100% of the daily water consumption (WC) based on pot capacity. Ethylene production depended on irrigation rate. Plants irrigated at 100% of daily WC were not stressed and did not produce ethylene. Irrigation at 60% of daily WC induced peak ethylene production 72 hours after treatment with decreased production as at longer times. Irrigation at 40% or 0% of the daily WC did not induce ethylene production because of the rapid dehydration. Drought-induced ethylene production in Cassia corymbosa appears to be closely related to the rate of dehydration and may provide a drought tolerance mechanism.

490 (PS 4)

Intsia bijuga Is Moderately Tolerant of Flooding

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Growth and physiological responses of *Intsia bijuga* trees to flooding were determined in a series of five container experiments to assess the relative tolerance of this species to flooding. The first measurable response to flooding was reduced leaf gas exchange, which began within 5 to 6 days of the onset of flooding. Development of hypertrophied lenticels at the water line and paraheliotropic leaflet movement were evident by 17 days of flooding. Emergence of adventitious roots on the stem above the water line began after about 30 days of flooding. Leaflet abscission was greatly accelerated by flooding. After more than 3 months of flooding, regrowth of roots, stems, and leaves began within two weeks of draining the medium. The data and observations support a relative ranking of moderate flood tolerance for *Intsia bijuga*.

491 (PS 4)

Effect of Shade on the Growth of Four Turfgrasses

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Four turfgrasses (Z-3, Seashore Paspalum, Common Bermuda, and Tif dwarf Bermuda) were grown outdoors in pots under different shade conditions (0%, 30%, and 50% shade) from August to December 1995. Dry weight of clippings taken every two weeks was determined. Turfgrass growth in the three shade treatments were significantly different, and the growth of the turfgrasses were highly significantly different. In the 0% and 30% shade treatments, Common Bermuda and Seashore Paspalum grew similarly, and their dry weights were significantly greater than those of Z-3 and Tif dwarf Bermuda. However, under 50% shade, only Seashore Paspalum grew significantly greater than the others. Comparing growth among the shade treatments for each turfgrass, we found no significantly differences. Only Common Bermuda grew significantly less under 50% shade than under 0% and 30% shade. Common Bermuda is good for golf courses because of its fast growth and attractiveness. Seashore Paspalum can be used for home lawns because of its vigorous growth and shade tolerance. Z-3 turfgrass, an attractive new variety for home lawns, despite its slow growth, is tolerant of different shade conditions.

492 (PS 4)

A Study to Evaluate Links between Leaf Anatomy and Environmental Stress in *Acer saccharum* Cultivars

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An anatomical study was conducted to determine and compare the internal leaf surface to volume (S/V) ratio of the spongy mesophyll in selected cultivars of *Acer saccharum*. A low S/V ratio is one of several selectively advantageous characteristics associated with xerophytic plants. It has been proposed that a correlation exists between certain injuries produced by environmental stress and plant leaf anatomy. The taxa included in the study were *Acer saccharum* cvs. Green Mountain and Legacy, *A. saccaharum* Caddo and Wichita Mountain (seedlings of Caddo County and Wichita Mountains, Oklahoma relictual populations respectively), and *A. saccharum* ssp. *nigrum* (syn. *Acer nigrum*). Leaf samples were taken from five different representative trees for each of the five cultivars. The results showed that Caddo, which is highly stress tolerant, had a significantly lower internal S/V ratio than the other four cultivars. 'Legacy' which is intermediate in stress tolerance had the next lowest S/V ratio. As expected the highly injury-susceptible selections *A. saccharum* ' Green Mountain' and *A. saccharum nigrum* had high S/V ratios. However, the Wichita Mountain variety which exhibits a stress tolerance similar to Caddo, also had a high S/V ratio. These results suggest that other factors may be involved in determining environmental stress tolerance.

106 POSTER SESSION (Abstr. 493–497) Education

493 (PS 2)

Seminar Courses—Content to Satisfy the Needs of Future Horticulture Professionals

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In the past, a seminar course was considered effective if the students were trained in oral presentation techniques. Two things have changed since then: 1) the growing popularity of the poster as a form of research communication and 2) new technologies such as the use of computers and LCD projection systems. Familiarity with these techniques then becomes a highly desirable part of a seminar course designed to satisfy today's needs. At Alabama A&M Univ., the undergraduate and graduate seminar courses require students not only to present an oral seminar but to participate in a public poster presentation once each semester. The entire department participates in viewing the posters, questioning the students and assigning scores. This allows students to participate in a simulated professional meeting environment and learn how to interact with other professionals concerning their posters. The seminar course also includes topics such as parts of a seminar, multimedia presentations, computer usage, developing a time sense, dealing with fear of public speaking, public speaking do's and do not's, impromptu talks, handling questions, and poster techniques. Graduate students serve as moderators for the oral seminar sessions thus gaining additional experience. An essential part of the course is peer grading and evaluation. Peer involvement in the process acts to promote a high standard for oral seminars and posters.

494 (PS 2)

Two Tropical Plants as Plant Materials for Teaching Seed Germination

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A local ground orchid, *Spathoglottis plicata* Blume, and coconut, *Cocos nucifera* L., were used in the classroom to teach seed germination. *S. plicata*, a common orchid on Guam, was utilized to demonstrate the aseptic culture of seeds under non-sterile conditions. The procedures were done in the classroom without a laminar air-flow cabinet. Nonsterile seeds were sown on growing media which were prepared without autoclaving, but by incorporating sodium hypochlorite into the media. Students had a high rate of success in germinating the orchid seeds without contamination by spraying sodium hypochlorite on the seeds. Different stages of coconut seed development were presented to students by simply cutting coconut in half. Unique features and botanical terms of coconut seed development can be taught throughout the year. Teaching materials on seed germination of the two tropical plants are being developed by print-on-demand methods.

495 (PS 2)

Honor's Students as Peer Tutors for Problem-based Learning

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The course "Biotechnology: Science and Socioeconomic Issues" has used problem-based learning (PBL) during the last quarter of the course for the past 3 years. One of the challenges of using PBL in medium-sized and larger classes is finding a way to facilitate each group of students with a limited number of qualified facilitators while avoiding unmanageably large numbers of students per group. This past year (95F) the course had both a nonhonor's and an honor's section. The honor's section met an additional hour each week to learn about PBL and peer tutoring skills. Training students to be peer tutors was divided up into four parts: 1) the science behind PBL, 2) experience working through a previously developed case study, 3) development of a case study, and 4) peer tutoring case studies in the non-honor's section. We will discuss the process of training students to be effective peer tutors for PBL.

496 (PS 2)

Exploring Accessibility: A Hands-on Teaching Tool

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As part of a horticultural therapy class assignment, groups of three to four students each spent 1.5 hours analyzing a Virginia Tech greenhouse while using various equipment to simulate disabilities that future clients may have. Their instructional goal was to analyze the greenhouse and area around for accessibility. The purpose of this assignment was to develop student insight into the handicapping impact that the environment and people can have on individuals with disabilities, student awareness of the need for and types of adaptations to facilitate horticulture for disabled individuals, and student empathy for future clientele. The results were the written comments from the students regarding the class. Their comments were most constructive and gave insight into the value of such an assignment for future use.

497 (PS 2)

Consolidation of Agricultural Programs at Tennessee State University

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The Dept. of Agricultural Sciences currently offers degrees at both the undergraduate and graduate levels. Undergraduate programs in Plant Science, Animal Science, and Rural Development were consolidated within the Dept. of Agricultural Sciences in the late 1980s due to the declining number of graduates. However, no personnel turnover or course changes occurred due to consolidation. Enrollment at the undergraduate level has doubled within the past 5 years. Student enrollment for Fall 1995 included 127 undergraduates and 31 graduate students. Graduation figures projected for 1995–96 include 26 undergraduates and 8 graduate students. Horticulture and Agronomy are now two of the concentrations available for the BS degree in Agricultural Sciences, and Plant Science is an option for the MS degree in Agricultural Sciences. Presently in the plant sciences there are approximately 30 undergraduates and 20 MS students. Faculty and professional staff affiliated with the Cooperative Agricultural Research Program are encouraged to submit teaching proposals to the 1890 Institution Capacity Building Grants Program, a USDA-funded competitive program for the agricultural sciences. Awards enable grantee institutions to attract more minority students into the agricultural sciences, expand institutional linkages, and strengthen education in targeted need areas. The Grants Program supports teaching projects related to curricula design, materials development, and faculty and student enhancement. Current teaching grants address graduate and undergraduate education in molecular biology and undergraduate education in soil sciences.

106 POSTER SESSION (Abstr. 498–503) Marketing and Economics

498 (PS 2)

Consumer Perceptions and Expectations of Garden Center Quality

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We compared service quality perceptions and expectations for consumers from five traditional garden centers (TGC) and three nontraditional garden center outlets (NTO) in Charlotte, N.C., in 1995. NTO and TGC customers had very similar expectations of service quality from their respective retailers. However, TGC customers perceived that their retailer better met their overall expectations. Service quality gaps, the difference between customer perceptions and expectations, were identified for both types of outlets for four of five service quality dimensions. Both TGC and NTO customers ranked assurance and responsiveness as the most important service quality dimensions. Empathy was more important than reliability to TGC customers. This order was reversed for NTO customers. Both sets of customers ranked tangibles as the least important service quality dimension.

499 (PS 2)

Demand for Herbaceous Ornamental Germplasm from the North Central Regional Plant Introduction Station

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In 1991, the USDA–ARS North Central Regional Plant Introduction Station made available for distribution 129 accessions of germplasm representing 31 genera of herbaceous ornamentals. This number increased to 329 accessions of 42 genera by 1995. During 1991–95, more than 500 seed packets were distributed to fulfill requests for these plants received from a diverse array of public and private researchers. An analysis of this demand together with expert advice from Crop Germplasm Committees and technical considerations, such as ease of culture and seed production, can help set priorities to plan germplasm regeneration to meet future demand. A recent analysis of demand at U.S. National Plant Germplasm System active sites indicated that demand ranging between 0.23 and 0.97 distributions per available accession per year was typical. Of the 42 ornamental genera analyzed in this study, 9 were demanded more frequently than was typical, 10 were demanded less frequently, with the remainder in the typical range. In order of increasing frequency, the nine genera with the highest distribution rates were *Verbena*, *Gypsophila*, *Echinacea*, *Lapeirousia*, *Delphinium*, *Cerastium*, *Baptisia*, *Lilium*, and *Tanacetum*. Six of these genera are represented only by a single available accession. Notably, *Echinacea* and *Tanacetum* are of research interest both as ornamentals and as medicinal/industrial crops. This poster gives a brief overview of the economic value of these genera, display the results of the demand analysis, discuss the results relative to recommendations from Crop Germplasm Committees and requestors, and consider how demand can shape management plans for the acquisition and regeneration of ornamental germplasm.

500 (PS 2)

Mail-order Custom Landscape Plans

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Americans' growing appreciation for excellent landscape design is creating a great need for reputable designers in the residential landscape design industry. Technology affords landscape planners the ability to fill that need with personalized landscape designs through the mail. The use of disposable cameras, over-

night mail, computer aided design, computer rendering, telephone, and fax all makes it possible for a designer to acquire a good knowledge of a particular site, quickly design an accurate, high quality landscape design, do several revisions to that design, and give the client a timely return of the design. *Southern Living* magazine's new department, Custom Landscape Plans, headed by Rebecca Bull, is one example of how this is done. Through a graduate assistantship with *Southern Living,* I can use these available technologies to design personalized landscape plans all over the south from my office at Clemson Univ. The methods of mail-order landscape design will be discussed in a verbal presentation.

501 (PS 2)

Marketing Shiitake Mushrooms for Their Health Benefits

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Shiitake mushrooms [*Lentinula edodes* (Berk.) Pegler] have several therapeutic effects such as antibiotic, immunoregulatory, hypocholesterolemic, and hypotensive. Human studies have proven that serum cholesterol can be lowered by consuming shiitake mushrooms on a regular basis. However, few studies have evaluated shiitake mushroom effects for more than a few weeks. In this study, male spontaneously hypertensive rats were divided into six groups. Each group received one of the following diets: 0% cholesterol (C); C + 5% shiitake mushrooms; C + 5% *Agaricus bisporus* (Lange) Imbach; 1% cholesterol (1C); 1C + 5% shiitake; 1C + 5% *A. bisporus.* Serum cholesterol was measured at the end of 9 weeks and systolic blood pressure was measured weekly for 6 weeks. At the end of the study, total serum (TC) and very low-density lipoprotein (VLDL) cholesterol ($mg \cdot dL^{-1}$) were significantly lower in both of the shiitake diets compared to 1C or 1C + 5% *A. bisporus.* The total cholesterol for diets 1 through 6 were 44, 34, 36, 71, 34, and 54 $mg \cdot dL^{-1}$, respectively. Systolic blood pressure was significantly lower over the 6-week period for the shiitake and *A. bisporus* amended diets. The addition of cholesterol to the diets did not significantly affect systolic blood pressure. Results of this study indicate that both shiitake and *A. bisporus* mushrooms may help reduce hypertension. Shiitake mushrooms may be superior to white mushrooms for hypocholesterolemic effect when cholesterol in the diet is high. The results of this study reinforce other work conducted in Japan on animals and humans. Promotion of shiitake mushrooms as a product that can reduce cholesterol or blood pressure can increase sales if scientific information supports these claims.

502 (PS 2)

Economic Analysis of Arizona Ash Sequentially Produced in Copper-treated or Nontreated 0.21-, 2.5-, and 11.8-Liter Containers

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Arizona ash (*Fraxinus velutina* Torr.) seedlings were grown in 0.21-L plastic liner containers, half treated with 100 g $Cu(OH)_2$/L latex carrier (formulated as Spin Out), and half nontreated. Seedlings were sequentially transplanted to larger containers, from liners to 2.5-L black plastic containers then to 11.8-L containers resulting in a $2 \times 2 \times 2$ factorial combination of container sizes and Cu-treatments (eight combinations with 30 replicates/treatment). Nursery conditions and production procedures were determined from regional nurseries using a modified Delphi technique. Growth responses (height, caliper, market grade) and costs of production were determined for each treatment combination through marketable size in 11.8-L containers. Significant interactions ($P \leq 0.05$) among liner and 2.5-L container treatments occurred for end of season trunk diameter and market ratings. Those seedlings grown in both Cu-treated liners and 2.5-L containers tended to have larger calipers and market ratings than other treatment combinations. Growth increases were not realized when containers were treated at a single stage. Copper-treated containers resulted in a 17-second labor savings per container at transplant from 2.5- to 11.8-L containers. Labor requirements were not significantly ($P \leq 0.05$) different among treatments at transplant from 0.21- to 2.5-L containers.

503 (PS 2)

Adapting a Nursery Production Budget to Containerized Specialty Vegetables

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Production budgets for both field grown vegetables and ornamental crops, field and container grown, are fairly common. Container grown vegetables, other than transplants, are much less common and do not have specific budgets which would allow growers to set realistic prices for individual plants. A specialized budget was adapted from one developed for container nurseries. Specific production costs were taken from a budget for field grown vegetables. This process could be adapted for use with other specialty crops. It could be used for county or state fairs and other situations where individual vegetable plants need to be raised in containers.

144 POSTER SESSION (Abstr. 504–507)
International Horticulture

504 (PS 6)

Up from the Ashes: Vegetable Crop Research Capacity Development in Cambodia, 1984–1995

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Civil war and the hostilities which followed it in Cambodia from 1972 to 1979 resulted in a 20% reduction in the country's population and the near total destruction of its educational and agricultural research infrastructure. As if this were not enough, western governments embargoed humanitarian aid to Cambodia during its most critical period of need from 1981 until multiparty elections were held in 1993. During this period a handful of nongovernmental agencies helped the government begin rebuilding some of its agricultural production capacity. One NGO, together with its government counterparts, established the country's first research station for vegetable crops in 1985 at the request of the Ministry of Agriculture. The Kbal Koh Vegetable Crops Research Station was built and its staff received training from 1985 to 1987. The facility has continued its four-part mission with very limited outside funding and technical support since 1987. Numerous variety and seed production trials have been conducted at the station and in farmers' fields since 1985; practical training programs for agricultural technicians and students began in 1986 and today provide much of the salary and operating budget support for the station. Coinciding with the phase out of NGO assistance in 1995, their are great expectations for continuing support through the newly formed Cambodia–Laos–Vietnam vegetable production and research network, AVRDC, and the Asian Development Bank.

505 (PS 6)

Indian Floriculture Industry is Poised to Bloom

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Floriculture is growing at a frenetic pace in India. From a few units in 1990, nearly hundred units are either fully operational or at various stages of implementation. Almost seventy of these produce rose for the cut flower export market. The average unit size is two hectare under poly-cover. Anthurium, carnation, chrysanthemum, orchids and gerbera comprise the other cut flower producing units. Technology has come mostly from Holland, with Israel now giving severe competition to the Dutch. Germany, France, United Kingdom, and New Zealand are the other countries involved in technology transfer. Many units have the fan and pad system for temperature control along with drip irrigation and computer mediated operations. Most units use natural soil as the medium of growth whereas some have a combination of sand and natural soil and a few have adopted complete sand bed culture as practiced by Israeli growers. These hybrid as well as the state-of-the-art floriculture technologies are competing for the Indian market and the next few years will determine the system that is most suitable for adoption under local conditions. The Agricultural and Processed Food Products Export Development Authority (APEDA), a wing of the Commerce Ministry of the Government of India, and the National Horticulture Board have indeed provided substantial support for the growth of Indian floriculture Industry. Meanwhile, more and more entrepreneurs are, on their own, setting up cold storages and operating cold trucks near major airports to maintain appropriate temperatures from harvest to destination. It is widely expected that more than 50% of the existing floriculture units will make good whereas the remaining may not survive either due to sourcing of unsuitable technologies or lack of expertise in floriculture production and management as well as international marketing prowess. There is also consensus that no single foreign technology giver is capable of meeting adequately

the total needs in the Indian context and often it is a matter of the collaborators learning together. What seems certain is that India will, by the year 2000, be a major player in international floriculture because of the diverse agroclimatically suitable locations, lower labor cost, and talented human resource.

506 (PS 6)

Integrated Approach to an Improved Citrus Production and Marketing System in Benue State of Nigeria

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The commercial production and handling systems in Benue State was undertaken under a World Bank assisted project to identify and seek solution to constraints facing citrus farming in some rural parts of Nigeria. Selected areas noted for intensive fruit cultivation like Gbako,Yandev,Katsina-ala, and Aliade was covered in a survey by citrus agronomists and postharvest specialists. The study looked into processes and activities at farmers plots, agriculture department extension plots and nurseries, local markets and processing plants. Key production constraints identified include pest management and weed problems,bush burning, and high labor costs for farm operations. Lack of organized marketing outlets, high transport costs, and fruit decay at collection centers were the main bottlenecks facing the postharvest operations. Local processors face the problems of poor-quality raw material supply and the unstable price regimes every season. Investigation revealed that improved extension linkages that emphasize appropriate orchard management skills, integrated pest management, and careful handling should be introduced.

507 (PS 6)

Agro-ecological Variation in the Growth and Development of Grain Amaranth (*Amaranthus* sp.) in Nigeria

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The pale yellow-seeded Amaranth is virtually a new crop in Nigerian agriculture. Under the sponsorship of the National Agricultural Research Project (NARP), 12 accessions were evaluated for agronomic characters and yield attributes in three agro-ecological zones of the country. The results showed significant variation in the agronomic characters of the accessions. Top accessions recorded average grain yields of 4.5, 3.5, and 2.6 $t \cdot ha^{-1}$ in Sudan savanna, derived savanna, and guinea savanna zones of the country, respectively. Response of the accessions to qualitative and quantitative characters in the zones are discussed.

106 POSTER SESSION (Abstr. 508–518) Teaching and Extension Methodology

508 (PS 2)

Farmer's Bookshelf: Hypermedia Information System to Recommend Trees for Landscaping

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A hypermedia information system was developed to recommend trees for landscaping and to obtain information on these individual trees. Using the software HyperCard on the Macintosh computer, we developed a system that uses the idea of index cards with information being stored on separate screens called "cards." Using a mouse, the user navigates from one card to another by click on a "button" on the card. The user may select from several criteria including tree type, tree height, soil type, drought tolerance, wind tolerance, shade tolerance, salt tolerance, and growth rate. The program then finds which trees meet the desired criteria and provides information on these trees. This easy-to-use system requires no typing except to enter a word to search for. The user can quickly browse for the desired information and save it as a text file or print it. The Farmer's Bookshelf provides a tool for extension agents, growers, and homeowners to easily obtain vitally needed information. The program has further application for landscape companies, Master Gardener programs, and in horticultural courses.

509 (PS 2)

Surveys Show Extension Workshops Improve Floridians' Adoption of Environmental Landscape Management Practices

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Environmental Landscape Management (ELM), an extension education program, approaches every landscape as a "system" in which cultural practices interact with each other and the environment. ELM guidelines integrate site conditions, landscape design, plant selection, cultural factors, and recycling in a comprehensive, environment-friendly strategy for managing a landscape. Use of ELM practices by Floridians will conserve resources and protect the environment. The ELM program was evaluated from 1992 to 1994 in 10 counties to measure the program's impact on participants' landscape practices and to provide information on ways to improve program delivery and effectiveness. The evaluation was accomplished by comparing pre-program information on the use of ELM practices with that of a follow-up conducted six months after the program. Responses of this Program Group (n = 473) were compared to those of a Comparison Group of randomly selected Floridians (n = 186). ELM training increased the Program Group's adoption of most practices pertaining to pest management, irrigation, and mowing and pruning. ELM training increased adoption of some fertilization practices and a few recycling and wildlife practices. Energy conserving practices were not widely used by respondents. Respondents maintaining their own yards or those without a permanent irrigation system were more likely to adopt a wide range of ELM practices. The Program Group generally had higher initial levels of adoption of ELM practices than the Comparison Group.

510 (PS 2)

Clemson University–Carolina Nurseries Partnership: An Innovative Approach to Improving Research and Outreach Programs

Ted Whitwell, John Kelly, and William B. Miller,* Dept. of Horticulture, Clemson Univ., Clemson, SC 29634

In 1993, Carolina Nurseries and the Department of Horticulture at Clemson Univ. entered into a partnership to create a research and development program to solve short and long term nursery production problems. Research is conducted on site at Carolina Nurseries in a specially designed 0.6-ha area built by the nursery. Faculty from the Depts. of Horticulture, Agricultural and Biological Engineering, Plant Pathology and Entomology have worked with graduate and undergraduate students located on site. The nursery staff is involved in overall planning and stay current with results so that research can be immediately implemented on the nursery. Yearly funding for the graduate student is provided by the nursery and grant funds are obtained from various companies for labor and supplies. Carolina Nurseries has committed to funding research to improve their production and also sharing the results with the rest of the nursery industry. Research findings are presented in peered reviewed articles, conference proceedings, abstracts, and oral presentations. Outstanding training opportunities for students and staff are available to also improve career development for future nursery managers. Faculty interaction with companies and the nursery industry are enhanced.

511 (PS 2)

Using a Research Facility for an Extension Outreach Program Festival of Color

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Most of Nebraska's population resides in the urban centers of eastern Nebraska. Traditionally, however, the Cooperative Extension Service has catered to the rural populations of the state. Now, it is imperative that the public and the legislative representatives from these urban areas learn that the research and outreach programs of the university also serve them. A Festival of Color was the vehicle for educators and aides, Natural Resource District personnel, and other professionals, including government officials. Both professionals and the general public responded enthusiastically to the Festival's innovative use of the research site. The educational objective was to creatively answer questions on low input landscapes; their design and maintenance. Information was presented by Extension Specialists and Assistants, Master Gardeners, Natural Resource District personnel, Dept. of Environmental Quality, State Energy Office, and Nebraska Association of Nurserymen.

512 (PS 2)

Horticulture Needs More Weed Scientists

Larry J. Kuhns and Tracey L. Harpster*, Dept. of Horticulture, The Pennsylvania State Univ., University Park, PA 16802.

Weeds must be controlled to produce marketable crop yields, for human safety, and for aesthetic reasons. Physical methods of weed control are highly labor and/or energy intensive, and in many cases are more dangerous to crops and people than herbicides. They are not practical solutions to most weed problems in developed countries. To properly work with and apply herbicides, researchers, and applicators should have a knowledge base that includes information on weed taxonomy, anatomy, and biology; herbicide chemistry and modes of action; spray adjuvants and carriers; soil characteristics and environmental factors that affect herbicide performance; application equipment technology; the development of herbicide resistance; alleleopathy; and the biological control of weeds. Herbicide use, in terms of product used or expenditures, is greater by a wide margin than that of insecticides and fungicides combined. Also, about two thirds of all pesticides produced in, and exported from, the United States are herbicides. Finally, about 40% of all of the herbicides used in the world are used in the United States. Only 32% of the insecticides and 14% of the fungicides are used in the United States. On the average, the leading universities in the country have only three faculty teaching courses in weed science, and they teach only two undergraduate and three graduate courses each year. Few are in horticulture. By comparison, there are 15 faculty teaching 13 undergraduate and 19 graduate courses in the leading entomology programs in the country. Weed control is an essential element in the production and management of all horticultural crops. Who is going to provide the education and training in weed science for the researchers, horticulturists, and consultants of the future?

513 (PS 2)

Home Horticulture Course/Master Gardener Training via the Fiber Optics Network

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A two-way interactive home horticulture course was developed for undergraduate and graduate students and for Master Gardener training. The three-credit course was offered at the broadcast site, as well as four other remote locations. Three-hour sessions were presented by state and regional Extension Specialists each week over a 15-week period. In addition to live broadcasts over the fiber optic network, each session was video-taped and sent to each location. Take-home exams and special student projects were required. Evaluations indicated that comprehension of subject matter was not impeded by the mode of delivery. This course was a cost-effective means of delivering Master Gardener programming and teaching nontraditional students simultaneously at remote locations. Moreover, travel time and expenses were reduced, allowing faculty to devote their time, usually spent traveling, on other endeavors.

514 (PS 2)

What Do Master Gardeners Do?

*Kathleen C. Ruppert**, Dept. of Environmental Horticulture, IFAS, Univ. of Florida, Gainesville, FL 32611

The Master Gardener Program in Florida began in 1979 with the three pilot counties of Brevard, Dade and Manatee. Today, 48 of the state's 67 counties manage this volunteer program. Data will be reported as to how many volunteers have been trained and the hours they volunteered each year, along with the percentage of time agents or program assistants estimate they devoted to the program each year since 1989. The activities of the volunteers for each year will also be depicted. These indicate a change in need by county agents over the years for the services of their volunteers.

515 (PS 2)

Determining Landscape Tree Knowledge of Fourth to Sixth Graders

Kathleen C. Ruppert and Gregory L. Davis*, Dept. of Environmental Horticulture, IFAS, Univ. of Florida, Gainesville, FL 32611

In his State of the Union Address (1990), President Bush proposed planting a billion trees annually for the next 10 years. Organizations such as Global ReLeaf are planning to plant 400 to 600 million trees by the year 2000. A review of science education periodicals and general information available on tree planting and care reveal little directed to children. Science education tends to focus on the nature, not the handling of trees, and where planting ideas are suggested, they tend to be about growing trees from seed. To determine the level of landscape tree care knowledge of 4th–6th graders, a questionnaire addressing how trees grow, site and tree selection, proper planting, and other areas was administered by 4-H agents and Univ. of Florida students throughout the state during five camps, involving 211 children during the summer of 1995. The questionnaire was revised with additional topics such as irrigation and mulching added and administered during three 4-H camps involving 77 4th–6th graders. Answers to these questionnaires were used to develop materials targeted for this age group and their teachers.

516 (PS 2)

Art in the Garden: An Interdisciplinary Program for Educating Children about Horticulture

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Education of future consumers is a frequently discussed objective to improve consumer relations with the horticulture industry. We have developed a program which addresses this objective. The program provides examples of art projects that can be combined with simple horticultural experiences. We are presenting this program as a model to be used by horticultural professionals for the instruction of child care providers, or for direct presentation to children. Our intent is to create a greater awareness of horticulture. Often, child care providers plan educational experiences for young people based on disciplines that have been established by tradition and that are considered essential to childrens' educational development. For example, teachers might plan a nature lesson, a simple math lesson or an art lesson. This interdisciplinary plan helps children feel the connectedness of the world in which they live rather than seeing it as a series of unrelated events. Traditional motor skills are taught, along with an appreciation for seeds, plants, and the environment. Teachers may adapt the information presented here to a wide variety of activities. This approach can serve as an example of how interdisciplinary programs involving horticulture might be structured. It offers a timeline to teachers who desire to duplicate such a program, and presents many ideas, along with detailed information on how to conduct individual projects. Hopefully, this integration of art and horticulture inspires those who work with children to creatively consider the possibilities of interdisciplinary planning.

517 (PS 2)

Interdisciplinary Horticulture Course Benefits Local Youth

Mary E. Olien[1], Jere A. Brittain[1], and Brenda J Vander Mey[2]*, [1]Dept. of Horticulture; [2]Dept. of Sociology, Clemson Univ., Clemson, SC 29634

"Garden Experiences in Youth Development" is a two-credit, (one lecture, one lab) 400-level course offered each spring semester by the Dept. of Horticulture at Clemson Univ. For the past 3 years, the course has met the following specific needs: 1) requests by horticulture students for more experiences related to horticulture and human well-being; 2) opportunities for other majors whose careers will or may focus on children to learn and to use horticulture with children; 3) a source of adult leaders for an after school children's gardening program at the South Carolina Botanical Garden. The lecture portion addresses issues related to children in horticulture, planning nature and gardening related activities with children, as well as a general background in gardening for nonmajors. During the lab, the students gain hands-on experience working with children who participate in Sprouting Wings, an after school gardening program offered by the South Carolina Botanical Garden. A multi-source evaluation of the effectiveness of the course and the youth program is being conducted. The poster will present the course syllabus, copies of selected course readings, outlines of student generated projects, and the results of the program evaluation.

518 (PS 2)

Gender Needs and Appropriate Horticulture-related Postharvest Technology Options for Rural Southwestern Nigeria

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A pilot sustainable rural initiative project was introduced to build capacity among trade associations consisting of women engaged in fruit agribusiness. The purpose was to improve production and encourage local processing of horticultural commodities of economic importance like citrus, pineapple and mango fruits. Training the trainer approach was used to extend simple techniques of food preservation including partial processing and juice bottling to potential entrepreneurs. Skills were transferred primarily to selected extension specialists

who coordinate grassroots training. The training and visit technique was utilized to measure adoption rate among the rural people. Impact of the scheme on postharvest food loss reduction is discussed in this presentation; there is ample opportunity to optimize resource utilization and increase income generation through applied horticultural technology.

104 POSTER SESSION (Abstr. 519–527) Culture and Management–Floriculture I

519 (PS 1)

Developmental Stages of Single-stem Cut Rose Production

Robert G. Anderson and Wenwei Jia*, Dept. of Horticulture and Landscape Architecture, Univ. of Kentucky, Lexington KY 40546-0091

Commercial quality cut-roses were produced in a single-stem production system from single node cuttings. A significant advantage to single-stem rose production is that specific environments can be used for specific developmental stages of rose growth. In stage 1 (propagation), cuttings were treated with a 5-second dip in 500 ppm IBA/250 ppm NAA solution, placed in growing media in 8-cm pots, and placed under intermittent mist (5 second every 5 minutes) with growing medium temperature of 35°C. In stage 2 (axillary budbreak and stem development to visible pea size flower bud), rooted cuttings moved to benches (200 stems/m^2) in a greenhouse at 14 to 16°C night, and plants received 12 hours supplemental light at 80 to 100 $mol \cdot m^{-2}s^{-1}$. In stage 3 (stem elongation and flower bud development), small rose plants (30 to 35 cm tall with a pea-size flower bud) were moved to 100 stems/m^2 in a greenhouse at 14 to 16°C night with ambient light. Through seven sequential crops of rose cuttings grown from Feb. through May 1995, rooting required a mean of 16 days, flower buds were visible in 42 days, and flower harvest required a mean of 58 days. Accumulated radiation and average temperatures through the spring had significant effects on the number of days in each developmental stage of rose growth.

520 (PS 1)

Effect of Cutting Characteristics on Cut-stem Quality of Single-stem Roses

*Robert G. Anderson** and *Wenwei Jia,* Dept. of Horticulture and Landscape Architecture, Univ. of Kentucky, Lexington KY 40546-0091

Commercial quality cut-roses were produced in a single-stem production system from single-node cuttings. Single-node cuttings from cut stems of 'Lady Diana' rose were characterized by the location of the node of origin in numerical sequence from the flower and initial stem size, large (thick stems, long length, many nodes), moderate (moderate thickness, moderate length, and node number), and small (generally not commercial quality). Cuttings were treated with a 5-second dip in 500 ppm IBA/250 ppm NAA solution, placed in growing media in 8-cm pots and placed under intermittent mist (5 second every 5 minutes) with growing medium temperature of 35°C. Seven sequential crops of rose cuttings were grown from Feb. through May 1995. The initial node of origin was significantly correlated to the final stem length of the single-stem rose and to the number of days for axillary budbreak on the cutting. The number of days to rooting was not effected by the initial node of origin of the cutting. The correlation with initial stem size had variable results.

521 (PS 1)

A Knowledge-based System for Control of the Environment for Single-stem Roses

Kuanglin Chao[1], *Richard S. Gates*[1], and *Robert G. Anderson**[2], [1]Dept. of Biosystems and Agricultural Engineering; [2]Dept. of Horticulture and Landscape Architecture, Univ. of Kentucky, Lexington KY 40546-0091

Knowledge engineering offers substantial opportunities for integrating and managing conflicting demands in greenhouse crop production. A fuzzy inference system was developed to balance conflicting requirements of producing a high-quality, single-stem rose crop while simultaneously controlling production costs of heating and ventilation. An adaptive neuro-fuzzy inference system was built to predict the rose status of 'Lady Diana' single-stem roses from nondestructive measurements. The fuzzy inference system was capable of making a critical decision based on the principle of economic optimization. Temperature set points for two greenhouses with similar rose status were treated significantly different by the fuzzy inference system due to differences in greenhouse energy consumption. Moderate reduction in heating energy costs could be realized with the fuzzy inference system.

522 (PS 1)

Calibration Coefficients Added to ROSESIM Improve Predictions of Growth in Greenhouse Conditions

*Douglas A. Hopper** and *Kevin T. Cifelli,* Dept. of Horticulture and Landscape Architecture, Colorado State Univ., Fort Collins, CO 80523

Growth predictions derived from data collected in controlled-environment chambers would be expected to differ from growth responses observed in variable greenhouse conditions. ROSESIM was developed as a dynamic plant growth model based on 'Royalty' rose (*Rosa hybrida* L.) response to 15 unique treatment combinations of photosynthetic photon flux (PPF), day temperature (DT), and night temperature (NT) under constant growth chamber conditions. Regression coefficients for growth equations are read from an external ASCII file, thus permitting coefficients up to a full quadratic model form. Calibration coefficients (CC) were added to ROSESIM to enable predictions to be altered proportionally to permit improved prediction of specific growth characteristics. Numerator and denominator values for CC are adjustable for the first 10 days (initial) growth equations, subsequent growth until anthesis equations, and for the prediction of anthesis. Validation studies were used to set CC values; this enables the model based on growth in controlled environment chambers to be systematically calibrated on site to fit actual growth measured at a specific greenhouse location.

523 (PS 1)

Silicate Sprays as Effective as Calcium Sprays at Suppressing Bract Necrosis in Poinsettia

Richard McAvoy and *Bernard Bible*,* Dept. of Plant Science, Univ. of Connecticut, Storrs, CT 06269-4067

Bract necrosis (BN) first appears at anthesis, and symptoms become more numerous and severe with time. Previously, we reported that 3.6 mM sodium silicate (Na_2SiO_3) sprays, applied during bract development, were as effective as 10 mM $CaCl_2$ sprays at suppressing BN on 'Supjibi' and 'Angelika White', but only for several weeks after initial anthesis. While applying Na_2SiO_3 during bract development dramatically suppressed BN (7.2% of bracts with BN 46 days after anthesis vs. 33.4% for untreated plants), applying Na_2SiO_3 after anthesis is ineffective (35.7% BN). In 1995, suppression of BN was evaluated on 'Supjibi' plants sprayed with similar concentrations (2 or 4 mM) of Na_2SiO_3 and $CaCl_2$; treatments were compared to unsprayed poinsettias, or plants sprayed with either deionized (DI) water, 4 mM $SrCl_2$, 4 mM NaCl, 4 mM $MgCl_2$, or a solution of Na_2SiO_3 plus $CaCl_2$ (1 or 2 mM each). At harvest (38 days after initial anthesis), 40.6% of the bracts on unsprayed plants and 35.8% of the bracts on DI water sprayed plants had BN. In contrasts, only 5.3% of the bracts on the 4 mM $CaCl_2$ treated plants and 5.9% of the bracts on 4 mM Na_2SiO_3 treated plants had BN. Plants sprayed with 4 mM $SrCl_2$ or the combination of 2 mM Na_2SiO_3 plus 2 mM $CaCl_2$ developed BN on 7.8% and 9.2% of bracts, respectively. NaCl and $MgCl_2$ sprays (4 mM) were not as effective (29.6 and 26.4% BN) as Ca, Si, or Sr sprays at suppressing BN over the duration of this study.

524 (PS 1)

Greenhouse Evaluation of Poinsettia Cultivars for Colorado

*C. Elizabeth Succop** and *Steven E. Newman,* Dept. of Horticulture and Landscape Architecture, Colorado State Univ., Fort Collins, CO 80523-1173

During 1995, 33 poinsettia cultivars were evaluated for Colorado greenhouse production conditions. Plants were supplied by the Paul Ecke Poinsettia Ranch, Fischer Geraniums USA, Oglevee, and Mikkelsens. At the end of the production period, Colorado greenhouse growers were invited to an open house and asked to judge the cultivars for plant, bract, and cyathia quality. As rated by the 24 growers, the best red cultivars in overall performance were 'Freedom Red', 'Nutcracker Red', 'Cortez', and 'Bonita', respectively. The best pink cultivars in overall performance were 'Nutcracker Pink', 'Maren', and 'Flirt', respectively. The best white cultivars in overall performance were 'Nutcracker White' and 'V-17 Angelika White', respectively. The best novelty cultivars in overall performance were 'Puebla' and 'Monet', respectively.

525 (PS 1)

Effect of Water Quality on Growth and Fertilization of Bedding Plants

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Irrigation water quality is an important factor in ornamental plant production; however, there is little information in this area. Saline (NaCl) and alkaline ($NaHCO_3$) water have been shown to cause general chlorosis, tip burn, and defoliation of plants. The growing medium used in crop production may be an important factor when irrigating with saline and alkaline water. Our objectives were to determine the effects of increasing concentrations of NaCl : $CaCl_2$ and $NaHCO_3$ in irrigation water on growth and development of spring and fall bedding plants grown in peat, peat/pine bark, and pine bark media. Plant dry weight, height, and width were significantly lower at 300 and 400 ppm NaCl : $CaCl_2$ and $NaHCO_3$ levels. Early visible symptoms were necrosis of leaf tips, some leaf discoloration and finally plant death in the NaCl : $CaCl_2$ experiment. The leaves of plants in the $NaHCO_3$ experiment became water soaked and chlorotic, and some leaf abscission occurred. The best plant growth in the $NaHCO_3$ experiment occurred in peat and the best plant growth in the NaCl : $CaCl_2$ experiment occurred in pine bark. Decreased uptake of K^+, Ca^{++}, and Mg^{++} occurred when high levels of sodium were present.

526 (PS 1)

Geographical Profiles of Alkalinity Levels in Greenhouse Irrigation Waters

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Alkalinity of irrigation water affects pH of the plant growing media. High alkalinity water raises media pH and affects nutrient availability to plants and, thus, plant growth. Alkalinity levels in irrigation water vary in different regions. Knowledge of alkalinity levels would help growers and advisors in modifying cultural practices to suit the levels. To find out how the levels vary in different states, we searched our database of thousands of water analyses from across the country. Overall, 38% of the waters had <100 ppm $CaCO_3$, a level not considered to be a concern for even small pots. About 74% of the waters had <200 ppm $CaCO_3$, a level considered to be safe for large pots. The majority of the waters in the states along the eastern seaboard had <150 ppm $CaCO_3$. In waters in the interior states, alkalinity levels varied. Pacific Northwest had most waters <150 ppm $CaCO_3$. Detailed results—bar charts showing percent of waters at different alkalinity levels in each state and in the country will be shown.

527 (PS 1)

Biofiltration of Metalaxyl Residue in Recirculating Irrigation Water Using Constructed Wetlands

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Recirculating irrigation systems (RISs) conserve water and decrease fertilizer application, providing cost-effective alternatives to other watering methods in greenhouses. However, RISs can potentially become contaminated from spray or drench pesticide applications. In this study, we determined the amount of metalaxyl residues (the active ingredient in Subdue) in RISs over 3 and 6 weeks using HPLC analysis. Also examined was the potential use of constructed wetlands for the remediation of RIS water contaminated with metalaxyl. Metalaxyl was found to persist in a RIS over 6 weeks with no decrease in concentration. After repeated metalaxyl treatments over an 11 month period, a possible breakdown product or chemical modification of metalaxyl was present in the RISs. Drench applications, 150 ml of an 18.8 ppm metalaxyl solution, (recommended dosage) resulted in 0.5 to 3.0 ppm contamination levels in the RISs. Small scale (≈70 L void volume), indoor, constructed wetlands (two planted with Scirpus and Iris, two unvegetated) were treated with 420 mg metalaxyl. Limited breakdown of metalaxyl occurred in the constructed wetlands during the first 30 days after treatment. After 3 months, metalaxyl concentrations in all wetlands had decreased or were below detection levels. This indicates a possible selection of microbial populations capable of metabolizing or degrading metalaxyl.

143 POSTER SESSION (Abstr. 528–534) Culture and Management–Floriculture II

528 (PS 5)

Efficacy of Ancymidol, Paclobutrazol, and Uniconazole on Growth of Tuberous-rooted Dahlias

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Plant growth retardant (PGR) media drench treatments (in mg a.i./pot) of ancymidol at 0.5, 1.0, 2.0, 4.0, or 8.0; paclobutrazol at 1.0, 2.0, 4.0, 8.0, or 16.0; uniconazole at 0.5, 1.0, 2.0, 4.0, or 8.0 were applied to tuberous-rooted dahlias to compare their effectiveness as a chemical height control. All paclobutrazol, ancymidol, and uniconazole rates applied significantly reduced 'Red Pigmy' plant height by 21% or greater compared to the nontreated control. Excessively short plants resulted from uniconazole and ancymidol drench rates ≥1.0 mg. 'Red Pigmy', a less vigorous cultivar, were acceptable as potted-plants with paclobutrazol rates of 2.0 to 4.0 mg, 0.25 to 0.5 mg of uniconazole, or 0.5 mg of ancymidol. All paclobutrazol, ancymidol, and uniconazole rates significantly reduced 'Golden Emblem' plant height by ≥11% when compared to the nontreated plants. Excessively short plants resulted from paclobutrazol drench rates of 16.0 mg, uniconazole rates of 2.0 mg and for ancymidol drenches ≥4.0 mg. 'Golden Emblem', the more vigorous cultivar, were acceptable as potted-plants with paclobutrazol rates of 4.0 to 8.0 mg, 0.5 to 1.0 mg of uniconazole, or 2.0 mg of ancymidol.

529 (PS 5)

Painted Containers: A New Method for Paclobutrazol Application

*Claudio C. Pasian** and *Daniel K. Struve,* Dept. of Horticulture and Crop Science, The Ohio State Univ., Columbus, OH 43210

The effectiveness of two application methods of the growth regulator paclobutrazol on the growth of Chrysanthemum plants, *Dendranthema ×grandiflora* (Ramat) (cv. 'Fina' and 'Cream Dana') were compared. Plants were grown in containers with their interior covered by a mixture of flat latex paint and several concentrations of paclobutrazol (0, 5, 10, 20, 40, 80, 100, 150, 160, and 200 $mg \cdot L^{-1}$) or were treated with a soil drench of the growth regulator according to label recommendations (59 ml/container of paclobutrazol solution at 4 $mg \cdot L^{-1}$). Plants grown in containers with the paint–paclobutrazol mix at concentrations >80 $mg \cdot L^{-1}$ were shorter than plants given the control and paint only treatments but taller than plants given the drench treatment. Increasing paclobutrazol concentrations in paint from 100 to 150 and 200 $mg \cdot L^{-1}$ did not produce proportionately shorter plants. Paint alone had no effect on growth and development. Plants subject to growth regulator treatments appeared greener than the control plants. None of the plants given treatments with paint with or without paclobutrazol showed any sign of phytotoxicity. These results suggest the possibility of a new application method for systemic chemicals with the potential of reducing or eliminating worker protection standard restricted entry intervals and reducing the release of chemicals to the environment. Chemical name used: beta-[(4-chlorophenyl)methyl]-α-(1,1-dimethyl)-1H-1,2,4,-triazole-1-ethanol (paclobutrazol).

530 (PS 5)

Painted Containers: A New Method for Imidacloprid Application

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The effectiveness of two methods of application of the insecticide imidacloprid in controlling 1) aphids (*Brachycaudus helichrysi*) on Chrysanthemum plants, *Dendranthema ×grandiflora* (Ramat) (cv. Nob Hill) and 2) whitefly (*Bemisia argentifolii*) on poinsettia, *Euphorbia pulcherrima* (Wild.) (cv. Freedom Red) were compared. Plants were grown in containers with their interior covered by a mixture of flat latex paint and several concentrations of imidacloprid (0, 10, 21, 42, and 88 $mg \cdot L^{-1}$), or treated with a granular application of the insecticide (1% a.i.) according to label recommendations. All imidacloprid treatments were effective in reducing aphid survival after 8 weeks. The two most effective treatments were: granular (1% a.i.) and 88 $mg \cdot L^{-1}$ with an average of 0.2 aphid per plant as opposed to 50.4 aphids per plant for the control. The 42-$mg \cdot L^{-1}$ treatment had an aphid survival rate 1.6 aphids per plant. All imidacloprid treatments were effective in reducing white fly larvae. The 42 and 88 $mg \cdot L^{-1}$ and the granular (1% a.i.)

were equally effective in reducing larvae numbers in lower poinsettia leaves: 0.5, 1.9, 0.9 larvae/2.5 cm leaf disk, respectively, while the control treatment had 62.9. None of the plants given treatments with paint showed any sign of phytotoxicity. These results suggest the possibility of a new application method for systemic chemicals with the potential of reducing or eliminating Worker Protection Standard (WPS) Restricted Entry Intervals (REI) and reducing the release of chemicals to the environment. Chemical name used: 1-[(6-Chloro-3-pyrimidil)]-N-nitro-2-imidazolidinimine.

531 (PS 5)

Using Temperature, Light, and Fungicides to Prolong the Storage Life of Rooted Geranium Cuttings

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Methods of cold storage for rooted cuttings of three cultivars of *Pelargonium* ×*hortorum* Bailey were examined. Cuttings were stored from 0 to 10°C for 7 to 56 days. Treatments included packing the cuttings in ice, storing them under irradiance levels of 0 or 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$, applying fungicides, varying cutting developmental stages, and varying the day temperatures. Cuttings packed in ice showed signs of chilling injury within 7 days and died. Applications of etridiazole and thiophanate-methyl or metalaxyl and thiophanate-methyl drenches or fosetyl-Al spray did not improve storage performance of the cuttings. Roots of cuttings held 7 additional days in the propagation area before storage grew faster after storage than those of cuttings with less time in the propagation area, but flowering time was not affected. Maintaining night temperatures at 5°C while allowing day temperatures to rise to 10°C delayed flowering by 6 days compared to maintaining a constant 5°C. Rooted cuttings held at 5°C under 50 $\mu mol \cdot m^{-2} \cdot s^{-1}$ irradiance for 9 hours each day could be stored up to 56 days with only a 2-day delay in flowering compared to unstored cuttings. Chemicals used were 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (etridiazole); thiophanate-methyl (dimethyl[1,2-phenylene)bis(iminocarbonothioyl)]bis[carbamate]) (thiophanate-methyl); *N*-(2,6-dimethylphenyl)-*N*-methoxyacetyl) alanine methyl ester (metalaxyl); aluminum tris (O-ethyl phosphonate) (fosetyl-Al).

532 (PS 5)

Single Basal Fertilization of MEISTER (Polyolefin-coated Urea) to Cyclamen

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A capillary watering system can easily control water supply to cyclamen and can save nutrient losses by leaching. Introduction of single basal placement using MEISTER will be useful to innovate the traditional cyclamen culture. The conventional cyclamen culture using Nutricote needs double transplanting and double fertilization. In the new cyclamen culture, cyclamen seedlings (sowed on the plug tray in early January) were transplanted to 15-cm pots fertilized with MEISTER in early June. The selected MEISTER was one belonging to the sigmoid dissolution group, which showed delayed release during summer and the maximum release in early September. The new fertilization supplied N to the plants until the end of growing season. The growth of cyclamen plants on two experimental plots were compared at the flowering stage. Numbers and weight of flowers per pot and bulb weight were greater in the new culture than in the conventional culture though the total volume of leaves was less in the former. Regarding the nutrient absorption, the plants of the new culture showed lower concentrations of N and P in the leaves but higher concentrations of Ca and Mg compared to those in the conventional culture. Such nutrient uptake could contribute to preventing the occurrence of tipburn in the new culture.

533 (PS 5)

Introduction and Cultivation of Money Plant (*Lunana annus*) in Shandong, The People's Republic of China

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Money plant may be a valuable plant to cultivate as an ornamental plant in China. Money plants are grown for the translucent, silvery, rotund, pseudo-septa that stay on flower stalks and are all that remain of ripened seed pods after the two outer coverings drop with the seeds. Money plant was first introduced from Canada into China in 1993. Seed germination and seedling development were successful. There were 18 to 34 leaves per plant and average plant height was 30 cm by the end of Nov. 1993. Plants exposed to environmental conditions (ENV) became dormant at low temperature. Plants grown under greenhouse conditions (GH) continued to grow until May. ENV plants escaped dormancy between April and May, grew normally, blossomed, and bore pods with seeds. GH plants blossomed; however, most of the blossoms dropped off and seed pods failed to develop. Flower stalks with many lateral inflorescences grew from ENV plant shoot apexes. In some cases, secondary and tertiary branches developed into the secondary and tertiary lateral inflorescences. There were ≈30 flowers per inflorescence and 30% of flowers were developed successfully into pods that usually contained five to six seeds with a maximum of nine seeds per pod. These results indicate that money plant may be successfully cultivated in Shandong, China.

534 (PS 5)

Evaluation of New Guinea Impatiens in Sun and Shade

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New Guinea Impatiens have become a major spring crop for many commercial greenhouses. Along with increased sales has come a proliferation of new varieties from which commercial growers must choose. To help provide growers with information to make these selections the ornamental horticulture extension program at Penn State has tested landscape performance of New Guinea Impatiens in the sun and the shade each year since 1994. Cuttings are obtained from commercial producers and six plants of each variety are planted in landscape beds in the full sun and six plants are planted in landscape beds under a shade structure. Plants are evaluated on flowering, foliage and overall appearance every 2 weeks throughout the summer. Commercial growers can evaluate varieties on their own during the trial field day and results are made available in an annual report and are posted on the internet. A survey of participants in the 1995 field day indicated that 98% of those responding used the printed report to make or change their variety selections. Supplementing the printed report with the internet for distribution of results allows broad dissemination of detailed information including photographs and graphics that could not be easily distributed in hard copy form. In the future trial results posted on the internet could be used to supplement point of sale materials, providing growers and retailers with a powerful new marketing tool.

145 POSTER SESSION (Abstr. 535–546) Substrates for Container Production–Floriculture/Woody Ornamentals

535 (PS 7)

Source and Processing Affects Chemical and Physical Properties of Coir Dust

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Chemical properties of unprocessed coconut husks varied significantly between 11 sources tested. The pH was significantly different between sources and ranged from 5.9 to 6.9. The electrical conductivities were significantly different between sources and ranged from 1.2 to 2.8 $mS \cdot cm^{-1}$. The levels of Na, K, P, and Cl were significantly different between sources and ranged from 23 to 88, 126 to 236, 8 to 33, and 304 to 704 ppm, respectively. The B, Cu, Fe, Ni, S, Zn, Mn, and Mo levels were all significantly different between sources and ranged from nondetectable levels to 12.7 ppm. The NH_4-N, NO_3-N, Ca, and Mg levels were not significantly different between sources and ranged from 0.2 to 1.8, 0.2 to 0.9, 2.9 to 7.3, and nondetectable to 4.6 ppm, respectively. Coir dust produced by screening of waste grade coir through 13-, 6-, or 3-mm screens had significantly different bulk densities, air-filled pore space, water filled pore space and water-holding capacities compared to nonscreened waste grade coir. However, total pore space and total solids were not significantly affected by screening. Screen size did not significantly affect physical properties. Compression pressures used for formation of coir dust blocks significantly affected physical properties. Additionally, coir dust age significantly affected chemical properties.

536 (PS 7)

Growth and Development of *Euphorbia pulcherrima* 'Freedom' and *Lilium longiflorum* 'Nellie White' in Sphagnum Peat- and Coir Dust-based Substrates

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Euphorbia pulcherrima 'Freedom' (poinsettia) were grown in coir dust, sphagnum peat, and perlite at the following ratios (respectively) 20:0:80, 40:0:60, 60:0:40, 80:0:20, 0:20:80, 0:40:60, 0:60:40, and 0:80:20 (v/v) substrates. Days to anthesis were not significantly different between substrates. Heights were greater for plants produced in 80% coir compared to plants grown in 80% peat. Overall, plants grown in coir-based substrates were taller than plants grown in peat-based substrates. Plants grown in 60% coir had a greater number of lateral shoots, increased shoot fresh weight and increased bract area compared to plants grown in 60% peat. Overall, plants grown in coir-based substrates had greater shoot fresh weights compared to plants grown in peat-based substrates. *Lilium longiflorum* 'Nellie White' (lily) plants were grown in 40:0:20:40, 0:40:20:40, 0:57:14:28, 0:73:9:18 (v/v sphagnum peat: coir dust: loam: perlite) substrates. As the proportion of coir in the substrate increased, height, and shoot and root fresh weights increased. Nodes to flower, days to flower, and number of flowers were not significantly affected by substrate.

537 (PS 7)

Comparison of the Physical Characteristics of Growing Media Containing Composted Oak Sawdust and Sphagnum Peat

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The physical characteristics of a container growing medium containing 2 oak sawdust composted with poultry manure : 1 vermiculite : 1 perlite were compared with those of a similar medium containing sphagnum peat rather than compost. Both media were amended with inorganic nutrients based on laboratory analysis to make them nutritionally comparable and with AquaGro wetting agent at 800 $g \cdot m^{-3}$. Moisture release characteristics of the media were evaluated using tension cups in which desorption at 5, 10, 20, 40, 80, 100, and 160 cm of water was measured. While bulk density of the peat mix (0.129 $g \cdot cm^{-3)}$ was, significantly lower than that of the compost mix (0.157 $g \cdot cm^{-3}$), total porosity of the peat mix (84%) was significantly greater than that of the compost mix (79%). Air-filled and water-filled porosities of the peat and compost mixes were 18.2% 16.2% and 75.2% 70.5% of container volume, respectively. While the peat mix held more water at tensions between 5 and 20 cm, there was no significant difference between the volumetric water contents of the two media between 20 and 160 cm. Fresh and dry weights of corn plants grown for 3 weeks in compost- and peat-based media were not significantly different.

538 (PS 7)

Effect of Different Substrate on Growth of African Violet (*Saintpauila ionantha*) Grown in Greenhouse Conditions

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Our purpose was to evaluate the vegetative growth and flowering of African violet (*Saintpauila ionantha*) grown in seven soils subtrates under greenhouse conditions. The following were tested: river lime, pine ushers, black clay, oak soil, peatmoss, Canadian peatmoss, and a compost soil. Pots were in a fully randomized experimental design with seven treatments, and four replications was used. A monthly 10N–20P–10K fertilization was applied to potted plants. The study lasted for 135 days, taking data every 15 days on leaf perimeter, length and elasticity of the petiole, plant height, and leaf color. Best vegetative growth was observed with oak and canadian peat moss due to their high capacity to hold water and their very good aeration. Least vegetative growth was observed with black clay, where plants failed to flower. Other substrates did not show differences in plant growth.

539 (PS 7)

Compost Usage for Growing Impatiens 'Accent Red'

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Three compost products [biosolids (SYT), refuse derived fuel residues (RYT), and municipal solid waste (MSW)] were compared to a commercial bedding plant medium of 60% Sphagnum peat : 25% shredded bark : 15% aerolite to support *Impatiens wallerana* 'Accent Red' growth. The treatments consisted of 100% compost as a stand alone medium plus blends in which compost was combined with control medium components at 60% compost or 30% compost. Shoot dry mass of plants grown in 100% SYT and RYT was greater than shoot dry mass of *Impatiens* plants grown in 100% MSW. Plants grown in SYT showed an increase in shoot dry mass from 1.29 to 1.64 g as the percentage of compost in the mix increased from 0% to 100%, while plants grown in MSW showed a linear decrease in. shoot dry mass from 1.29 to 0.18 g. Shoot dry mass of plants grown in RYT did not differ significantly from 0% to 100% compost in the media.

540 (PS 7)

Growth of *Euphorbia pulcherrima* and *Pelargonium* ×*hortorum* in Shredded Rubber-containing Substrates

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Euphorbia pulcherrima 'Freedom' (poinsettia) and *Pelargonium* ×*hortorum* 'Pink Elite' (geranium) were grown in 75:25:0, 50:50:0, 27:75:0, 75:0:25 50:0:50, 25:0:75 (v/v sphagnum peat : 0.25-grade rubber : 0.10-grade rubber) substrates or in a 50 sphagnum peat : 30 perlite : 20 loam (v/v) standard greenhouse substrate. Geranium root and shoot fresh weights, height, and number of axillary shoots were reduced when grown in rubber-containing substrates compared to plants grown in the standard control. As the proportion of either grade of rubber increased, root and shoot fresh weights, height, and number of axillary shoots decreased. Flowering in geranium was delayed and the number of inflorescences reduced as the proportion of the 0.10-grade rubber increased. Plants grown in the 0.25-grade rubber failed to flower by the termination of the experiment. Poinsettia plants grown in rubber-containing substrates had reduced shoot fresh weight, height, number of bracts, and bract area compared to plants grown in the standard control. As the proportion of either grade of rubber increased, height, shoot fresh weight, number of bracts, and bract area decreased. Number of axillary branches was reduced in substrates containing 50% and 75% of the 0.10-grade rubber. Days to anthesis was unaffected by substrate.

541 (PS 7)

Growth and Nutrition of Geraniums Grown in Media Developed from Components of Waste Tires

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Our objective was to determine the feasibility of using waste tire rubber and fiber from the processing of waste tires as a root-zone medium for greenhouse crops. Two cultivars of zonal geraniums, 'Danielle' and 'Kim' were grown in media containing three grind sizes of rubber (10, 6, and 2.4 mm) and fiber from the fabric belting processed from waste tires in three proportions (1 rubber : 1 peat moss, 1 rubber : 1 vermiculite : 2 peat moss, and 2 rubber : 1 vermiculite : 1 peat moss, by volume). Two control media were also included: 1 vermiculite : 1 peat moss and 1 rock wool : 1 peat moss, by volume. The largest plants were grown in the 1 vermiculite : 1 peat moss medium, whereas the smallest plants were grown in the media containing the rubber grinds 2.4 mm and 6 mm making up 50% of the media. The media 1 rubber : 1 vermiculite : 2 peatmoss, regardless of grind or fiber, produced plants equal to the 1 rock wool : 1 peatmoss medium. All plants grown in media containing rubber by products had elevated levels of Zn and Cu in the foliage, but was greatest in media containing 50% rubber. Foliar P : Zn ratio was less for plants grown in media where rubber was 50% of the volume. The P : Zn ratio also was lower in plants grown in media with smaller grind sizes of rubber. Geranium plants can be successfully grown in media containing up to 25% rubber waste products without reducing plant quality.

542 (PS 7)

Shredded Waste Tires as a Growing Media Amendment for Production of Flowering Vinca

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Catharanthus roseus plants were grown in three media, each containing one of two by-products of shredded waste tires. The media were no. 1) 1 rubber* : 1 peat moss, no. 2) 1 rubber* : 1 vermiculite : 2 peat moss, and no. 3) 2 rubber* : 1 vermiculite : 1 peat moss (by volume) where rubber* indicates either 0.6 cm shredded rubber or a fibrous by-product. Control plants were grown in 1 peatmoss : 1

rockwool and 1 vermiculite : 1 peatmoss (by volume). *Catharanthus roseus* cv. Peppermint Cooler plants were grown for 7 weeks in 10-cm containers at a commercial Denver-area greenhouse. Data taken included plant heights, plant widths, flowers per stem, and dry weights. Visually, plants grown in the no. 2 mix, with either fiber or 0.6-cm rubber, were similar to the controls and superior to the other two mixes. Ending plant heights were similar among the two controls and no. 2 with fiber and were taller than all other combinations. Flower numbers were greater in the 1 rockwool : 1 peat moss control and no. 2 mix with fiber than any other treatment. The same was true for stem number and dry weight. Results indicate that the no. 2 mix of 1 fiber : 1 vermiculite : 2 peatmoss has potential for container crop production.

543 (PS 7)

Inflorescence Color Manipulation in Hydrangea Forced in Media Containing Coal Bottom Ash and Mine Soil

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Dormant budded plants of *Hydrangea macrophylla* (Thunb.) cvs. Blaumeise Blue and Pink were planted on 29 Jan. 1996 in 15-cm azaleas pots containing media with topsoil, peat, perlite, coal bottom ash, and mine soil, mixed in varying proportions. Media pH levels were initially adjusted with dolomitic limestone to a range of 6.0 to 6.1 for pink inflorescences and with ammonium sulfate to a range of 4.4 to 5.9 for blue inflorescences. Plants of Blaumeise Blue and Blaumeise Pink in low pH media were drenched on 29 Feb. with a solution of aluminum sulfate at 6 g·L^{-1}. Number of shoots per plant were reduced in media with the highest proportion of coal bottom ash (40%, v/v) plus 30% mine soil. Plant diameter was affected very little by type of media. Tallest plants were 'Blaumeise Pink' growing in media containing at least 20% top soil or mine soil plus 20% coal bottom ash. These mixes also contained 20% or 40% perlite. Inflorescence diameters ranged from 10.88 to 17.43 cm. and were mostly unaffected by media type. Inflorescence number per plant appeared to be reduced in 'Blaumeise Blue' regardless of media. Inflorescence color brightness ranged from L = 55.26 to 61.38 and was affected very little by media type in both cultivars. Bluest inflorescences occurred on 'Blaumeise Blue' plants growing in a combination of zero top soil, 40% peat, 30% perlite, 20% coal bottom ash, and 10% mine soil with no lime, and'Blaumeise Pink' plants growing in media with zero topsoil, 40% peat, and 20% mine soil. Blue color did not develop well in media containing top soil and no mine soil. This study demonstrated that florists' hydrangea can be satisfactorily forced in media containing substantial amounts of coal bottom ash and mine soil and that color regulation is also possible in some of these media.

544 (PS 7)

Effect of Media Containing Processed Fiber, Micronutrient Application, and Mixing Ratio of Processed Fiber with Perlite on Plant Appearance and Growth of Pansy Plants

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Effect of media containing processed fiber (methane digested cow manure) as a substitute for peatmoss, micronutrient application, and medium mixing ratios of processed fiber with perlite were investigated in pansy cv. Maxima mix plants (*Viola*×*wittrockiana*). Neither medium components nor micronutrients significantly influenced plant growth and appearance when plants were potted in medium containing either 60% processed fiber and 40% perlite, 100% processed fiber, or 60% peatmoss and 40% perlite and supplemented with either N–P–K or N–P–K with micronutrients. The plant size and biomass production of leaves increased with increasing proportion of perlite in the mixtures containing processed fiber while the number and biomass of flowers were not affected. Water content of leaves or flowers was not influenced by mixes of processed fiber and perlite. The processed fiber, either alone or mixed with other media components, was satisfactory for the production of pansy plants with or without micronutrient application.

545 (PS 7)

Effect of Media Containing Processed Fiber, Fertilization, and Fumigation on Appearance and Growth in Containerized Woody Perennial Plants

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Applicability of processed fiber (methane digested cow manure) as a substitute for peatmoss for production of various containerized perennial woody plant species with various fertilization and fumigation practices was investigated in this study. Liner plants of five species and rooted cuttings of 41 species were potted in various media containing processed fiber as the replacement of peatmoss with or without fertilization and fumigation, with commercial mix as control. Plants varied in their responses to the media, fertilization, and/or fumigation. Most plant species performed well in the media containing processed fiber. The physical and chemical properties of processed fiber, either alone or mixed with other media components, were satisfactory for producing woody perennial species even with less fertilization and no fumigation.

546 (PS 7)

Comparing Potting Media Available to Consumers through Garden Centers and National Chain Stores

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A study was initiated to determine how well plants would grow in potting media available to consumers through garden centers and national chain stores. Nine media were evaluated. The chemical and physical characteristics were determined, and six geraniums (*Pelargonium* sp) and six marigolds (*Tagetes patula*) were grown in each of the media. Three of each six were fertilized, three were not. The plants that were fertilized received 100 ppm N and K and 50 ppm P once a week. Three months after seeding the flowers, flowers and buds on the marigolds were counted and the plants were harvested. Dry weights were determined. Nitrate-N ranged from 6 to 627 ppm, pH from 4.9 to 7.1, phosphorus from 88 to 502 pounds/A, potassium from 1.0 to 6.9 meq/100 g, magnesium from 1.4 to 10.8 meq/100 g, calcium from 5.2 to 30.0 meq/100 g, soluble salts from 20 to 151 mmhos, and CEC from 13.0 to 43.8 meq/100cc. Bulk density ranged from 21 to 53 g/100cc, water holding capacity from 32 to 53 ml/100cc, percent air-pore space from 2.7 to 15.7, and total porosity ranged from 65% to 78%. Unfertilized marigolds weighed between 0.1 and 9.6 g; fertilized marigolds weighed 1.4 to 17.2 g. Unfertilized geraniums weighed between 1.4 and 23.3 g; fertilized geraniums weighed 4.4 to 56 g. There were 1.3 to 16 flowers on unfertilized and 7 to 24.3 flowers on fertilized marigolds.

144 POSTER SESSION (Abstr. 547–556) Container Production–Woody Ornamentals/ Landscape

547 (PS 6)

Woody Ornamental Plant Response to Fertilization and Using of Organic Residues as a Partial Constituent of Substrate Mixtures

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Large spaces are required to eliminate waste by burying and this method is very costly. The horticulture use of waste seems to be one of the best optional methods of disposal. This study was performed to evaluate the effects of fresh bio-filters (FBF), composted sewage sludges (CSS), and composted de-inked sludges (CDS) on growth of three woody ornamental species (*Spiraea japonica* 'Little Princess', *Spiraea nipponica* 'Snowmound', and *Physocarpus opulifolius* 'Nanus') produced in containers. Three fertilization regimes (N at 200, 400, and 600 mg·L^{-1} in the form of soluble fertilizer 20–20–20) were applied weekly onto containers during 3.5 months. Plants were potted in 10 substrates. The control substrate contained 4 peatmoss : 5 composted conifer bark : 1 fine crushed gravel (by volume). In the other nine substrates, peatmoss was partially substituted by one of the three organic residues (10%, 20%, or 30% of FBF, CSS, or CDS). The experimental design was a split-split-plot with four replicates and two samples by treatment. Chemical analysis of the organic residues proved that the fertilization value of CSS was greater than the other residues and heavy metals are below the undesirable limits for the three residues. The amount of available major mineral elements in these residues is too low to satisfy the mineral nutrient needs of plants. In addition, there is a linear effect of the fertilization on plant growth. The CDS required a high dose of the fertilizer (600 mg·L^{-1}) which may be due to the immobilization of N. The 10% proportion of FBF and CDS, combined with the other materials, was the most adequate proportion and did not reduce the growth of plants (height, aerial, and root dry matter). However, CSS can be used with a high proportion (20%) especially for *Spiraea japonica* 'Little Princess'.

548 (PS 6)

Effect of Humic Acid on Growth of 'Muskogee' Crape Myrtle after Container Shielding Treatments

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Rooted cuttings of crepe myrtle (*Lagerstroemia indica* L. x L. *fauriei* 'Muskogee') were transplanted into 3.8-L black polyethylene containers filled with a bark-based rooting substrate and exposed for 2 months during Summer 1995 to either of three container shielding treatments: containers shielded from insolation (container shielded inside a whitewashed 11.4-L black polyethylene container), containers exposed to insolation, or containers shielded for 1 month then exposed for 1 month. Mean highest temperature in the western quadrant of rooting substrate of exposed containers was 16°C higher than for those in shielded containers. Containers exposed for 2 months had reduced root and shoot growth and increased leaf N compared with the other two treatments. Crape myrtle plants were next transplanted into 27.0-L polybags, transferred into a temperature-controlled glasshouse, and fertigated to container capacity every 3 days with humic acid extract at concentrations of 0, 50, 150, or 300 $\mu l \cdot L^{-1}$ for 2 additional months. Effects of the container shielding treatments for all growth parameters remained evident until the end of the experiment. Shoot and root extension growth of plants previously in containers shielded for 2 months and containers exposed for 2 months, responded in a quadratic fashion to humic acid extract concentration levels.

549 (PS 6)

Proper Selection of Root Medium and Fertilization Regime Increases Dry Mass of Amur Maackia

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Amur maackia (*Maackia amurensis* Rupr. & Maxim.) is a nodulating leguminous tree with potential for increased use in cities and in the dry, cold climates of the upper Midwest and Great Plains of North America. There has been little research on nutritional requirements and production methods of this species. We determined the effect of growth medium and form of applied N on seedling growth. Amur maackia attained 3.3-times more dry mass in a medium of 5 peat : 3 perlite : 2 soil (by volume) and in coarse 1 vermiculite : 1 coarse perlite (v/v) than in three soil-less mixes that contained large proportions of composted bark. When seedlings were grown in an aerated nutrient solution, dry mass after 5 weeks was similar regardless of whether NO_3^-, NH_4^+ or a combination of these was supplied. But, leaf N content was 1.3-times greater in plants grown in a solution that contained at least 50% NH_4^+ compared to plants provided with all NO_3^-. Plants grown in solution with 750 μM N had 1.8-times more dry mass than those grown in solution with 3.75 μM N. Seedlings grown for 70 days in 5 peat : 3 perlite : 2 soil (by volume) attained the greatest dry mass when fertilized with Excel all purpose fertilizer that contained N at 10.8 $mol \cdot m^{-3}$, or with a nutrient solution that contained N at a 1.5 μM, at least half of which was NH_4^+. For container-grown Amur maackia, we recommend using a soil-based medium and providing N as either all NH_4^+ or as a mixture of NH_4^+ and NO_3^-.

550 (PS 6)

An Irrigation Management Method to Reduce the Nitrogen Content of Effluent from Nursery Containers

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Container nurseries often irrigate daily with a fixed amount of water that exceeds the water-holding capacity of the container substrate, thus, leaching a portion of the applied water and nutrients. We compared the influence of daily container irrigation based on substrate moisture tension (SMT) to that of daily irrigation with a set amount on irrigation volume, container effluent volume, total effluent N content, and plant growth. *Rhododendron, Ilex,* and *Juniperus* were grown outdoors in 11.3-L containers in a pine bark-based substrate at four rates of fertilization with a controlled-release fertilizer. Drip irrigation was applied each morning until an electronic tensiometer signaled an irrigation controller that SMT was less than a set value corresponding to container capacity. Irrigation at 1.5 $cm \cdot d^{-1}$ served as the control. Irrigation treatment had little influence on growth and no influence on growth response to fertilizer rate. Irrigation volume, effluent volume, and total effluent N content were lower for each species when irrigation was based on SMT. For *Juniperus*, irrigation volume, effluent volume, and total effluent N content were 62%, 69%, and 60% less, respectively, for tension-based irrigation than for irrigation with a set amount.

551 (PS 6)

Number of Containers Affects Nitrate Nitrogen in Runoff

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Multiple branched liners of *Rhododendron* sp. cv. Duc de Rohan were potted in 3-L containers using a 5 pine bark : 5 Florida peat : 1 sand medium (by volume) amended with Prokote Plus (20N–1.3P–8.3K, 9.2 $kg \cdot m^{-3}$) and placed on one of five treatment platforms (1.2×2.4 m) in a commercial nursery in Manatee County, Fla. Treatments were 88 plants per square grid with containers touching (T1), 44 plants per square grid with containers touching (T2), 44 plants per square grid with containers touching in rows and 15 cm between rows (T3), 22 plants per square grid with containers touching (T4), and 22 plants per square grid with 15 cm between containers in rows and 15 cm between rows (T5). Irrigation was applied by overhead impact nozzles (0.13 cm/0.5 h) before collecting runoff. Runoff volume was measured and ppm nitrate N determined on day 6, 23, 38, 63, 92, 161, 189, 217, and 274. Average nitrate N ranged from 97 ppm for T1 to 10 ppm for T5 and corresponded to volumes of 19 and 20 L, respectively. Volumes were not different due to spacing or number of containers; however, nitrate N increased linearly with container number when containers were touching (T1, T2, and T4). Nitrate N in runoff was similar for the same number of containers regardless of spacing.

552 (PS 6)

Plastic Bed Surface Decreases Water Drainage from Container-grown Plants

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Growers report that plants on gravel bed surfaces require more frequent irrigation compared to plastic surfaces. The objective of Expt. 1 was to determine if bed surface type influenced container environment and plant growth of azalea and Japanese holly plants on plastic- or gravel-covered beds. Measurements included bed, substrate, and plant canopy temperatures; evapotranspiration (ET), stem water potential, and plant widths also were determined. The objective of Expt. 2 was to determine the amount of water retained following irrigation and drainage for four pre-irrigation substrate water contents (230%, 208%, 185%, 162%; mass basis) on gravel or plastic bed surfaces. Containers on plastic or gravel beds were irrigated, drained for 1 hour, and the amount of water retained in the container substrate was determined. In Expt. 1, plastic bed surface temperatures (0730 to 1930 HR) were higher than for gravel. Container substrate temperatures on plastic were 1°C higher than gravel from 2300 to 0400 HR with no temperature differences from 0500 to 2300 HR. There were no treatment differences for other characteristics. In Expt. 2, containers on plastic retained 21%, 15%, 23%, and 16% more water than on gravel for the 230%, 208%, 185%, 162% pre-irrigation water content treatments, respectively. When containers are seated on plastic, the bottom drainage hole is sealed resulting in more water retention compared to gravel.

553 (PS 6)

Controlling Circling Roots in Container-grown Ornamentals with Root-inhibiting Herbicides

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SpinOut is a commercial product containing copper hydroxide that is designed to prevent the development of circling roots in container grown ornamentals. Our objective was to determine the effect of two root-inhibiting herbicides (oryzalin and trifluralin) on the development of circling roots in container grown ornamentals when painted onto the inside surface of the containers or on stakes inserted around the walls of the containers. Rooted cuttings of wintercreeper euonymus (*Euonymus fortunei* Hand.-Mezz) were planted in a 1 peat : 1 perlite : 1 soil mix on 8 to 10 Feb. 1995. There were 16 containers for each of 20 treatments. Eight were rated for circling roots then harvested 17 to 22 May, and eight were rated and harvested 6 to 7 July 1995. Root circling was rated on a scale of 1 to 5, with 1 indicating no circling roots and 5 indicating many circling roots. Following harvest stem growth was measured and the dry weights of the roots, stems, and leaves were determined. Treated stakes did not prevent circling roots Trifluralin in Vapor Gard reduced the amount of circling roots, but not to acceptable levels. Trifluralin in latex paint was ineffective at 0.5%, slightly reduced the development of circling roots at 2%, and at 4% reduced circling rooting to the same extent as the SpinOut. Surflan at 0.5% in Vapor Gard reduced the development of

circling roots to the same extent as the SpinOut. All other rates of Surflan, in both carriers, almost totally eliminated circling roots. There were no significant differences in root weight or total plant weight among any of the treatments at either date of evaluation.

554 (PS 6)

Direct Potting of Ornamental Grasses using Two Division Sizes

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Nursery production of many ornamental grasses involves potting of established liners into 8.5-L containers. Direct potting of bare root divisions into 8.5-L containers may represent a more efficient production method. Large and small divisions (based on number of tillers and volume) of eight ornamental grasses were potted directly into 8.5-L containers. The potting medium used was a 3 aged pine bark : 2 peat moss : 1 sand nursery mix (by volume), amended with dolomitic lime at 3 kg/yard^3, and top dressed with Sierra 17-6-10 plus minors at 40 g/container, 8 to 9 month fertilizer. Plants were grown outdoors in a container nursery from May through September. All grasses tested performed well using the direct potting method, with 100% survival. Large divisions of *Miscanthus sinensis* cultivars produced plants with greater fresh weight, dry weight and number of tillers than did small divisions. Division size did not affect *Miscanthus* foliage or flower height but did affect number of flowers for 'Graziella' and 'Purpurascens'. Large divisions of *Calamagrostis* 'Karl Foerster', a grass grown primarily for flowering, produced twice as many flowers as small divisions. *Panicum virgatum* and *Pennisetum alopecuriodes* showed signs of nutrient stress when grown from large divisions. Although a greater number of tillers was produced by large divisions of *Panicum* and *Pennisetum*, fresh weight, dry weight, flower height, and foliage height were similar to or less than that observed on plants from small divisions.

555 (PS 6)

Controlled-release Fertilizer Rate Influences Plant Growth, Flowering, and Tillering of *Pennisetum alopecuroides*

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Information on fertility optimization for container-grown ornamental grasses is limited. For ornamental grasses, growers are concerned with the degree of flowering, number of tillers, and height and width of the plants as well as other growth or ornamental components. *Pennisetum alopecuroides* divisions potted into 8.5-L containers were grown outdoors in a container nursery from May through September. The potting medium used was a 3 aged pine bark : 2 peatmoss : 1 sand nursery mix (by volume), amended with dolomitic lime 3 kg/yard^3. Sierra 17-6-10 plus minors, 8 to 9 month controlled-release fertilizer (CRF) was top dressed at 20, 30, 40, 50, or 60 g/container. Foliage height increased linearly with increasing CRF rate. Flower height increased to a maximum at 40 g of CRF per container and then decreased with higher levels of CRF. Basal plant width exhibited a quadratic response to CRF rate, reaching a maximum at 40 g of CRF per container. The greatest number of flowers and tillers were obtained using 50 g of CRF per container. Maximizing the number of flowers is important for marketing of *Pennisetum*, since this plant is grown primarily for its flowering.

556 (PS 6)

Preemergent Weed Control in Container-grown Herbaceous Perennials

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Herbicides were applied to container-grown herbaceous perennials and evaluated on the basis of weed control, phytotoxicity, and effect on plant growth. During the 1995 season six preemergent herbicides [(in kg·ha^{-1}) Napropamide (Devrinol 10G), 4.5 and 9.1; Isoxaben (Gallery 75DF), 1.1 and 2.3; Oxadiazon (Ronstar 2G), 4.5 and 9.1; Oxyfluorfen + Oryzalin (Rout 3G), 3.4 and 13.6; Oryzalin (Surflan AS), 2.8 and 4.5; and Trifluralin (Treflan 5G) 4.5 and 9.1, were tested on *Callirhoe involucrata*, *Delosperma nubigenum*, *Dendranthemum ×morifolium* 'Jennifer', *Festuca cinerea* 'Sea Urchin', and *Gypsophila paniculata* 'Fairy's Pink'. Isoxaben (both rates) resulted in visual phytotoxicity symptoms and sometimes death to *Dendranthemum*. Oxadiazon (9.1 kg·ha^{-1}) and Oxyfluorfen + Oryzalin (both rates) resulted in plant chlorosis and necrosis to *Delosperma* soon after herbicide application, but plants outgrew herbicide damage. Napropamide (both rates), applied to *Delosperma*, resulted in less dry weight when compared to some of the other herbicide treatments. Oryzalin (4.5 kg·ha^{-1}) resulted in visual phytotoxicity and less plant dry weight to *Festuca*. Data analysis revealed no significant differences in *Callirhoe* and *Gypsophila*. In general, most herbicides controlled weeds effectively.

106 POSTER SESSION (Abstr. 557–567) Culture and Management–Field Nursery/ Landscape

557 (PS 2)

Growth Index and Disease Ratings of 55 Crape Myrtle Cultivars in Tennessee

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Fifty-five accessions of commercially available crape myrtle cultivars were established with 10 single-plant replications during Fall 1993 and Spring 1994. Drip irrigation began on a regular basis May 1994 and plants were fertilized regularly. In contrast to the 1994 growing season with heavy powdery mildew infestation, little powdery mildew occurred in 1995. Mean growth index (GI = centimeter height + centimeter mean width) was calculated for each cultivar in Fall 1994 and 1995. Fastest growth occurred in 'Tuskegee' and 'Biloxi' (GI = 276, 246, respectively), followed by a group including 'Tonto', 'Comanche', 'Choctaw', 'Hardy Lavender', 'Natchez', 'Potomac', and 'Tuscarora' (GI = 185 to 227). Slowest growth occurred in the group including 'Pecos', 'Seminole', 'Baton Rouge', 'Petite Orchid', 'Bourbon Street', 'Cherokee', 'Monink Pink', 'Moned Red', 'Delta Blush', 'Low Flame', 'New Orleans', 'Monow', and 'World's Fair' (GI = 5 to 53). Data will be presented on powdery mildew ratings and physiological injury sustained during Winter 1995–96.

558 (PS 2)

Growth Index and Disease Ratings of 60 Lilac Cultivars in Tennessee

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Sixty accessions of commercially available lilac cultivars were planted May 1994 and immediately placed under drip irrigation and fertilized regularly. Powdery mildew appeared in July 1994 and was rated on a scale of 0 (healthy) to 5 (totally mildewed) in July, August, and September. Mean growth index (GI = cm height + cm mean width) was calculated for each cultivar in Fall 1994 and 1995. Fastest growth (GI = 75 to 45 respectively) occurred in the group including *chinensis* 'Rothomagensis', *meyeri* 'Dwarf Korean', *reticulata* 'Ivory Silk', *prestoniae* 'Isabella', 'Mrs. Harvey Bickle', 'Excel', 'Katherine Havemeyer', 'Mme. F. Morel', 'Silver King', 'Leon Gambetta', 'Mount Baker', and *microphylla* 'Superba'. Data will be presented on powdery mildew ratings for the 1995 season.

559 (PS 2)

Fastest Growing Oaks in Species/Cultivars Trials at TSU-NCRS, McMinnville, Tenn.

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Eighty-one accessions of oak species, hybrids, and cultivars from commercially available sources were established at TSU-NCRS in Fall 1993 and Spring 1994, using 10 single-plant replications in a randomized complete block. Drip irrigation was begun on a regular basis May 1994, and plants were fertilized regularly. Height and diameter was recorded Fall 1994 and 1995. Fastest growing oaks in order of cm height growth increment over the two growing seasons were *nigra, phellos, texana nuttalli, cerris, macrocarpa, falcata pagodaefolia, macrocarpa* 'Maximus', *acutissima, austrina, shumardii, muehlenbergi, falcata, robur fastigiata, lyrata, virginiana, palustris, acutissima* 'Gobbler', *glandulifera, macrocarpa* 'Ashworth', *gambelli ×macrocarpa, alba.* Most evergeen oaks did not survive Winter 1995–96, and data will be reported on winterkill.

560 (PS 2)

Foliar Variation of Black and Sugar Maples Indigenous Near the 43°N Latitude from Maine to Iowa

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Its more westerly native range and apparent xeromorphic foliar traits have led

to speculation that black maple (*Acer nigrum* Michx.f.) is more drought resistant than sugar maple (*Acer saccharum* Marsh.). We examined differences in morphology and anatomy of leaves of trees of these species indigenous near the 43°N latitude in the midwestern and eastern United States. Leaves were collected during July, Aug., and Sept. 1995, from 10 trees in each of 24 sites at longitudes of 71°W in Maine to 94°W in Iowa. Density of trichomes on abaxial surfaces and lamina surface area showed quadratic relationships with longitude and were greatest for leaves from westerly sites in Iowa. The percentage of total lamina surface area partitioned in the two most basipetal lobes increased linearly with longitude. Abaxial surfaces had 6 to 960 trichomes/cm^2, lamina surface area was 28 to 176 cm^2, and surface area partitioned in basipetal lobes was 5% to 9%. A quadratic regression function related increases in trichome density to decreasing mean annual rainfall at collection sites. Specific leaf mass ranged from 3.5 to 7.6 $mg \cdot cm^{-2}$ and did not relate to longitude. Scanning electron microscopy showed leaves throughout the range had similar trichome morphology, and light microscopy is being used to examine variation in leaf anatomy and stomatal traits.

561 (PS 2)

Urban Mesoclimate Effects on Winter Survival and Damage of Ornamental Species in Fort Worth, Texas

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Urban areas are typically 2 to 3°C warmer than surrounding rural areas throughout the year. Winter minimum temperatures are often 4 to 5 °C warmer in the city and, during extreme episodes may exhibit differences of 12 to 13°C. Because the USDA Hardiness Maps compile readings from individual stations in an area, temperature differences may not be apparent at the local scale. This study was conducted to compare ornamental plant damage during Winter 1995–96 in Fort Worth, Texas. AVHRR 1-km thermal satellite imagery was used to determine the warmest and coolest portions in Fort Worth, Texas. Each temperature area was divided into five 0.5-km blocks on the basis of similar landscape features and plant types. During Mar. 1996, these areas were evaluated on the basis of plant damage to several species. Asian jasmine (*Trachelospermum asiaticum*), indian hawthorn (*Raphiolepis indica*), St. augustine turf (*Stenotaphrum secundatum*), southern magnolia (*Magnolia grandiflora*), and Live Oak (*Quercus virginiana*) were the primary species damaged. Asian jasmine and St. Augustine turf were either completely killed or severely damaged in the coldest areas but suffered only moderate or light damage in the warmest areas. Indian hawthorn, live oak, and southern magnolia suffered leaf and stem damage in the coldest areas but little to no damage in the warmer areas.

562 (PS 2)

Effect of Cold Storage and Pretransplant Desiccation on Root Growth Potential and Budbreak of Washington Hawthorn and Norway Maple

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Two-year-old Washington hawthorn (*Crataegus phaenopyrum* Med.) and Norway maple (*Acer platanoides* L.) seedlings were subjected to varying cold storage durations and four storage treatments: whole plant covered in polyethylene bags, shoots exposed, roots exposed, and whole plant exposed. After storage, half the seedlings were immediately plant and half received a 12-hour desiccation treatment before transplanting. Root growth potential (RGP), time to budbreak, and marketability were measured. With the root covered treatments, Norway maple RGP increased while Washington hawthorn RGP decreased with increased cold storage duration. RGP for both species remained low throughout storage for treatments exposing roots. The 12-hour desiccation treatment reduced RGP for both species with hawthorn being more affected than maple. Days to budbreak for both species decreased with increased storage time for whole plant covered treatments but increased for both species when stored with exposed roots. Maple marketability for root covered treatments was high for most storage durations. Hawthorn marketability was generally low except for the whole plant covered treatment during the first 6 weeks of storage. For the respective storage durations, hawthorn RGP, time to budbreak and marketability values for the shoots exposed treatment were similar to the root exposed treatments. In contrast, values for the shoots exposed treatment were similar to the whole plant covered treatment for maple. There was a high positive correlation between RGP and marketability for both species.

563 (PS 2)

Effect of Postfrost Pruning on Winter Hardiness of Selected Garden Chrysanthemums

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Pruning aboveground tissues back to the plant crown in preparation for winter is a common cultural practice for garden chrysanthemums [*Dendranthema grandiflorum* (Ramat.) Kitamura]. But some landscape managers suggest pruning immediately before the onset of low temperatures may be responsible for predisposing plants to winter injury. To evaluate the effect of pruning garden chrysanthemums in November and December on winter survival, rooted cuttings of 19 chrysanthemum cultivars were obtained from Yoder Brothers and were field-planted in a randomized complete-block design with five replications. Pruning treatments were 1) plants pruned to 2 cm above the crown on 1 Nov., 2) plants pruned to 2 cm above the crown on 1 Dec., and 3) plants not pruned. Survival and regrowth data were gathered the following summer. Cultivars differed in their response to the treatments, but in general, survival percentages and regrowth shoot dry weights were greater for plants that were not pruned.

564 (PS 2)

Effectiveness of Ethephon Treatments in Reducing Seed Set in *Kalmia latifolia* L.

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Nursery production of Mountain Laurel (*Kalmia latifolia* L.) often involves manual disbudding or deadheading flower clusters immediately after flowering, to stimulate the formation of one or several new shoots. Experiments were initiated on populations of *K. latifolia* 'Angel' (41 plants), 'Snowdrift' (17 plants), and 'Hoffman's Pink' (37 plants) to test the effectiveness of single applications of 0 (water control), 500, 1000, and 2000 ppm ethephon in reducing seed set and stimulating new shoot formation. Ethephon was applied on 9 June 1995 when an average of 52.9%, 53.4%, and 27.3% of the flowers were open in each flowering cluster of 'Angel', 'Snowdrift', and 'Hoffman's Pink', respectively. On 17 to 19 July 1995, data were collected for numbers of green seed capsules per flower cluster and the number of new shoots per plant. One way analysis of variance showed the treatments had highly significant effects on seed capsule numbers per flower cluster and in stimulating the production of new shoots per plant in the three cultivars. The average number of green capsules per flower cluster and new shoots per plant for each cultivar treated with 2000 ppm ethephon were: 2.2 capsules and 57.2 shoots in 'Angel', 1.1 capsule and 40 shoots in 'Snowdrift', and 6.6 capsules and 39.3 shoots in 'Hoffman's Pink'. In contrast, the controls had 20.1 capsules and 2.8 shoots in 'Angel', 22.9 capsules and 8 shoots in 'Snowdrift', and 27.3 capsules and 2 shoots in 'Hoffman's Pink'.

565 (PS 2)

Use of Sulfentrazone (F6285) for Weed Management in Field-grown Ornamentals

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The nursery industry currently has few options for effective season-long weed control, because few soil persistent herbicides are registered for use in ornamentals. An herbicide that provides season-long weed control with minimal injury to ornamentals would be extremely beneficial because it would enable the nurseryman to produce high-quality ornamentals with minimal weed interference Sulfentrazone (F6285), a newly developed herbicide from the FMC Corp., has shown promising results for weed control in field trials with ornamentals. Additional, trials are needed to further evaluate sulfentrazone in hopes that it may be registered for use in ornamentals in the future. Our objectives are 1) to increase long-term weed management in ornamentals, including woody species and groundcover; 2) to evaluate rate structures of sulfentrazone and combinations, including preemergence and postemergence herbicides; 3) to evaluate sulfentrazone selectivity in weed species and in ornamentals; 4) to evaluate sulfentrazone mode of action in weed species; and 5) to measure the soil activity of sulfentrazone. To achieve the first three objectives, a randomized complete block design will be used to evaluate 10 woody species and 17 herbicide combinations. The response variables will be weed control and phytotoxicity ratings taken at 0, 4, 8, and 12 weeks after treatment. The results of this study will be used in ongoing research trials in an attempt to register sulfentrazone (F6285) for use in ornamentals.

566 (PS 2)

Herbicide Injury Symptoms on Landscape Plants; A Photo CD-ROM Image File

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Damage caused by misapplication of herbicides in landscape management or drift from agricultural fields on to nearby landscape plantings is often difficult to diagnose. Symptoms may vary with herbicide, species that is damaged, and other factors. To address this need, a photo CD-ROM has been developed to help plant damage diagnosticians determine if damage has been caused by herbicides. Fourteen herbicides or herbicide combinations commonly used in turfgrass, landscape, or field crop production applications were applied to 21 taxa of landscape trees, shrubs, groundcovers, or herbaceous perennials. More than 800 photographic transparencies of damage symptoms (representing all 21 taxa and 12 herbicides) were taken, and 457 were selected for storage in the digitized photo CD format for rapid retrieval. In all cases, as damage symptoms were observed, they were photographically recorded using a Nikon FM camera with a 55-mm micro-NIKKOR lens and Fujichrome Velvia transparency film under ambient, sunlit conditions. Species and plant taxa lists are displayed and the CD-ROM is demonstrated.

567 (PS 2)

Clopyralid Uptake, Translocation, and Ethylene Production in Resistant and Susceptible Yellow Starthistle (*Centaurea solstitialis*) Plants

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Resistance to the auxin-like herbicide picloram has been reported in a yellow starthistle population growing in Washington. In addition, this population is cross resistant to clopyralid, another auxin-like herbicide. To understand the mechanism of resistance to clopyralid, studies were was conducted to determine uptake and translocation and to characterize clopyralid-induced ethylene production in the susceptible (S) and resistant (R) biotypes. R and S yellow starthistle plants were grown under ambient greenhouse conditions until full rosette stage and then transferred to a growth chamber (14-hour photoperiod, 25°C, 200 $mol \cdot m^{-2} \cdot s^{-1}$) 48 hours before treatment. Radiolabel solutions were prepared from ^{12}C and ^{14}C-clopyralid. Each treatment in the uptake experiment contained 0.009 Ci (20,000 dpm) and in the translocation experiment 0.225 Ci (500,000 dpm). Clopyralid 11.7 mM (420 g a.e./ha) solutions were applied as six 0.5-L droplets to the adaxial surface of completely expanded leaves using a microsyringe. Radioactivity was quantified by Liquid Scintillation Spectrometry. Uptake was determined at specified times after treatment. Almost all clopyralid uptake occurred within the first 2 hours, with no significant differences between the two biotypes. The amount of picloram translocated was 2.4%, 40.2%, and 50.7% of that absorbed at 2, 24, and 96 hours after treatment, respectively, but was not different between biotypes. Clopyralid induced about ten times greater ethylene production in S than in R. Ethylene production was followed by epinasty and chlorosis but appears to play only a small role in the resistance mechanism.

106 POSTER SESSION (Abstr. 568–579) Culture and Management–Small Fruits

568 (PS 2)

Wine and Table Grape Cultivar Evaluation in Missouri

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Wine and table grape vineyards were planted at Mountain Grove in 1985. Twenty-seven wine and 10 table grape cultivars were evaluated in respective 12 and 18 vine plots, replicated five times. Vineyard management practices were single curtain cordon training, dormant season balance pruning, protective spray program according to Missouri recommendations, grass sod row middles with preemergence herbicide applied underneath the trellis, and fertilization according to soil and petiole analysis. Cluster thinning and shoot positioning were done as needed. Productivity data was measured yearly and included: pruning weight, yield, cluster and berry weights, and juice °Brix, titratable acidity, and pH. Disease evaluation data was also taken on these cultivars. Based on these data and current market trends, two wine grape cultivar groups were identified: recommended, 'Catawba', 'Cayuga White', 'Chambourcin', 'Norton', 'Seyval blanc', 'Vidal blanc', and 'Vignoles'; not recommended, 'Aurore', 'Baco noir', 'Bellandais', 'Chancellor', 'Chelois', 'Couderc noir', 'DeChaunac', 'Delaware', 'Horizon', 'LaCrosse', 'Leon Millot', 'Marechal Foch', 'Melody', 'Missouri Riesling', 'Niagara', 'Rayon d'Or', 'Rougeon', 'Ventura', 'Villard noir', and 'Vivant'. Three table grape cultivar groups were identified: recommended, 'Mars' and 'Reliance'; recommended for limited planting, 'Canadice', 'Vanessa', and 'Vinered'; and not recommended, 'Challenger', 'Einset', 'Festivee', 'Himrod' and 'Venus'. This information is used by growers to make cultivar decisions and also serves as a benchmark for comparing new grape germplasm coming into the state.

569 (PS 2)

Evaluation of Harmony and 1616 Grape Grafted Rootstocks Using the Cultivar Fantasy Seedless as Scion and Control

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Caborca is the most important viticultural area in Mexico; however, in the last 10 years, the nematode population become a big problem and many vineyards are affected for nematode attack. Our objective was to evaluate the susceptibility or resistance of two grape grafted rootstocks and direct planted 'Fantasy Seedless' cultivar as scion and control.The observed results at second production year were 1800, 950. and 550 table grape boxes/ha for Harmony, 1616 grafted rootstocks and direct-planted Fantasy S, respectively; also, table grape from Harmony rootstock showed better sizes and quality than others. The nematode populations were 0.7, 2.0, and 75 nodes/50 g of roots for Harmony, 1616 and direct-planted Fantasy, respectively. No one treatments were affected in the phenology stages during the seasons.

570 (PS 2)

Root Distribution of Mature 'Thompson Seedless' (*Vitis vinifera* L.) Grapevines under Aboveground Drip, Subsurface Drip, and Furrow Irrigation

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Using subsurface drip irrigation (SDI) is increasing in California vineyards. Reports from growers indicate increased yield, increased water-use efficiency, enhanced soil pest control, and reduced canopy disease pressure for SDI when compared to aboveground drip irrigation (AGDI). However, little information is available in the literature regarding this relatively new irrigation technology for grapes and other perennial crops. A long-term trial was established to evaluate the performance of AGDI and SDI in a mature 'Thompson Seedless' raisin vineyard. Portions of a furrow irrigated vineyard block were converted to AGDI and SDI before budburst in 1993. Vine performance, water use, and irrigation system performance data are being collected. As part of this trial, changes in root distribution were examined after harvest in Nov. 1995. Treatments included AGDI, SDI, and furrow irrigation. Root distribution was quantified using the trench profile method. Trenches were opened perpendicular to the row and ≈30 cm from the vine. Roots were mapped along the profile wall using a 1×1 m frame, which was divided into one hundred 10×10 cm sections. Roots were counted and categorized into four size classes: small (<2 mm), medium (2 to 5 mm), large (5 to 12 mm), and very large (>12 mm). Root distribution differed significantly for AGDI, SDI, and furrow irrigation. The type of irrigation used had the greatest impact on small roots. SDI had more small roots and total roots than AGDI or furrow irrigation. High root densities were observed near the emitter under AGDI and SDI. In addition, both drip irrigation treatments had higher root density near the soil surface than furrow irrigation. Root intrusion was not observed in the SDI treatment.

571 (PS 2)

Effects of Gibberellic Acid Treatments on Fruit and Seed Development of Muscadine Grapes

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Gibberellic acid, a plant growth regulator commonly sprayed for seedless bunch grape cultivars, was used to spray on the seeded muscadine grape cultivars 'Carlos', 'Fry', 'Higgins' and 'Triumph'. GA_3 at 100 to 300 ppm were sprayed

on leaves and fruit clusters before and after anthesis. The flower/fruit clusters also were dipped into a much higher concentration (1000 ppm) in addition to the sprayed concentration of GA_3. Berry weight significantly increased in all the sprayed vines, with a maximal increase up to 50%. Early and more uniform ripening was observed in the cultivar 'Triumph'. More than 20% of seedless berries also were found on the GA_3-sprayed 'Triumph' vines. However, the latter two responses (early ripening and seedlessness) did not occur in other cultivars tested. Similar results also were obtained in the dipping treatments. The results indicated that the seeded muscadine grapes responded well to the GA_3 treatments in general, but genotype variation is obvious.

572 (PS 2)

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

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Corn gluten meal (CGM), a by-product of corn wet-milling, has weed control properties and is a N source. The weed control properties of CGM have been identified in previous studies. The hydrolysate is a water soluble, concentrated extract of CGM that contains between 10% to 14% N. Our objective was to investigate corn gluten hydrolysate as a weed control product and N source in 'Jewel' strawberry production. The field experiment was a randomized complete block with a factorial arrangement of treatments with four replications. Treatments included application of granular CGM, CGM hydrolysate, urea, urea and DCPA (Dacthal), and a control (no application). Granular CGM and urea were incorporated into the soil at a depth of 2.5 cm with N at 0, 29, 59, and 88 g/plot. Plot size was 1×3 m. Percent weed cover data on 12 Aug. showed plots receiving the 29 g N from CGM hydrolysate had 48% less weed cover than the control (0 g). Plant growth variables showed similar numbers of runners and runner plants among all nitrogen sources.

573 (PS 2)

Identifying Strawberry Plant Dormancy for Optimum Digging Date

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In northern regions, strawberry nursery plants are often dug in the late fall, packed and stored for winter, and shipped to markets in the early spring. Success depends on identifying when plants are dormant and can be safely stored. Beginning on 11 Oct., plants of Kent and Veestar were dug at weekly intervals from three fields in the Annapolis Valley, N.S., Canada. At each digging date root respiration was measured at 5, 10, 20 and 30°C. Six "first daughter" plants of each cultivar were wrapped in plastic and placed in ≈1.5°C refrigerated storage. Other plants were separated into roots and leaves for carbohydrate analysis. Fall temperatures were relatively mild with 417 crown chilling hours (8°C base) accumulated to 7 Nov. Only those plants dug on 11 Oct. did not survive when planted to the field on 1, June but vigor (number of daughters/runners) improved for plants dug later in the fall. For Kent, vigor increased through the last digging date (5 Dec.), but for Veestar, vigor did not change after 7 Nov. Early dug plants had relatively high rates of root respiration, low concentrations of leaf and root glucose, fructose, sucrose, and raffinose and high leaf starch, and low root starch concentrations. Most leaf sugar concentrations increased rapidly after 7 Nov., and root starch reached a maximum at the same date. Leaf and root carbohydrate concentrations were correlated with poststorage field vigor and may reflect the degree of plant dormancy at time of digging.

574 (PS 2)

A Single Basal Application of MEISTER (Polyolefin-coated Urea) to the Strawberry Greenhouse Soil in Kumamoto, South Japan

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It is not uncommon that tipburns, deformation, and poor coloring of strawberries, delaying of differentiation of flowering buds and flowering, etc., occur reflecting rapid changes in soil solution concentrations by repeated applications of conventional fertilizers. These physiological disorders contribute to lowering the yield and quality of strawberries to a significant extent. Polyolefin coated urea called "MEISTER" is one of the excellent controlled availability fertilizers whose dissolution is primarily controlled by temperature. Therefore, blended materials of a few MEISTER products can supply N matching the plant demand for the long growing season (8 months). This results in contributing to the prevention of occurrences of the physiological disorders described above. Treatment plots using blended materials of MEISTER products were early dissolution, even dissolution, and late dissolution and were fertilized with a single basal application. Compared with the conventional plot, the late dissolution plot was most suitable for strawberry growth, producing the largest yield of high quality. The new fertilization using MEISTER will contribute to decreasing the amount of fertilizer to apply, eliminating topdressing, saving labor cost, etc.

575 (PS 2)

An Innovative Application of MEISTER (Polyolefin-coated Urea) to Strawberry Pots to Supply N for the Whole Growing Season in Kumamoto, South Japan

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A hundred days and 240 days are required for growing strawberry plants in the nursery and in the greenhouse, respectively. Therefore, fertilization using conventional fertilizers is often repeated. To eliminate repeated topdressing,to decrease the amount of N to apply, and to save farming labor, a new fertilization method using MEISTER was studied. Since MEISTER is an excellent controlled fertilizer, the new method can apply all N necessary to grow strawberry plants almost for a year only by a single application (no N fertilizer is applied to the greenhouse soil). The experimental plots basically consist of two kinds of treatment: changing ratios of soil volume per pot or per plant (50 to 800 ml/pot) and kinds and levels of fertilizers (conventional fertilizer and two kinds of MEISTER). The experimental results showed 1) soil of ≥200 ml/pot is necessary to grow strawberry seedlings in summer when the soil is subjected to drying, 2) a blended material of two MEISTER products with sigmoid dissolution can supply N for the whole growing season, and 3) MEISTER application can reduce 40% of the total N conventionally applied.

576 (PS 2)

Influence of Rockphosphate on Root Development and Growth of Strawberry Tips Inoculated with Endomycorrhizae

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Strawberry (*Fragaria ×ananasa* Duch. 'Chandler') tips containing only root initials were inoculated with mycorrhizal fungus *Glomus intraradices* and were fertilized with rockphosphate levels of 1, 2, 4 and, 6 $mg \cdot cm^{-3}$ to study root growth and mycorrhizal infection. The addition of rockphosphate at >2 $mg \cdot cm^{-3}$ decreased mycorrhizal infection. Root dry weight of mycorrhizal strawberry plants increased significantly over the controls with addition of rockphosphate, and mycorrhizal infection significantly decreased the shoot : root ratio. Foliar P levels decreased in mycorrhizal plants fertilized with up to 4 $mg \cdot cm^{-3}$ of rockphosphate and a quadratic relationship was seen between rockphosphate levels and foliar P. In nonmycorrhizal plants, the highest foliar P level was with rockphosphate at 1 $mg \cdot cm^{-3}$. The study revealed rockphosphate at 1 to 2 $mg \cdot cm^{-3}$ is beneficial for greater root growth with mycorrhizal inoculation.

577 (PS 2)

Severity and Timing of Mechanical Rejuvenation Pruning Affects Vegetative and Reproductive Growth of Blueberry

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Mature 'Sharpblue' southern highbush and 'Beckyblue' rabbiteye blueberry plants were mechanically pruned at two heights on three dates after fruit harvest during the 1994 growing season. No pruning had occurred for at least 3 years ('Sharpblue') or 5 years ('Beckyblue') before initiating experiment. Pruning heights were 45 and 85 cm and nonpruned for 'Sharpblue' and 45 and 95 cm and nonpruned for 'Beckyblue'. Pruning dates were 3, 6, and 9 weeks after peak harvest for each cultivar. Regrowth was measured in Mar. 1995 before initiation of spring growth. Pruning 'Sharpblue' bushes to 45 cm increased new shoot number and mean and total shoot length but decreased fruit yield compared to the 90-cm pruning treatment. No difference in yield occurred between the 90-cm pruning treatment and the nonpruned control. As time between fruit harvest and pruning increased, new shoot number, mean and total shoot length, plant height, canopy volume, and fruit yield decreased. There was no difference in yield between the earliest pruning treatment and the control. For 'Beckyblue', mean and total shoot length of regrowth and flower bud density decreased with increasing time from harvest to pruning. Yield data for 'Beckyblue' were not collected in 1995 because of gall midge infestation.

578 (PS 2)

Nitrate Reductase Activity in Leaves and Roots of Two Blueberry Species

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Commercial blueberry production is limited primarily to soils where ammonium, rather than nitrate, is the predominant N form. However, *Vaccinium arboreum*, a species native to northern Florida, often is found growing in soils where nitrate is the major N form. This species may serve as a breeding source or rootstock for commercial blueberries, expanding the potential soil types that may be used for blueberry cultivation. In our study, in vivo nitrate reductase activity (NRA) was measured in roots and leaves of 2-year-old seedlings of *V. arboreum* and a commercial cultivar, *V. corymbosum* 'Sharpblue'. Plants were grown hydroponically in sand culture and fertilized with a modified Hoagland's solution containing N as either ammonium, ammonium nitrate, or nitrate. *Vaccinium arboreum* averaged nitrite at 200, 60, and 20 nmol/g fresh weight per h for nitrate, ammonium nitrate, and ammonium fertilized plants, respectively. 'Sharpblue' root NRA was significantly lower, averaging nitrite 50, 38, and 8 nmol/g fresh weight per h for nitrate, ammonium nitrate, and ammonium fertilized plants, respectively. NRA was much lower in leaves than roots of *V. arboreum*, averaging nitrite at ≈15 nmol nmol/g fresh weight per h across N treatments. No NRA was detected in the leaves of 'Sharpblue', regardless of N treatment. These data suggest that *V. arboreum* may be used as a rootstock or breeding source to expand blueberry production into soil types that are higher in nitrate than the soils typically used for blueberry production.

579 (PS 2)

Cranberry Crop Manager Computer Software Package

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Cranberry Crop Manager is a predictive software package for commercial cranberry growers. The package consists of linked modules. Predictive models for insect, disease, and weed development are the most important features. With appropriate weather and scouting information the models will make control or no control recommendations. To support the predictive models the program will maintain weather records of air temperatures, evapotranspiration, irrigation, and rainfall. Data can be imported or entered by hand. The program will maintain bed records including pesticide applicators, pesticide and fertilizer applications, and scouting reports. Output options include screen or printed reports or data export. An electronic encyclopedia of cranberry disease, insect and weed pests on CD will accompany the package. Minimum computer requirements are 486 CPU, 6 MB RAM, 6 MB hard drive space.

147 POSTER SESSION (Abstr. 580–585) Culture and Management–Subtropical Tree Fruits

580 (PS 8)

Growth of Sour Orange in Response to Mesic or Xeric Geographic Isolates of *Glomus intraradices* under Two Irrigation Frequency Regimens

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Sour orange (*Citrus aurannum* L.) seedlings were inoculated with geographic isolates of an endomycorrhizal fungus, *Glomus intraradices* Smith and Schneck, from a xeric (New Mexico) or mesic (Florida) climate or not inoculated as controls, and were grown for 5 months under high (soil water potential more than or equal to –0.1 MPa, irrigated once every 3 days) or low (more than or equal to –1.0 MPa, irrigated once every 12 to 15 days) irrigation frequency regimens. Similar leaf P concentrations were achieved in all plants by giving more P fertilizer to nonmycorrhizal plants than mycorrhizal plants. Plants inoculated with the xeric isolate had more arbuscules and fewer vesicles than those inoculated with the mesic isolate. Mycorrhizal fungi had little affect on plant growth under high irrigation frequency. Low irrigation frequency reduced plant growth compared with high irrigation frequency. Under low irrigation frequency, shoot and root growth increased for mycorrhizal plants; however, the magnitude of increase of shoot growth was greatest for plants inoculated with the xeric isolate. Additionally, low irrigation frequency was associated with a dramatic decrease in vesicle formation in roots inoculated with the mesic isolate. This study showed that sour orange plants especially benefited from inoculation with an isolate from a xeric climate under low irrigation frequency, independent of P nutrition.

581 (PS 8)

Performance of 'Ambersweet' Orange Trees on Cleopatra Mandarin and Swingle Citrumelo Rootstocks

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Because of the many concerns about fruit quality and fruit production of 'Ambersweet' cultivar, this study was conducted in Florida to evaluate the performance of this cultivar budded on two rootstocks and grown in three locations. The effects of Cleopatra mandarin (CM) rootstock on tree growth, yield, fruit quality, and leaf mineral concentration were compared to those of Swingle citrumelo (SC). Although tree shape differed with the rootstock, no consistent difference was found in tree growth between the two rootstocks. Significant differences in yield, fruit size, and fruit quality were found between the two rootstocks. Fruit produced on CM were large with a rough, thick peel and poor color. Swingle citrumelo rootstock promoted higher yield and better fruit and juice quality than CM. Earlier fruit maturity and higher soluble solids and juice content were obtained from trees grown on the Flatwoods compared to trees grown on the central ridge. With the exception of magnesium, no consistent difference in leaf mineral concentration was found between the two rootstocks.

582 (PS 8)

Perennial Peanut Establishment and Potential Environmental Benefits to Citrus

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A 2-year establishment study of perennial peanut (*Arachis glabrata* Benth.) planted in row middles of a 1-year-old citrus grove was initiated in southwest Florida. The effect of herbicide and fertilizer treatment combinations on perennial peanut density was measured. Treatments were Fluazifop-p-butyl (Fusilade 2000 1E) herbicide, K-Mag fertilizer, Fluazifop-p-butyl + K-Mag + N, and a nontreated control. Four replications were arranged in a randomized complete-block design. After 2 years, there were no significant differences in plant density between treatments (96% cover) and the control (89% cover). Applications of Fluazifop-p-butyl in years one and two were effective in controlling grassy weeds such as common bermudagrass [*Cynodon dactylon (L.) Pers*]. In this experiment. initiated 1 year after planting, perennial peanut without inputs (herbicide, fertilizer) was able to suppress common bermudagrass and to obtain a high level (89%) ground cover in 3 years (1991–94).

583 (PS 8)

Commercial Evaluation of Five Almond Cultivars in Northwestern Mexico

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The total shell almond production in northwestern area in Mexico is ≈80 tons per year; therefore, almond fruit tree would be a potential fruit crop in this agricultural area. Also, this crop offers some advantages with lower costs than other fruit crop, and the water requirement needs for almond trees is low in support to the limited water availability. Our objective was to test new five almond cultivars of low chilling requirement. Almond cultivars were grafted on Nemaguard rootstock and planted during 1990. The data were collected from the almond orchard using the inshell kernel. The average yield during 1993 and 1994 were 970, 602, 552, 419, and 388 kg·ha^{-1} for 'R-633', 'Cavaliera', 'Constantini', 'Um El Fahm', and 'Rane', respectively. 'Cavaliera' and 'Um El Fahm' showed good inshell percent and kernel weight. 'Cavaliera' was harvested early in last week of June compared to the other cultivars that were harvested in mid-July.

584 (PS 8)

Evaluation of Four Pistachio Rootstocks in California's Central Valley

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Four pistachio rootstocks, *Pistacia atlantica*, *P. integerrima*, and two selections of the same interspecific hybridization, *P. atlantica*, *P. atlantica* x *P.*

integerrima (A.K.A. PGII and UCB #1) budded with *P.vera*, *P. vera* cv. Kerman females have been evaluated since 1989 in three locations in California's central San Joaquin Valley. Thus far, Atlantica is the most cold tolerant, followed by the interspecific hybrids and Integerrima. Integerrima and UCB no. 1 have produced significantly more clusters and nuts per tree, but all rootstocks have produced the same numbers of nuts per cluster. Trees on no.1 and Integerrima rootstocks also have produced significantly more kilograms of nuts per trunk cross sectional area than Atlantica and PGII. UCB #1 and Integerrima also are significantly more tolerant of the soilborne fungus *Verticillium dahl.* All rootstocks are equally infected with three species vesicular–arbuscular mycorrhizzae. Two seasons of irrigation with water up to 8.00 $dS \cdot m^{-2}$, have not affected rootstock performance or yield. UCB #1, Integerrima, and PGII all require supplemental boron, zinc, and copper nutrition for good production. Thus far, Integerrima is the best rootstock for soils with verticillium infestations unless winter temperatures are frequently below freezing. UCB #1 is the best rootstock for locations with cold winters.

585 (PS 8)

Estimating Leaf Area of Macadamia and Coffee

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One hundred mature leaves of macadamia (*Macadamia integrifolia*) were selected from 10 trees in a commercial orchard in Papaikou on the island of Hawaii. Length (L), width (W), and area (A) of each leaf were taken. L and W were significantly correlated ($r = 0.93$), L and A ($r = 0.98$), W and A ($r = 0.94$), and ($L \times W$) and A ($r = 0.99$). L and W showed curvilinear relationships with A. Seventy-five mature leaves of coffee (*Coffea arabica* 'Guatemalan') were selected from five trees at the Waimanalo Expt. Station on the island of Oahu. Leaf L, W, and A were measured. L and W were significantly correlated ($r = 0.72$), L and A ($r = 0.89$), W and A ($r = 0.93$), and ($L \times W$) and A ($r = 0.98$). L and W showed curvilinear relationships with A. For both macadamia and coffee, although using $L \times W$ as a term in linear equations resulted in higher adjusted R^2s, the use of these equations would involve taking an additional measurement in the field. A quadratic equation using width (for coffee) or length (for macadamia) best described the relationship between these measurements and area and provide a quick method for estimating leaf area in the field.

144 POSTER SESSION (Abstr. 586–598) Culture and Management–Temperate Tree Fruits

586 (PS 6)

Chemical Defoliation of Apple and Pear Nursery Stock

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Hand-defoliation of field-grown 'Golden Delicious' apple and 'Bradford' pear nursery trees before autumn digging is a major production cost. One-year-old field-grown trees were sprayed to runoff on 18 Oct. 1994 with; 1) 1% FeEDTA, 2) 1% CuEDTA, 3) 1% ZnEDTA, 4) 100 ppm Harvade, 5) 50 ppm Dropp, 6) 500 ppm Folex, or 7) 2.5% EDTA or 8) leaves were removed by hand or 9) leaves left on trees (control). Treatments were arranged in a randomized complete-block design, with three trees/plot and four replications. Leaves on each tree were counted before treatment and 7, 14, 21, 28, and 35 days after treatment (DAT). One tree per plot was dug, stored until February and grown the following summer. Nontreated apple and pear trees had 13% and 38% defoliation, respectively, 35 DAT. CuEDTA treated apple trees had 62% and 93% defoliation 7 and 14 DAT, respectively. Pear trees treated with Cu had 18% and 100% defoliation 7 and 14 DAT, respectively. Treatment with FeEDTA resulted in 96% defoliation of pear within 7 DAT but only 57% defoliation of apple 35 DAT. ZnEDTA, Harvade, Folex, or Dropp did not significantly promote defoliation. Copper-treated apple trees had less budbreak than nontreated trees but similar budbreak as hand-defoliated trees. None of the treatments influenced budbreak of pear. None of the treatments affected the cumulative dry weight of trees at the end of the next growing season.

587 (PS 6)

Fruit Drop in 'Empire' Apple by Position within the Cluster in Unthinned Trees vs. Trees Thinned to Single-fruited Clusters

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For 4 years, six-flowered clusters on 20, unthinned, open-pollinated 'Empire'/MM106 trees were labeled at bloom and fruit drop monitored at the king (K) and lateral positions L1 (basal) to L5 (distal) (100 to 120 clusters/year). Depending on year, fruit dropped in 1, 2, or 3 major periods by 8 weeks postbloom (PB), with total percent dropped between 65% and 75%. K fruit dropped least, L4 and L5 most. Trends were that K fruit at October harvest were largest and heaviest (significantly so in some years) and L5 fruit smallest. In nine trees, hand-thinned to single-fruited spurs at 12 days PB, where the fruit at the retained position was known, there was no statistical difference in fruit weight, fruit size, or seed count between cluster positions at final harvest, although L5 fruit tended to be smallest. Numbers of spurs labeled varied from 45 to 72. Percent fruit retained at each position at October harvest was K = 89%, L1 or L2 = 87%, L3 = 83%, L4 = 83%, and L5 = 85%. Presumably, in unthinned trees the limited resources are preferentially taken by the K fruit, which especially seems to reduce set and size of its nearest lateral fruit. However, in thinned trees under lighter cropping stresses, a fruit retained at any of the positions within a cluster has a similar potential for achieving the size and weight typically seen in king fruit.

588 (PS 6)

Long-range Yield of High-density Apple Orchard on Seedling Rootstock

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Apple orchard was planted in 1963 with treatments of 8, 6, or 4 m between rows and 8, 6, 5, 4, 3, and 2 m between trees in the row. Pruning of trees corresponded to the space requirement imposed by each treatment. Spherical canopy seldom formed in treatments of $8 \times 2,3,4$, or 5 m and the size of canopy was equal to the distance between trees. In treatment of row spacing 6 or 4 m the size of the canopy across the row was 3 or 2 m, respectively, with the length of the canopy equal to the distance between the trees. Tree height was 3 m in all treatments. The cultivar was 'Antonovka' on *Malus sylvestris* rootstock. There were four replications. Fruiting in all treatments begun at the age of 8 years. During the 25 years of productive time of the orchard, there were 7 years without fruit. During the 33 years of orchard operations fruit yield was in treatments (in $t \cdot ha^{-1}$) $8 \times 8 = 301$, $8 \times 4 = 417$, $6 \times 3 = 508$, $4 \times 3 = 612$. Yield efficiency, based on cross-section of trunks in 1995 did not depend on orchard density or orchard design.

589 (PS 6)

Fruiting of High-density Apple Orchards on Clonal Rootstocks

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Orchard densities from 833 to 2500 trees/ha were studied on sod-podzolic soil (annual precipitation 550 mm). An orchard was planted in Spring 1990 and 1991 using 2-year-old nursery trees grown in film containers. The interval between trees in the row was 1 to 1.5 to 2 to 2.5 and 3 m. The trees were grafted on dwarf rootstock (62-396) and semi-dwarf (54-118). The commercial fruiting of 'Tellisaare' began the third year after planting, 'Antey' the fourth, and Spartan at fifth. The initial yield of 'Antey in the most dense treatment was 14.5 $t \cdot ha^{-1}$, 'Tellisaare' was 15 to 22 $t \cdot ha^{-1}$, according to rootstocks. Average yield of 'Antey' on 62-396 for 1992–95 at the orchard density of 2500 trees/ha was 10 $t \cdot ha^{-1} \cdot year^{-1}$ and on rootstock of 54-118 it was 21 $t \cdot ha^{-1.}$ However, yield of 'Tellisaare' 54-118 for 1992–1995 was 13 to 15 $t \cdot ha^{-1}$ in all treatment of orchard density from 1666 to 833 trees/ha. The annual yield of this cultivar grafted on rootstock 54-118 at a tree density of 2500 plants/ha increased to 18.3 $t \cdot ha^{-1}$.

590 (PS 6)

Design of Digitally Controlled Evaporative Cooling System for Apple Trees

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An evaporative cooling system for apple trees was implemented. The system is automated to conserve irrigation water. The automation is based on the digital, integrated thermometer and thermostat chip embedded in the artificial fruit. The

thermometer–thermostat chip drives a solid state relay. The relay controls a solenoid operated valve. A typical duty cycle consisted of 1 to 2 minutes of wetting (water on) to 4 to 10 minutes drying (water off). Differences in the length of duty cycles between individual chips were observed. The reliability of the system was adequate. The waterproofing of the system's electrical components was its weak point. Irrigation water deposits accumulated on the apple fruit surface during the growing season were readily removable with a simulated brush technique.

591 (PS 6)

Generative Patterns: A Potential Role in the Management of Complexity in Production Agriculture

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A novel way to capture long-standing agricultural experience and knowledge in the form of generative patterns is proposed. These patterns can be thought of as solution paradigm where the solutions are the essence of the patterns. A pattern does not provide a concrete solution to a problem but can be considered of as a worldview of the problem or a solution space. A pattern initiates and generates human cognitive behaviors that indirectly facilitate, elucidate, and solve a problem. An application of generative patterns to production agriculture is proposed. An individual pattern, as described here, associates a problem, its context, the forces affecting it, and a solution. A pattern recurring in production agriculture, the so-called uniformity pattern, is presented, and its horticultural example is discussed.

592 (PS 6)

Tree Size of Ten Asian Pear Cultivars on Five Old Home x Farmingdale Rootstocks

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The influence of five Old Home x Farmingdale (OHF) rootstocks on tree size with 10 Asian pear scion cultivars was examined after 10 years in an experimental orchard in central Washington state. The effect of rootstock on tree size varied among scion cultivars. Within 'Chojuro', 'Hosui', 'Niitaka', and 'Seigyoku', trunk cross-sectional areas were similar regardless of rootstock. Within ' Li', OHF 333 produced larger trees than OHF 282 and OHF 217. 'Okusankichi' trees, which were generally the same size as 'Hosui', were significantly larger on OHF 217 and OHF 97 than on OHF 333. 'Kikusui' trees, which were generally similar in size to 'Niitaka' and 'Seigyoku', were larger on OHF 217, OHF 97, and OHF 282 than on OHF 333. ' 20th Century', which was similar in size to 'Chojuro' and 'Shinseiki', appeared to be the cultivar most sensitive to rootstock. '20th Century'/OHF 217 were significantly larger than trees on OHF 97 and OHF 282, which were larger than trees on OHF 51. 'Shinseiki'/OHF 97 were larger than trees on OHF 333. The smallest trees were 'Shinko', with trees on OHF 217, OHF 97, OHF 333, and OHF 51 all being larger than trees on OHF 282. Contrary to research with some European pear scions, consistent trends did not emerge from this research that would allow a general prediction of the relative influence of these five OHF clonal rootstocks on Asian pear tree size.

593 (PS 6)

Orchard Performance of Seedling and Clonal Rootstocks for Peach on a Severe Peach Tree Short-life Site

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Thirteen rootstocks grafted with Redhaven peach were established on a severe peach tree short-life (PTSL) site in central Georgia. Most rootstocks tested were peach seedling types: Lovell, Nemaguard, Guardian (BY520-9), BY520-8, Boone County, Bailey and two 'Tennessee Natural' selections. A seedling plum rootstock, St. Julian, was also used. Clonal type rootstocks included a peach x almond hybrid, GF677; plum, GF43 and Damas 1869; and a plum hybrid, GF655-2. Trees on Guardian displayed the best survival with only 20% mortality due to PTSL, through 7 years. In contrast, 40% of trees on Lovell succumbed to PTSL. Currently, Lovell is the recommended rootstock for PTSL-prone sites. Other rootstocks ranged from 50% to 100% mortality due to PTSL. Trees on Guardian displayed significantly higher vigor through the first 4 years following planting compared to trees on Lovell. Furthermore, trees on Guardian produced significantly greater yields than those on Lovell, in all but 1 year. Rootstock effects on tree survival, vigor, bloom and harvest dates, fruit yield and size, and suckering will be discussed.

594 (PS 6)

Field Performance of Wildpeach (*Prunus persica* L.) as a Rootstock for Peach Compared with Lovell and Nemaguard

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A planting of 48 trees of 'Redhaven' scion on Lovell, Nemaguard, and Wildpeach rootstocks (RS) was established in 1990, with four replications in randomized complete-block design. Cultural practices common in Georgia were used to maintain the planting. Orchard performance for peach tree short life (PTSL) related tree survival, RS suckering, fungal gummosis, and tree stresses from cold injury and *Pseudomonas* canker, was investigated to examine RS potential of Wildpeach compared with Lovell and Nemaguard. Trees on all RS showed 100% survival for the first 5 years in the orchard. Although canker became more prevalent in later years, trees had significantly higher ratings on Nemaguard (2.88) and Lovell (2.50) RS than on Wildpeach (1.44). However, PTSL stress enraged by *Pseudomonas* killed one tree each on Lovell and Wildpeach RS during 1995. Trunk cambial browning that estimated cold injury was trivial due to mild winters; however, trees on Nemaguard had higher TCB ratings (1.25) than on other RS. Trees on Wildpeach had fewer suckers than on Nemaguard or Lovell. Gummosis ratings were higher on Nemaguard RS than on Lovell and Wildpeach. The results showed that Wildpeach has good potential for a peach RS.

595 (PS 6)

Influence of Training Systems on Tree Size, Yield, and Fruit Quality of 15 Peach Cultivars

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A peach and nectarine cultivar and training trial was planted in 1989. Training methods were open center (OC) and central leader (CL). The orchard was divided into three sections for early, mid-, and late season peaches with 10 individual-tree replications. The following characteristics were measured from 1989 to 1994: trunk cross sectional area, fruit yield, number of fruit, and fruit color. Early season peaches, those ripening with and before 'Salem' in the OC system had significantly greater TCSA at the end of the fifth growing season. At the end of the sixth growing season, however, there was a significant training cultivar interaction. There were no differences between the mid- or late season cultivars. Measurable yields were obtained in 1991 through 1993. In all years, greater yields per tree were observed from trees in the CL system, although not significantly different for the late season cultivars. 'Redhaven' and 'Newhaven' had the highest yields for the early season cultivars, 'Glohaven' for the mid-season cultivars, and 'Cresthaven' and Biscoe for the late season cultivars. Trees in the CL system tended to have higher tree efficiency than trees in the OC system. Fruit color at harvest varied by year and training system.

596 (PS 6)

Using a Tensiometer Control Valve to Schedule Peach Irrigation

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An irrigation control valve that uses the suction developed in a tensiometer to start and stop the flow of water to the irrigation system without the need of electricity was constructed. When soil water suction reached –22 cbars at 25 cm, the valve opened and then closed at –18 cbars. Peach trees at 6×6 m (three trees per plot) or 4.9×3 m (five trees per plot) spacing were irrigated with either pulse microsprinkler or drip irrigation. Evapotranspiration (ET) was calculated from pan evaporation and adjusted for each plot, based on canopy diameter. Flow meters measured water use for each plot in a split plot design with six replications. In Sept. 1995, drip ET was 30%, and pulse ET was 200% of calculated ET for both plant spacings. Spatial variability in actual and calculated plot ET was >200%, and actual plot ET was highly correlated with calculated plot ET. Data for the 1996 field season will be presented. The results indicate that spatial variability in water use is high, and the tensiometer valve is effective and reliable in scheduling irrigation in a heterogeneous environment.

597 (PS 6)

Promoting Lateral Branching on Young Sweet Cherry Trees

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Young sweet cherry (*Prunus avium*) trees are typically upright, vegetatively vigorous, and nonprecocious, taking 5 to 6 years to come into production. To

produce fruit in high-density orchards by year 3 or 4, development of lateral shoots for potential fruiting is critical in year 2 or 3. An experiment was designed to promote lateral branching on 2-year-old trees. The experiment was conducted in a commercial orchard in Roosevelt, Wash., with 'Bing' and 'Van' on the vigorous rootstocks Mazzard and Colt. The trees were planted at 415 trees per acre with three scaffolds trained into a "V" canopy design. The experimental variables were treatments with and without Promalin (1.8% BAP plus 1.8% GA_{4+7}), applied at a ratio of 1:3 in latex paint at green tip stage; superimposed on these treatments were either heading cuts of each scaffold to 2 m long (or tipping the scaffold if it was <2 m), removing four to five buds subtending the terminal bud, a combination of heading and bud removal, or controls. On trees that were not treated with Promalin, three additional treatments included either removing subtending buds at budbreak, or removing buds at multiple locations along the scaffold at green tip or at budbreak. New lateral shoots were counted 4 weeks after budbreak, and the quality of the shoots (shoot diameter and angle of emergence) was measured at the time of summer pruning. Interactions between Promalin, bud manipulation, and pruning will be discussed in relation to development of canopy structure.

598 (PS 6)

The Pawpaw Regional Variety Trial (RVT): Background, Rationale and Early Data

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In 1993, PPF and KSU embarked on a joint venture to test within pawpaw's native range many of the commercially available named pawpaw cultivars and PPF's advanced selections. Orchards for RVT were planted in 17 locations from Fall 1995 through Fall 1996 (possibly into 1997) consisting of 300 trees each. At each RVT site, eight replicate trees of each of the 28 grafted scion varieties will be tested in a randomized complete-block design. Named varieties that are secured for testing include Middletown, Mitchell, NC-1,Overleese, PA-Golden, Sunflower, Taylor, Taytwo, Wells, and Wilson. The other 18 clones to be evaluated originated in PPF orchards at the Univ. of Maryland Experiment Stations at Wye and Keedysville. Seedling trees from local native sources were planted around the perimeter as a buffer against edge effects and to allow comparisons with local germplasm. Identical orchards of the RVT are located in the following states: Arizona, Indiana, Iowa, Kentucky (two sites), Louisiana, Maryland, Michigan, Nebraska, New York, North Carolina, Ohio, Oregon, South Carolina, Tennessee (two sites), and the Chinese Academy of Forestry, Beijing, China. An orchard of nonidentical design is located in Florida. Additional sites in Connecticut and Chile are contemplated. Variables being studied in the trial include climate, culture, pests, growth, flowering, yield, and fruit characteristics. Trees will be evaluated for several years for yield, year-to-year consistency, regional suitability, etc. At the end of the trial period, regional recommendations will be made. Scion–rootstock compatibility based on percent scion take, scion growth (scion height and cross-sectional area), and first year field data are presented and discussed.

107 POSTER SESSION (Abstr. 599–611) Culture and Management–Vegetables

599 (PS 3)

Specialty Vegetable Crops Production and Marketing in Ohio

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Specialty vegetables are defined as crops that are different in color, size, shape or nutrient content for that particular crop, those not normally grown in a specific area, or crops grown out of season. Knowing the clientele and what they demand is the first step in successfully marketing these less common crops. Due to market demand, "uncommon" crops are more frequently requested by produce buyers and the public. What is in demand one year may not be marketable the next. Our attempts to produce >25 specialty crops under Ohio growing conditions over the past 3 years resulted in successes and failures. Regardless of the outcome, our findings were important to vegetable growers who are interested in producing these crops. Crops tested from 1994 to 1996 included globe artichokes, luffa gourds, chili peppers, habanero peppers, okra, tomatillos, baby corn, and several specialty tomato varieties. Crops produced successfully in Ohio were marketed through several farm markets, food terminals, and produce brokers. A summary of cultural practices, production tips, and marketing opportunities on these less common vegetable crops based on our research in Ohio will be presented.

600 (PS 3)

Potato Production in Wide Beds Compared to Conventional Rows

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Regional growers have expressed an interest in the feasibility of producing potatoes on wide beds. Using wide beds decreases compaction and may increase water available to the crop due to the elimination of postplanting cultivation, or hilling, required in conventional rows. The middle row of wide beds may have cooler soil temperatures than the other rows in the bed. In addition, wide beds allowed for a planting density 1.5-times greater than conventional rows, which could significantly increase yields. Potatoes, 'Atlantic', were planted mid-March into conventional rows on 38-inch centers and 6-foot 4-inch-wide beds, each bed with three rows. Plots were 50 feet long. Initial soil moisture contents in the middle of the bed, the outer rows of the bed and the conventional rows were not significantly different. Initial soil temperature data suggests that fluctuations in temperature are greatest in the conventional rows and least in the middle row of the wide beds. Soil temperature and soil moisture are reported. Marketable yields from wide beds are compared to marketable yields from conventional rows. Influence on potato size distribution and quality factors also are reported.

601 (PS 3)

Fresh Market and Long Shelf Life Tomato Response to Rowcover Treatments in a Dry Temperate Climate

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Floating rowcover (R), Dupont's "Lawn and Garden Blanket", with 75% to 80% light transmittance, was applied on black plastic mulch (M) and over transplanted seedlings of tomato (*Lycopersicon esculentum*). Peto Seed's fresh market (F) 'Al Wadi' and long shelf-life (L) 'PSX 19392' were transplanted on 11 Apr. 1995 to drip-irrigated beds that were covered with M or not covered (C). The R was removed 4 (R1) or 5 (R2) weeks after its application. The climate is temperate with ≈200 days frost-free and 400 mm rainfall. Each cultivar was grown in a field with the treatments randomized in a complete block with four replications. Fruit harvest was done weekly for 6 weeks. Yield of the first 2 weeks was considered indicative of earliness. Yield earliness was enhanced by the shorter period treatment (R1) with the L cultivar showing more response to R1 ($P < 0.05$) than the F cultivar. Early average fruit weight was comparable among all treatments ($P > 0.05$) in both cultivars, but total average fruit weight was increased by R1 in L cultivar. ($P<0.05$). Total yield was comparable among the treatments in F cultivar ($P > 0.05$) and was lowest under M treatment in the L cultivar ($P < 0.05$). We recommend using R for shorter periods on tomato grown in a dry temperate climate, where clear skies can cause excess heat build up under rowcovers during day time.

602 (PS 3)

The Effect of Ornamental Grasses Used as a Windscreen on Chili Pepper Yield

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Chili pepper yield may be hampered by wind-blown sand and high evaporative demand common in semiarid regions. Initial establishment of the crop is of great importance to overall yield. Due to their reduced size, ornamental grasses could serve as windscreens in urban gardens. In this project, seven species of ornamental grasses (*Cortaderia selloana* 'Pumila', *Erianthus ravennae*, *Miscanthus sinensis* 'Autumn Light', *Miscanthus sinensis* 'Gracillimus', *Miscanthus sinensis* 'Silberfeder', *Miscanthus sinensis* 'Variegatus', *Miscanthus sinensis* 'Zebrinus', and *Pennisetum setaceum* 'Rubrum') were used as aesthetic windscreens. *Capsicum annuum* 'NuMex Big Jim' chili pepper yield was significantly affected by species of grass in the windscreen. The number of peppers per plant was also significantly affected by species; however, the weight of each pepper was not significantly impacted. Effect of species of ornamental grass in the windscreen may be due to differences in wind resistance, moisture competition,or shading between species. The durability, increase in yield, and aesthetic nature of the ornamental grasses used as windscreens provides several reasons to take advantage of these perennial grasses for an aesthetic form of garden protection.

603 (PS 3)

Relationship of Nitrogen and Plant Populations to Yield and Stem Diameter in Broccoli

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Commercial production of bunched broccoli on the Eastern Shore of Virginia has been limited because of shortened internodes resulting in thick, tough stalks. A field study was completed to examine the influence of plant type (transplants or direct seeded), plant population (5800 or 8700 plants/ha), and N application (112 kg/N with zero, one, or two sidedress applications of 40 kg·ha^{-1}) on marketable yield, head diameter, and stem diameter of 'Packman' broccoli. None of the measured characteristics improved significantly with sidedress N application. Marketable yield and average head weight were significantly correlated ($P = 0.01$) to the total number of heads harvested ($r = 0.70$ and $r = -0.91$, respectively). More heads were harvested for the high population, direct-seeded treatment and fewer for the low-population transplants. Average stem diameter of transplants was slightly greater than that of direct-seeded broccoli being significant ($P = 0.05$) in the second and third harvests. However, few stems were of commercially acceptable diameter regardless of treatment combination. Additional evaluation of cultural management strategies and cultivar selection is needed to successfully promote commercial production of bunched broccoli in this growing area.

604 (PS 3)

Nitrogen Use in Garlic

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Nitrogen is essential to development of bulbing crops such as garlic (*Allium sativum* L.). Little scientific research thus far has concentrated on the optimum timing and concentration of applied N fertilizer for garlic grown under conditions found in the northeastern United States. A trial in Freeville, N.Y., on a gravely loam soil used three levels of ammonium nitrate fertilizer, 0 kg·ha^{-1}, 52 kg·ha^{-1} sidedressed in mid-Apr., and 52 kg·ha^{-1} applied in mid-Apr. and early June 1995. The samples included a nonbolting (softneck) garlic and a bolting (topset) clone 'Spanish Roja', both grown under wheat (*Triticum aestivum*) straw mulch. A separate trial in East Ithaca studied the same clones plus another topset, Merrifield Rocambole, on a sandy loam soil, using two levels, 0 and 52 kg·ha^{-1}, of ammonium nitrate applied in mid-April only. The East Ithaca trial also examined the efficacy of hairy vetch (*Vicia villosa* Roth) as an alternate N source. Application of ammonium nitrate in April increased average bulb size of topset in Freeville >30%, and the average bulb size of softneck by 23%. Applying in April and June increased average bulb size of topset by 35% and of softneck by 26%. Earlier timing of the second application might enhance these increases. The East Ithaca trial found N fertilization increased average bulb size by 30% for 'Spanish Roja', by 20% for Merrifield Rocambole, and 23% for softneck. Analysis of leaf tissue of garlic grown with vetch found that ammonium N increased by 22% to 28% in topset garlic and 14% to 26% in softneck. These results indicate that N fertilization, in the form of either chemical fertilizer or a legume, can benefit this crop in northeastern United States.

605 (PS 3)

Properties and Use of MEISTER (Polyolefin-coated Urea) with Accurately Controlled Availability in Japan

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Polyolefin-coated urea commercially called "MEISTER" was invented by T.Fujita and his co-workers. It shows primarily temperature-dependent dissolution and is divided into two groups of dissolution: ordinary (linear) and delayed (sigmoid).The dissolution of MEISTER in the soil is predicted easily with reasonable accuracy by a portable computer using temperature data. Thus, we can select kinds of MEISTER that can release N meeting the plant demand. It has been common knowledge that polymer-coated materials are used mainly on lawns, professional turf, and container-grown ornamental and horticultural plants and to a limited extent, in vegetable production. However, MEISTER is applied not only to high-value crops but also to low-value crops in Japan because this fertilizer can contribute to innovative fertilizer placement and farming systems (described later in this abstract), thereby the total farming cost can be notably reduced. Innovative fertilizer applications; co-situs placement and single basal application Innovative farming systems; paddy rice 1) no-till rice culture by direct-seeding and a single basal co-situs application and 2) no-till transplanting rice culture by single basal fertilization; and upland and horticultural crops 1) multi-cropping by a single basal fertilization and 2) no-till cropping by a single basal co-situs application.

606 (PS 3)

Energized Bio-Green Water Supply Stimulated the Growth and Development of Green Peppers (*Capsicum annuum* L.)

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The energized water, Bio Green Water (BG water) was manufactured through a series of processes: tap water, purification, adding catalysts, spectra energy imprinting, filtering, BG water. BG water was supplied at four times at 3-week interval to the bench soil of green peppers ('Nokwang') in the plastic film house. BG water-treated green pepper showed the reduced plant highs compared to the control, although there were no difference in the number of nodes and leaves between the BG water treatment and the control. This was attributed to shorter internode length by the treatment. The BG water treatment significantly increased fruit weight, length, and diameter and decreased abnormally curved fruit. The treatment also increased harvested fruit numbers and yields outstandingly. Postharvest, the green peppers harvested from the treated plants were not changed in green color; however, fruit in the control were gradually discolored to dark brown.

607 (PS 3)

The Effect of an Alternative Cropping System on Tomato Fruit Quality

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Rye (*Secale cereale*) residues used in an alternative cropping system will affect nutrients, soil moisture, and soil temperatures. Each of these factors can affect tomato fruit quality. A field study was conducted comparing the effects of a rye cover crop, tomato variety, and N fertility on tomato fruit quality. In October, cereal rye was seeded at 100 kg·ha^{-1} to one-half of the plots. The rye was killed in mid-May by applying glyphosate at 1.1 kg·ha^{-1}. Tomato seedlings were planted into the rye and bare-ground plots in late May. Four tomato varieties differing in cracking and soluble solids were used. There were two fertilizer regimes, no additional fertilizer, and N fertilizer applied broadcast before tomato planting, and as a sidedress based on soil tests, leaf analysis, and current recommendations. Tomato quality was evaluated based on 1) color as assessed using a Minolta chromameter, 2) cracking based on type and severity, and 3) soluble solids as determined by HPLC.

608 (PS 3)

Establishing Bumble Bees as a Supplementary System for Honey Bees in the Pollination of Watermelon, *Citrullus lanatus* (Thunb.)

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The effectiveness of bumble bees, *Bombus impatiens*, and honey bees, *Apis mellifera*, on the pollination of watermelon, *Citrullus lanatus* (Thunb.), was compared at the individual bee level. Correlations between the number of bee visits a flower received and the resultant seed set and fruit abortion rates were established. Using 'Royal Jubilee' watermelon, *B-impatiens*-visited flowers resulted in higher seed sets than *A. mellifera* when compared at equal bee visit numbers. This difference between bee types was highly significant. With respect to fruit abortion rates, no statistical difference between bee types was detected. However, bee visit count was significant. Increasing the number of bee visits received by a flower resulted in a lower percentage of aborted fruit.

609 (PS 3)

Prospects for Mechanical Harvest of Zucchini Squash

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Removing a portion of the foliage of zucchini squash without reducing yield would increase the efficiency of mechanical harvest since less plant material would be passed through the harvester. Pruning 50% of the leaves and petioles at either first or second harvest had no effect on third harvest fruit yield. Primary or secondary fruit growth rates were not affected by leaf removal. Presence of a primary fruit reduced the number of secondary fruit developing to marketable size but the rate of secondary fruit development was similar on plants with one, two, or three fruit. The maximum fruit to develop at one time in this planting was two per plant. Following one or two hand-harvests of zucchini squash, mechanical harvest efficiency will be increased after removal of 50% of the leaves and maturation of two marketable fruit per plant.

610 (PS 3)

Rating the Pod Setting Habit of Lima Bean (*Phaseolus lunatus* L.) Cultivars to Improve Harvest Recovery

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Mechanical pod strippers are the predominant method of harvesting lima beans (*Phaseolus lunatus* L.) for processing. Field losses are high, averaging 20% of potential yield in over 90 tests conducted in commercial fields. The three most significant factors that affect lima bean recovery are the field levelness, the relationship between ground speed and picking reel speed, and the lima bean variety. Further study on the relationship between pod location of four lima bean cultivars and the recovery of lima beans harvested with pod stripper combines was conducted in commercial fields. Pod location was categorized into three distinct zones of the plant. These three zones represented pods falling below the point the mainstem comes out of the ground, the first 5 cm from that point up the main stem, and all other pods higher than 5 cm above the stem. Differences in four cultivar's habits of setting pods in the three zones were established. 'M-15' placed more pods in the lower zones than other cultivars. 'M-15' also exhibited consistently more harvest loss than other cultivars when harvested with pod stripper combines. Other cultivars set pods higher in the plant and exhibited less harvest loss. With the harvest loss and pod set data, a rating procedure for the harvestability of lima beans was explored. While several potential rating systems demonstrated strong correlation with harvest loss data, a simple rating based on the percentage of pods in the canopy of the plant had the highest correlation coefficient ($r = 0.96$) with harvest loss. New cultivars can be evaluated for their harvestability characteristics using this rating system.

611 (PS 3)

Estimating Amount of Watering of Greenhouse-grown Muskmelons

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In greenhouse-grown muskmelon (*Cucumis melo* L.) cultivation at Shizuoka Prefecture, Japan, growth, fruit enlargement, and translocation rates must be controlled by water content of plants through environment control. To produce high-quality muskmelons, growers have to control soil moisture appropriately through daily watering, but it has been difficult to estimate the suitable amount of water. Our study was performed to estimate watering using simple watering model. It is well known that evaporation and transpiration rates are in proportion to the differences between water vapor density of atmosphere and that of leaf and soil, respectively, and are inversely related to their resistances. Therefore, an amount of water to be watered was estimated from air temperature, soil temperature, relative humidity, solar radiation, and grower's experience. The evaporation and transpiration resistances were set up to make evapotranspiration close to amount of watering. First, to estimate amount of irrigation, the relationship between the grower's imaginary watering, which ignored neither yesterday's watering nor today's soil moisture, and today's weather index, which indicate today's evapotranspiration rate, was investigated. Secondly, the yesterday's estimated evapotranspiration and yesterday's amount of evapotranspiration rate were compared. From the comparison, soil moisture conditions before watering whether soil is wet or dry were estimated. Third, revised coefficient of watering was decided by grower. Finally, estimated amount of watering was obtained from the following things; today's weather index, comparison of the prediction and actual evapotranspiration, revised coefficient. As the result, anybody who had no special knowledge could manage the soil moisture by only observing today's weather like skilled growers.

143 POSTER SESSION (Abstr. 612–623) Sustainable Production–Vegetables

612 (PS 5)

Yield and Nitrogen Concentration of Tomato following Winter Cover Crops

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Our objective was to determine the effect of winter cover crops on the yield and N concentration of the following crop of tomato. No commercial fertilizer was applied to the tomato crop. Cover crops were planted in fall in a randomized complete-block design with control (fallow), rye, hairy vetch, and crimson clover treatments. 'Mountain Pride' tomato was planted in spring after incorporating cover crops into the soil. Soil inorganic N content during the tomato growing season was significantly affected by the nature of cover crops planted during winter. Tomato planted after legumes had significantly greater amounts of inorganic N available for uptake compared to nonlegume or control. A rye cover crop did not have any effect on the yield of the ensuing tomato crop. On the contrary, a 15% increase in tomato fruit yields resulted from cover cropping with legumes. The N concentration in fruit in all treatments was similar. However, tomato grown after rye had significantly lower vegetative N concentration. Total N uptake was significantly greater in tomato succeeding legumes compared to nonlegume or fallow. It was concluded that by adding inorganic N into the soil, legumes increased the fruit yield and N uptake of the succeeding tomato crop.

613 (PS 5)

Cover Crop and Tillage Effects on Production and Nitrogen Nutrition of Sweet Corn

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A split-plot factorial experiment examined effects of tillage and winter cover crops on sweet corn. Main plots received tillage or no tillage. Cover crops consisted of hairy vetch, winter rye, or a mix, and N treatments consisted of plus or minus N fertilization. No significant effects of tillage on sweet corn yields were detected. Following corn not receiving inorganic N, vetch produced cover crop total N yields of 130 $kg \cdot ha^{-1}$ that were over three-times greater than those obtained with rye. Following rye winter covercrops, addition of ammonium nitrate to corn significantly ($P < 0.05$) increased corn yields and foliar N concentrations compared to treatments not receiving N. However, following vetch, corn yields and foliar N concentrations obtained without N fertilization equaled those obtained with N fertilization following rye or vetch. Available soil N was significantly ($P < 0.05$) greater following vetch compared to rye for ≈9 weeks after corn planting and peaked ≈4 weeks after planting. It was concluded that no-tillage sweet corn was successful and N fixed by vetch was able to sustain sweet corn production.

614 (PS 5)

Impact of Pesticide Residues in Composted Lawn Waste Compost on Vegetable Crops

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To conserve space in the Lincoln city landfill, a program for composting urban yard waste was initiated in 1992. Analysis of the first year's compost showed pesticide residues, including chlordane, DDT, DDE, and pendimethalin. We are investigating the concerns of the City Health officials regarding the risk of returning the compost to an urban environment, including use as a soil amendment for garden crops. To determine background levels of the contaminants, a survey was conducted of foundation, lawn, and garden soils of Lincoln properties. Sampling was based on the age of the house: 1 to 24, 25 to 49, 50 to 74, and 75 to 100+ years with three samples taken from each foundation, lawn, and garden. Higher residues were found in the soils of the 25 to 100+ houses than were found in the compost. No pesticide residues were found in the soil from the 1- to 24-year-old houses, with the exception of foundation samples. Chlordane (523 ppb) and heptachlor (44 ppb) were detected in these samples. Greenhouse garden crop studies showed no adverse growth of tomato, petunia, marigold, or sweet corn. Root crops are being analyzed for bioaccumulation.

615 (PS 5)

Effects of Repeated Application of Four Rates of Two Composts Varying in Carbon : Nitrogen Ratio on Soil Nitrogen and Leaf Lettuce Yield

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The effects of repeated application of two composts differing in carbon : nitrogen (C : N) ratio on soil NO_3-N, soil NH_4-N, and leaf lettuce yield was studied over three sequential crop cycles from 1995 to 1996. One compost type (HiCN) was prepared primarily from yard wastes and had a C : N ratio of 29 to 32:1 The other compost (LoCN) was a compost composed of a mixture of crude materials including yard wastes, feedlot manures, and vegetable trimmings and had a C : N ratio of 10 to 12:1. Before transplanting leaf lettuce, both composts were applied

and incorporated in the same plots repeatedly over three crop cycles at rates of 9, 18, 36, and 54 Mg·ha^{-1} (dry mass) in each application. In the first crop cycle, no differences were observed for weekly soil NO_3-N, NH_4-N, or leaf lettuce yield among compost types or rates. In the second and third crop cycles, weekly soil NO_3-N and soil NH_4-N were directly related to LoCN compost application rates. First harvest lettuce yield was also directly related to LoCN rate in the second and third cycles, but total yield was not related to LoCN rate. In the second and third cycles, soil NO_3-N and early and total lettuce yield were inversely related to rate of application of the HiCN material. Weekly soil NH_4–N was not consistently related to application rates of HiCN or LoCN material.

616 (PS 5)

Evaluation and Distribution of Onagraceae Species in the Texas Panhandle and Texas South Plains

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Oenothera biennis, common evening primrose, produces seeds that have a high oil content containing gamma-linolenic acid (GLA), a fatty acid of medicinal, and dietary importance. These plants are commonly found in sandy or gravelly soils and have the ability to tolerate hot, dry conditions. Plants containing economically important oils such as GLA are potential crops for arid environments with minimal irrigation. Many native species of evening primrose have not yet been evaluated for oil content. In this project, a systematic survey of native Onagraceae species was conducted in the Texas Panhandle and the Texas South Plains. Six species of *Oenothera* and two species of *Calylophus* were found. Locations were recorded with a Global Positioning System (GPS) to facilitate relocation and collection. Distribution maps were made for each species. The occurrence of species varied greatly from north to south, with the exception of one species that occurred throughout the area surveyed. Seeds were collected from each species and from various locations within the range of each species. Germination percentages were determined for each species and had a wide variation. Evaluation of the oil content of this native germplasm could possibly lead to development of new commercial sources of GLA.

617 (PS 5)

Leaching of Nitrate, Ammonium, and Phosphate from Compost Amended Soil Columns

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Compost amendment to agricultural soils has been shown to either reduce disease incidence, conserve soil moisture, control weeds or improve soil fertility. Application of compost can range from 5 to 250 Mt·ha^{-1} (N content up to 4%). Large application of compost with high N and P levels may result in excessive leaching of nitrate, ammonium, and phosphate into groundwater. It could be a serious concern on the east coast of Florida with its high annual rainfall and shallow water table. In this study, five composts (sugarcane filtercake, biosolids, and mixtures of municipal solid wastes and biosolids) were collected from different facilities throughout Florida. Composts were applied on a surface of 15-cm sandy soil columns at the rate of 100 Mt·ha^{-1} on the surface basis and leached with deionized water by 300 ml·d^{-1} for 5 days (equivalent to 34 cm rainfall). The concentrations of NO_3-N, NH_4-N, and PO_4-P in leachates reached as high as 246, 29, and 142 mg·L^{-1}, respectively. The amount of N and P leached following 5-day leaching events accounted for 3.3% to 15.8% of total N and 0.2% to 2.8% of total P as inorganic forms.

618 (PS 5)

Sustainability of Organic Fertilization of Macadamia with Macadamia Husk–Manure Compost

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A fertilization experiment, started in 1989, evaluated the merits of macadamia husk-manure compost as fertilizer for the production of macadamia. Three fertilization treatments were compared at four sites over 4 years on the MacFarms of Hawaii Honomalino orchard. The treatments were conventional fertilization, a combination of solid and liquid mineral fertilizers annually adjusted by the orchard manager based on leaf and soil analysis; compost only as 5 tons of a macadamia husk-cattle manure compost applied annually between July and October; and compost plus supplemental mineral fertilizers deemed needed by the orchard manager based on leaf and soil analysis. In-shell nut and kernel yield and quality was not significantly different between treatments. Change in leaf nutrient values appears minimum except for slightly lower N at two sites for the compost treatment. Higher Mg was noted for the compost but not the compost plus treatments at the irrigated sites. The effect of compost on the soil nutrient levels was more distinct and may have a delayed and longer term effect. Total exchange capacity of the soil increased, as did soil pH, Ca, Mg, K, and Na. Organic matter increased only at the site with least soil. Extractable soil Fe decreased, this maybe related to the change in pH, but had no consistent effect on leaf Fe. Compost fertilization was not considered sustainable as the cost of compost and its application exceeded conventional fertilization.

619 (PS 5)

Nutrient Application Reduction to Vegetable Production Land Through Soil Testing and Demonstration Plots

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A cooperative project between the Univ. of Florida Cooperative Extension Service, USDA Natural Resources Conservation Service, and Consolidated Farm Services Agency to address farm nutrient use and water management in the Lake Apopka hydrologic unit area of Florida began in 1991. This area was selected due to the vegetable production on the organic soils (muck) and sandy soils north of Lake Apopka, Florida's most polluted large lake. Discharge of nutrient-laden water into the lake from the 4050-ha vegetable production area has been implicated as a major contribution to the hypereutrophic status of the lake. Changes in cultural practices including water management, which would lead to a reduction in nutrient loading, should aid in the restoration of the lake. A grower survey of fertilizer application rates was conducted each year for 4 years with the baseline established by the 1991 survey. Demonstration plots using soil tests as the basis for fertilizer rates compared to normal grower rates of fertilizer were established for carrots, sweet corn, and celery. In 1995, muck growers had reduced their total application of N by 16%, P 52%, and K 32%, without reducing yields or quality. Nutrient applications were reduced by over 656 t/year over the years surveyed. Farms have saved fertilizer and reduced environmental risks.

620 (PS 5)

On-farm Demonstrations of Soil and Pest Management Options within California's San Joaquin Valley Row Crop Production Areas

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A participatory, on-farm research and extension program has been established around 16 demonstration comparisons of biologically integrated soil building– pest management systems and conventionally managed systems within the West Side row crop area of California's San Joaquin Valley. In each of the biologically integrated parcels, cover crops and composted organic materials are integrated into rotations wherever appropriate, whereas in the conventionally managed parcels, mineral fertilizer applications are made. Pest management practices are evaluated and biologically and informationally intensive alternatives are developed through a participatory process. Indices of soil quality including nutrient status, water stable aggregates, organic matter content, and phospholipid fatty acids are routinely monitored. Information related to the objectives, structure and monitoring activities of this project during the establishment phase will be discussed.

621 (PS 5)

Rotating Vegetables and Peanuts

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Monoculture can lead to reduced yields due to pressure from biotic or abiotic sources. This pressure may be reduced by rotating crops. In the first year, a 0.5-ha of a Bernow fine-loamy, siliceous, thermic Glossic Paleudalf soil was planted to peanuts at Lane, Okla. In each of the following 5 years, the area was subdivided in to four rotations that were replicated four times. Bell pepper, cucumber, navy bean and cabbage were planted after 1, 2, or 3 years of peanuts. The first vegetable planting in each rotation was followed by either vegetables or peanuts, and

these crops were planted in 3 of the 6 years in each rotation. Half of each plot was treated with soil fungicides, and half of the peanut plots were treated with foliar fungicides. Sclerotia, likely in the genera *Sclerotia* and *Sclerotinia*, were counted in the spring of each year starting in the second year. Peanut yields in the first year were 6.6 $Mg \cdot ha^{-1}$ but were <2.5 $Mg \cdot ha^{-1}$ thereafter. Yields of vegetables planted to follow 1 or 2 years of peanuts were normal for this location. Yields in later vegetable plantings in these rotations were reduced by 50%, and yields of vegetables planted after 3 years of peanuts were significantly less than vegetables planted after 1 or 2 years of peanuts. Numbers of sclerotia fluctuated over time, but numbers in the spring of the second year were the same as in the spring of the sixth year. The vegetables tested here should not be planted after >2 years of peanuts at this location.

622 (PS 5)

Protective Border Plantings

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The viability of urban interface agriculture (located near housing tracts, shopping centers, roadways, schools, and parks) depends on the ability of growers to allow their neighbors to enjoy the full benefits of their property. Growers must eliminate or minimize the noise, dust, flies, spray drift, odors, and field worker improprieties that can be associated with agricultural enterprises. An excellent way to minimize "ag/urban interface" problems is to grow a protective border planting between housing and agricultural production fields. Border plantings increase the aesthetic value of agricultural open spaces and screen out unwanted agricultural activities for those living adjacent to production areas. An ideal protective barrier planting consists of plants that 1) grow quickly and are easy to maintain; 2) provide a good physical barrier to dust, spray, and noise; 3) are inexpensive and aesthetically pleasing; 4) do not harbor insect pests that would damage crops or surrounding landscape plantings; and 5) support beneficial insects that prey on crop insect pests. Border planting sites were developed to identify plants that are adapted to border planting use and to gather information on insect populations that are supported by those plantings. Early results indicate that native plants including coyote bush, wild lilac, buckwheat, coffeeberry, yarrow, deer grass, and purple-needle grass can provide the desired physical barrier and beneficial insect support. Bio-diversity is the key to increasing populations of beneficial insects and several different native plant species have, therefore, been incorporated into the border plantings. Beneficial insect populations have been increased with appropriate border plantings.

623 (PS 5)

Ecologically Sound and Aesthetically Pleasing—Aesthetic Design for Effective Wildlife Habitats

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In the past decade, there has been a growing trend toward conservation and management of wildlife and the environment. Growing suburban development has increased displacement of native animals from their natural habitats; thus, there is an ever-increasing need to manage not only existing forests and large land holdings for wildlife but also developed land areas. The idea of "backyard habitat" gardening and the "green movement" in golf course design address these issues of wildlife habitat and provide design solutions that hail the growing need for natural habitats. The same principles also can be used in commercial landscape design and ultimately in reclaiming grazing pasture land for dual habitat by farm animals and native wildlife. Just as the "American Lawn" provides minimal support for wildlife due to its lack of diversity, the manicured pasture of the American farm can also be limiting for wildlife. Providing areas of cover for nesting and protection can benefit the "kept" and "unkept" animals inhabiting the area. Furthermore, the biophilic landscape provides a psychologically healthy biosphere for the personnel working on the farm. In designing landscape plans with the primary goal of aesthetic enhancement of university experimental research farms, the principals of water conservation, integrated pest management, and providing wildlife cover and food are applied to develop an aesthetically pleasing design that also provides habitat for displaced wildlife. The intent of the project is to explore the possibilities in designing successful habitats for wildlife while preserving the ultimate goal of livestock production. Implementing successful ecologically sound landscapes enable the land-grant university to teach the public the benefits of wildlife conservation and the importance of its incorporation to all aspects of land use.

104 POSTER SESSION (Abstr. 624–628) Nutrition–Fruits

624 (PS 1)

Using Leaf Chlorophyll Meter to Predict Nitrogen Status and Yield of Grapefruit Trees

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Rapid and accurate diagnosis of plant nutrient deficiency is critical for growers to use fertilizer economically and to minimize environmental concern. The objective of this study was to evaluate the use of leaf chlorophyll meter (SPAD-502) to predict nitrogen status and yield response of grapefruit trees. The study includes two irrigation treatments, three fertilizer sources, and four fertilizer rates. No significant differences in SPAD readings and leaf N were found between two irrigation treatments. Correlations between SPAD readings and leaf N were higher for the spring flush ($r = 0.61$) than that for summer flush ($r = 0.49$). There were poor relations between SPAD meter readings and the extractable chlorophyll content in the spring flush on a dry-weight basis ($r = 0.25$). Higher correlations between SPAD meter readings and N rates or fruit yields than between leaf N concentrations and N rates or fruit yield.

625 (PS 1)

Effect of Foliar Boron on Fruit Yield and Quality of *Citrus sinensis* cv. Hamlin

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A field trial conducted at Yuma, Ariz., examined the effect of foliar boron application on fruit yield and quality of *Citrus sinensis* cv. Hamlin. Boron was applied to 5-year-old trees at five treatment levels (0, 500, 1000, 2000, and 3000 ppm) before or after flowering in a split plot design. At harvest, fruit number, size and quality were determined. Yield ($P = 0.01$) and average fruit number per tree ($P = 0.02$) were different among treatments. The highest yield was obtained with the 500 ppm treatment. In this first year of the trial there was no difference in average fruit weight, fruit pH, titratable acidity, peel thickness, juice volume, or soluble solid content of fruit between the treatments. Previous studies indicate that boron influenced in vivo and in vitro pollen germination in many crops. Increased fruit yield may have occurred because boron was transported to the flowers where it exerted its influence on increased fruit set through an effect on pollen viability or pollen tube growth. Further investigation of this hypothesis is underway.

626 (PS 1)

Estimation and Significance of Nutrient and Starch Storage Pools in Mature, Alternate-Bearing Pistachio (*Pistacia vera* L.) Trees

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The effect of crop load on nutrient and starch storage in mature, alternate-bearing pistachio trees was examined. Tree storage pools were estimated from the differences in nutrient and starch contents of perennial tree parts between dormancy (the period of highest nutrient and starch content) and following spring flush (the period of lowest nutrient and starch content). Following a lightly cropping (off) year, trees contained significantly larger N, P, and K storage pools than following a heavily cropping (on) year. The relative contribution of leaf nutrient resorption to tree nutrient storage pools varied depending on the crop load. Nutrient storage is a function of net leaf nutrient resorption and current uptake from the soil. Leaf nutrient (N, P, and K) resorption was a more significant component of nutrient storage in on-year than off-year trees. The contribution of nutrient storage to shoot (i.e., leaves, fruit, current-year wood) nutrient contents was evaluated following the spring flush (May) and nut fill (September) periods. Nutrient storage pools are an important source of nutrients during the spring flush of growth, but nutrient demands during nut fill are met primarily by current nutrient uptake from the soil. The relationships between nutrient storage and uptake are discussed.

627 (PS 1)

Aluminum and Phosphorus Interactions in Mycorrhizal and Nonmycorrhizal Highbush Blueberry Plantlets

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Aluminum and P interactions were investigated in mycorrhizal (M) and nonmycorrhizal (NM) highbush blueberry plantlets in a factorial experiment. The toxic effects of Al on highbush blueberry were characterized by decreased shoot, root, and total plant dry weight. Many of the negative effects of Al on plant root, shoot, and total dry-matter production were reversed by foliar P and N application, indicating P or N uptake were limited by high Al concentration. However, Al mediated growth reduction in P-stressed plants suggested that the restriction of P uptake by high Al may not have been the only mechanism for Al toxicity in this experiment. Root Al and P concentration were negatively correlated in NM plantlets but not in M plantlets, suggesting mycorrhizal infection may alter P uptake processes. Al uptake also was affected by M infection, with more Al accumulating in M plantlet roots and leaves. Correlations among foliar ion concentrations were also affected by M fungal infection.

628 (PS 1)

Behavior of Red Roomy Grapevines to Cycocel and Some Micro Nutrients: II. The Effect on Nutritional Status of the Vines, Berry Set, and Yield

A.M. Akl; F. Ahmed Faissal,* and *S. Youssef William,* Hort. Dept. Fac. Agric. Minia Univ. Egypt

Nutritional status of the vines, berry set, and yield as effected by the application of cycocel at 0.0, 500, 1000, or 1500 ppm and/or using a mixture of Mn, Zn, Cu, and Fe at 0.3% were studied. Cycocel was applied at different periods starting immediately after pruning and ending at 30 days after berry set. Results showed that three sprays of cycocel immediately after pruning, 15 days before first bloom, and at 30 days after berry set, particularly with the application of the four micronutrients together at 0.3%, proved much more effective in increasing the leaf content of total carbohydrates, total N, Zn, Mn, Cu, and Fe as well as berry set, number of clusters, yield and average cluster weight. Spraying Red Roomy vines three times with cycocel at 1000 ppm in combined with Mn + Zn + Cu + Fe at 0.3% gave satisfactory improvement in nutritional status and yield.

108 POSTER SESSION (Abstr. 629–636) Nutrition–Vegetables and Herbs

629 (PS 4)

The Effect of Calcium Treatments on the Incidence of Gray Mold Rot in Three Tomato Cultivars

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Due to the declining availability of fungicides for use in commercial tomato production, there is a need to investigate alternative disease control methods. Several theories of disease resistance are associated with an increase in plant tissue calcium content, which has increased resistance of tomato seedlings to bacterial wilt and other diseases. Three tomato cultivars ('Mountain Supreme', 'Sunrise', and 'Celebrity') were grown in a greenhouse hydroponic system to study the role of Ca in reducing decay of fruit by *Botrytis cinerea*. Calcium treatments of 20, 200, or 1000 ppm were applied in a modified Hoagland's solution. A 3×3 factorial randomized complete-block design was used. Mature whole leaves were collected from immediately below the third flower clusters and the calcium content analyzed by inductively coupled plasma emission spectrophotometry. Harvested fruit were inoculated with a 5×10^5 spore/ml conidial suspension of *B. cinerea* and the decay lesion diameter measured once daily for 7 days. This was repeated for 8 consecutive weeks. Leaf Ca content significantly increased ($P < 0.01$) as the Ca treatments increased from low to medium (310%) and from medium to high (150%). The medium and high Ca treatments significantly reduced the area of decay caused by gray mold rot ($P < 0.01$). There were no differences in Ca content or decay among cultivars, and the Ca $\times$ cultivar interaction was not significant. It appears that leaf Ca content is negatively associated with resistance of greenhouse-grown tomatoes to gray mold rot, strengthening the hypothesized role of calcium in promoting disease resistance.

630 (PS 4)

Effects of Calcium on Yield and Incidence of Blossom-end Rot of Three Tomato Cultivars

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An experiment was conducted to investigate the effect of Ca nutrition on yield and incidence of blossom-end rot (BER) in tomato. Three levels of Ca (low = 20 ppm, medium = 200 ppm, and high = 1,000 ppm; selected to represent very deficient, normal, and very high levels of calcium) were applied to three cultivars of tomatoes ('Mountain Supreme', 'Celebrity', and 'Sunrise'; selected to represent genetic differences in susceptibility to BER) grown in modified Hoagland solutions using a greenhouse hydroponic system. The experiment was constructed in a randomized complete-block design with three blocks, two replications, three cultivars, and three calcium treatments. The source of basic nutrients was a 5–11–26 soluble fertilizer containing micronutrients. The ratio of N–P–K was adjusted to 1.0–1.3–3.0 by adding NH_4NO_3 (34% N). Calcium was added as $CaCl_2$. Nitrogen concentrations were maintained at 30 (first month), 60 (second month), and 90 ppm (during fruit growth), while the concentration of other nutrients followed proportionally. Cultivars differed significantly in yield and average fruit weight but not in incidence of BER or leaf Ca concentration. There was no cultivar $\times$ calcium treatment interaction. Leaf Ca content across cultivars was increased by 34% and 44%, respectively, by the medium and high Ca treatments. Average fruit weight and total yield per plant were not significantly different between the low and medium Ca treatments, however, both were reduced by the high Ca treatment. Incidence of BER was 95% higher in the low rather than in the medium Ca treatment. There was no significant difference in BER between the medium and high Ca treatments.

631 (PS 4)

Nitrogen Management of Drip-iIrrigated Peppers

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Inadequate N can reduce growth and yield, but excess N can be uneconomical and environmentally harmful. Our objective was to investigate the potential for using fertigation and on-farm plant-nutrient monitoring to improve the efficiency of N fertilizer use by bell peppers (*Capsicum annuum* L.). Two N fertilizer treatments were compared: 1) all N applied preplant and 2) one-third of the N applied preplant and the remainder injected into the drip-irrigation lines throughout the growing season. Total application rates were N at 118 $kg \cdot ha^{-1}$ for both treatments. Data were collected for total yield, marketable yield, and fruit size. Leaf and petiole samples were collected every 2 weeks and were used to monitor plant N status throughout the growing season. A Horiba/Cardy nitrate meter was used to measure nitrate concentrations in freshly-pressed petiole sap. A SPAD chlorophyll meter was used to measure leaf chlorophyll content and give an indirect measure of leaf N concentrations. Subsamples of leaves and petioles also were saved for conventional laboratory analyses. Whole (aboveground) plant samples were collected every 2 weeks, analyzed, and used to calculate differences in N accumulation. Suction cup samplers were installed at the 24-in soil depth and water samples collected every 1 to 2 weeks for nitrate analysis. Except for early in the growing season, petiole sap nitrate and leaf chlorophyll were higher in the fertigation treatment. Plant dry matter and total N accumulation also were much larger, but fertigation did not increase yield. Nitrate leaching was greater early in the season with 100% preplant N, but later in the season it was greater with fertigation. Data suggested that adequate plant N, reduced nitrate leaching, and equivalent yields are possible with fertigation at reduced N-rates compared to 100% preplant fertilizer applications.

632 (PS 4)

Evaluation of Five Different Plant Nutrients for Their Effect on Yield, Quality, and Postharvest Condition of Bell Peppers in a Subtropical Environment

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Fertilization programs used commercially for bell peppers (*Capsicum annuum*) in the subtropical Lower Rio Grande Valley of Texas may vary substantially from recommendations based on research. Therefore, a commercial fertilization pro-

gram used on a significant fraction of the pepper production in this area was evaluated at two locations. Preplant soil tests showed NO_3-N levels were low at one location and very high at the other. Nitrogen application where preplant soil NO_3-N was low resulted in a six-fold yield increase (from 197 to 1203 kg·ha^{-1}), and improvements in fruit weight, fruit volume, fruit density, wall thickness, wall strength, and carotenoid and chlorophyll a and b contents. No other nutrient application at either location or N application at the site where preplant soil NO_3-N levels were high significantly affected yield by size class, fruit quality characteristics, storage properties, or mineral and organic components. Nitrogen application had the greatest effect on dry-weight accumulation and N uptake during fruit set and maturation when N demand was high. Where N responses were observed, N application increased total dry weight in plant and fruit by 150% and total N uptake by 186%, yet this increase amounted to a N fertilizer uptake efficiency of only 12%. Thus, N should be used judiciously to prevent pollution of drainage and ground waters.

633 (PS 4)

A Recirculating Hydroponic System for Micronutrient Studies on Rapid Cycling Brassica and Its Experimental Evaluation

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Rapid cycling brassica (RCB) plants, because of their short life cycle and ease of growth under laboratory conditions, offer a valuable tool for studying *Brassica* nutrition. We have been particularly interested in B nutrition in *Brassica* and, therefore, a hydroponic system was developed to accurately deliver micronutrient concentrations to RCB plants. RCB plants were supported in predrilled holes in the lids of brown 1-L plastic containers. Nutrients were supplied by spraying a modified Hoagland's solution onto the plant roots as they developed inside the containers. This system provided adequate solution aeration for plant growth and allowed analysis of both plant shoots and roots. RCB seeds were pregerminated for radicle emergence, then placed in the holes in the plastic container lids. The effect of B nutrient concentration on B uptake was examined using nutrient solutions containing 0.08, 0.02 and 0.00 ppm added B. Leaf B contents were 139.5, 26.1, and 7.1 g·g^{-1} for plants grown in 0.08, 0.02 and 0.00 ppm added B, respectively. Effects of drought stress on B uptake and distribution were studied by adjusting nutrient solution osmotic potential using polyethylene glycol (PEG) 8000. PEG-induced drought, (osmotic potential –0.1 MPa) reduced leaf and root B content ≈50% compared to plants grown in nutrient solution only (–0.05 MPa). Boron content in the shoots and pods, however, was not affected by PEG-induced drought stress. These results suggest that this system provides a reliable tool for studying nutrition and drought stress effects using RCB plants.

634 (PS 4)

Effects of Water Stress on Boron Partitioning and Glucosinolate Composition in Two Hydroponically Grown Canola Cultivars

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High glucosinolate content in brassica meal is a limiting factor in consumption of rapeseed. In recent years canola cultivars of rapeseed with decreased glucosinolate content have been developed. However, environmental and nutritional factors are also believed to influence glucosinolate content. This study was conducted to determine the relationships among water stress, B nutrition, and glucosinolate content in canola. Two canola cultivars ('Cyclone' and 'American A112') were grown in a continuously recirculating hydroponic system with modified Hoagland solution (0.6 ppm B). Water stress was induced gradually (2% per day using polyethylene glycol 8000) starting when plants were 4 weeks old. Osmotic potential was maintained at –0.1 MPa (high stress level), –0.085 MPa (medium stress), or 0.05 MPa (control). Treatments were arranged in a randomized incomplete-block design, with three blocks, four replications, two cultivars, and three treatments. Upper leaves (no. 15 and higher) were collected and analyzed by inductively coupled plasma emission spectrometry for B content. Total and indole glucosinolate content of seeds were measured colorimetrically and by HPLC. The leaf B content of stressed plants decreased by 55% in 'Cyclone' and 29% in 'American A112'. Total glucosinolate content increased 28% and 12%, respectively, in stressed plants of 'Cyclone' and 'American A112'. Indole glucosinolate content was 44% and 13% higher in the same plants. The interaction between cultivar and water stress was not significant for glucosinolate content but was significant for B content of the leaves.

635 (PS 4)

Influenced of Plant Production and Nitrogen Fertilization Rates on the Yield of Garlic (*Allium sativum* L.)

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National Research Inst. of Agriculture of Uruguay defined garlic as an important crop because its potential for exportation. Plant population and N management have been studied since 1992. Plant population of 112, 250, 333 and 500 thousand plants/ha at rates of N at 0, 75, 150 and 225 kg·ha^{-1} were tested in 1992, 1993, and 1995. Drip irrigation and plastic mulch with populations from 240 to 960 thousand plants/ha in 1992 and from 236 to 586 plants/ha in 1993 were evaluated. Nitrogen rates of 0, 40, 80 and 120 kg/ha, and application times were also tested with a population of 250 thousand plants/ha, in 1992 and 1993. Plant population of 240, 320 and 560 thousand plants/ha yielded 12,0; 12,4 and 14,2 t·ha^{-1} respectively. As plant population increased, bulb size decreased. Yield increased up to rate of N at 150 kg·ha^{-1}.

636 (PS 4)

Nitrogen, Phosphorus, and Soil pH Effects on Goldenseal (*Hydrastis canadensis* L.) Growth, Root Yield, and Quality

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Goldenseal was grown in pots of forest soil under a wood-lath structure for 3 years. Soil treatments consisted of four pH levels (4.5, 5.5, 6.5, and 7.5) and four rates of P and N (P or N at 0, 0.1, 0.2, and 0.3 kg·m^{-3} of soil) arranged as a RCB factorial with eight replications. Final root weights were highest with pH 5.5 and 6.5. Although response to N and P rates varied from year to year, final root weights showed no response to P and decreased with increasing N. Increase in fresh weight from initial weight of the planting stock to final total root weight ranged from 5.7× (pH 4.5, P at 0 kg·m^{-3}, and N at 0.3 kg·m^{-3} treatment) to 28.5× (pH 5.5, P at 0.2 kg·m^{-3}, and 0 N treatment). Flowering, fruit set, plant height, leaf number, and fibrous roots : rhizome ratio were highest at pH 5.5 and 6.5 and not influenced by P or N rates. Preliminary analysis suggest that root alkaloid content was also affected by soil pH.

147 POSTER SESSION (Abstr. 637–645) Nutrition–Woody Ornamentals/ Floriculture

637 (PS 8)

Seasonal Patterns of Nitrogen Use in Three Woody Ornamentals

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Seasonal patterns of N uptake and allocation in *Buxus microphylla*, *Acer* x *freemanii* and *Fothergilla gardenii* were investigated for improving fertilization strategies. Rooted cuttings were planted to 3.5-L containers 25 May 1995. Plants were drip-irrigated on an as-needed basis with N at 50, 100, or 200 mg·L^{-1} solutions. Leaves, stems, and roots were destructively harvested every 6 weeks, starting 24 June. Net changes in dry weight and N uptake were determined for each of four, 6-week periods. Increasing N rate increased tissue N concentration in all species, and reduced root : shoot ratios in *Acer* and *Fothergilla*. Dry weights of *Acer* increased with N rate; whereas other species gave no positive response in dry weight beyond N at 100 mg·L^{-1}. Nitrogen at the 200-mg·L^{-1} rate caused severe injury to *Fothergilla*. Nitrogen uptake of the deciduous species increased in the first three periods, with greatest N uptake between 1 Sept. and 12 Oct. Greatest N uptake in *Buxus* occurred between 15 July and 1 Sept. Total N content in *Buxus* increased between 15 Oct. an 1 Dec. with a large proportion of N appearing to shift from leaf to stem tissue. In the other species, leaf abscission caused a net reduction in total N contents in the 100 and 200 mg·L^{-1} rates, although stem and root N contents increased. Increasing N rate in *Acer* delayed fall coloration but hastened leaf abscission. End-of-season N recovery (N taken up/N applied) was extremely low, and decreased with increasing rate of N. *Acer* had the highest recoveries (4.1%, 2.6%, and 2.0%) for low, medium, and high fertilizer rates, followed by *Buxus* (2.6%, 2.2%, 1.0%) and *Fothergilla* (1.7%, 1.8%, 0.4%).

638 (PS 8)

Nutrient Uptake Patterns in Forsythia

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Nutrient uptake and allocation patterns of *Forsythia ovata* x *europaea* 'Meadowlark' grown in a recirculating hydroponic system in the greenhouse were observed for 5 months. Dormant rooted cuttings were placed in the system on 8 May 1995. The nutrient solution supplied (in $mg \cdot L^{-1}$) 100 N, 48 P, 210 K, 30 Mg, 60 Ca, 117 SO_4, 3 Fe, 0.5 Mn, 0.15 Zn, 0.15 Cu, 0.5 B, 0.1 Mo. Solutions were completely replaced every 2 weeks. Leaves, stems, and roots were harvested for dry weight and nutrient analysis at monthly intervals. Nitrogen uptake and dry-weight accumulation in the roots increased throughout the experiment, reaching a maximum in the fifth month (September). Nitrogen uptake and dry-weight accumulation of leaves and stems increased rapidly throughout the first 3 months, then leveled off. Whole-plant N recovery (N taken up/N in hydroponics system) reached a maximum (58%) between 6 July and 3 August. N recovery in the hydroponics system was about 10 times greater than what we observed in related experiments with woody plants in typical production environments, suggesting that there is potential for manipulating fertilization and cultural practices to increase fertilization efficiency in woody ornamentals. Nutrient recovery and accumulation patterns of P and K also will be presented.

639 (PS 8)

Does Nitrogen Nutrition in the Nursery Affect Plant Establishment and Performance in the Landscape?

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Ilex opaca and *Lagerstroemia indica* plants were grown over 9 months using complete nutrient solutions differing in N concentration [$(N)_A$: 15, 30, 60, 120, 210 and 300 $mg \cdot L^{-1}$]. Biomass production increased as $(N)_A$ were raised from 15 to 60 $mg \cdot L^{-1}$, but was depressed by higher concentrations. Increases in $(N)_A$ produced higher shoot : root ratios. Maximum leaf N concentration was observed at 60 $mg \cdot L^{-1}$, with similar values at higher $(N)_A$. Plant survival, establishment and performance was evaluated over 15 weeks following transplant (15 WAT) to a landscape with minimum management conditions. Despite the initial significant differences in growth, shoot : root ratios and plant N status, plant establishment was not affected following transplant. Plant characteristics changed significantly over time, and by 15 WAT, all of the measured variables were statistically the same across all treatments. Flowering was, however, delayed over several weeks for *Lagerstroemia indica* plants grown at the higher $(N)_A$. Analysis of these results indicate that plant production under relatively low N levels in the nursery maximizes N fertilizer use efficiency without affecting landscape establishment and performance.

640 (PS 8)

Nitrogen Form and Stage of Development Affect Growth and Nutrient Uptake of Poinsettia

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Crop-specific tailoring of fertilizer composition and timing of application reduces expense and runoff pollution. We examined the effects N forms and ratios have on growth, development, and utilization of nutrients in poinsettia (*Euphorbia pulcherrima* Willd. Ex Klotz.). Rooted cuttings of poinsettia 'Freedom' were grown to flowering (10 weeks) in aerated solution culture under greenhouse conditions. Treatments consisted of five N ratios (percent ammonium : percent nitrate) of 100:0, 75:25, 50:50, 25:75, and 0:100 with a total N concentration of 150 $mg \cdot L^{-1}$. Dry mass for all plant parts and height increased as the ratio of NO_3^- increased. Leaf and bract areas were greatest with ratios of 25:75 and 50:50, respectively. Plants receiving 100% NH_4^+ exhibited severe ammonium toxicity symptoms and uptake of all macronutrients was suppressed. Average weekly uptake of NH_4^+, NO_3^-, P, and K was significantly affected by the treatments. Maximum uptake of NO_3^- and K occurred with 100% NO_3^-, P with 25:75, and NH_4^+ with 100% NH_4^+. Uptake averaged across all treatments was divided into physiological growth stages (GS) to identify peak demand periods. The greatest uptake of NH_4^+ and NO_3^- was from the beginning of treatments to floral induction (GSI). Uptake of P, K, and Mg peaked at GSII, floral induction to visible bud. Visible bud to anthesis (GSIII) had the lowest uptake for all nutrients. These results demonstrate how NH_4^+: NO_3^- ratios and stage of development can influence growth and nutrient absorption.

641 (PS 8)

Improvement of Plant Stress Resistance with Low Phosphorus

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Impatiens (*Impatiens* x *hybrida* 'Impulse Orange'), and marigold (*Tagetes* x *hybrida* 'Janie Tangerine') plants grown under low phosphorus were more resistant to drought stress than plants grown with a conventional, high-P fertilization program. Low concentrations of P were supplied using alumina-buffered P incorporated into the peat media. Alumina was charged with two levels of P, giving two levels of P-desorption. The alumina-buffered P amendment amounted to 2% by volume of the medium. Control plants (high-P treatment) were fertilized with a nutrient solution containing a P concentration of 1.5 mM. Phosphorous leaching was reduced by 96% to 99.4% in the low-P treatments compared with controls. Low-P plants showed no signs of P deficiency or aluminum toxicity. Impatiens plant diameter was significantly reduced by low-P fertilization, and leaf area was reduced by low P in both species. In marigold plants, roots were confined to a small volume beneath the drip tube in high-P plants, while in low-P plants they were well distributed through the medium. Impatiens roots showed no obvious differences in root distribution. Plants at the marketing stage were exposed to drought. The low-P plants of both species wilted more slowly and recovered more quickly when irrigated than the high-P controls. The reduced leaf area on the low-P plants may account for the improvement in drought tolerance.

642 (PS 8)

Marigold Varieties Vary in Susceptibility to Iron Toxicity

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Our objective was to assess the susceptibility of seven marigold varieties to Fe toxicity. Marigold varieties included were one hedge type, 'Orange Jubilee'; five semi-dwarf types, 'First Lady', 'Gold Lady', 'Orange Lady', 'Marvel Gold', and 'Yellow Galore'; and one dwarf type, 'Discovery Orange'. Plants were grown in a greenhouse in a soilless medium and treatments consisted of 0.018 mM (low) and 0.36 mM (high) Fe-DTPA incorporated into a nutrient solution. Plant height was not affected by Fe treatment and ranged from 32 cm in 'Orange Jubilee', 13 to 14 cm in the semi-dwarf varieties, and 7.0 cm in 'Discovery Orange'. Leaf dry weight per plant was not affected by Fe treatment and ranged from 1.15 g in 'Orange Jubilee', 0.68 to 0.95 g in the semi-dwarf varieties, and 0.56 g in 'Discovery Orange'. Symptoms of Fe toxicity only developed in the high Fe treatment, and the percent leaf dry weight separated at harvest as symptomatic ranged from 97% in 'Orange Jubilee', 55% to 85% in the semidwarf varieties, and 15% in 'Discovery Orange'. The Fe concentration in leaves in the high Fe treatment was 5.7-times greater in 'Orange Jubilee', 2 to 3-times greater in the semi-dwarf varieties, and 1.6-times greater in 'Discovery Orange' than in the low Fe treatment. Based on these findings, 'Orange Jubilee' and 'Discovery Orange' were the most and least susceptible varieties, respectively, to Fe toxicity of the seven marigold varieties evaluated in this study.

643 (PS 8)

Nitrogen Mineralization and Immobilization and Plant Growth Response to Nitrogen Fertilization in Potting Media Containing Compost.

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The potential for N mineralization or immobilization in potting media containing compost was investigated in experiments using sunflower (*Helianthus annuus* 'Sunrich Yellow') as a test crop with potting media formulated from 3 aged pine bark : 2 sphagnum peat or compost : 1 vermiculite (by volume). Cropped and uncropped media in 350-mL pots were fertilized by subirrigation with complete nutrient solutions containing N at 2, 4, 6, 8 or 12 $mmol \cdot L^{-1}$ as ammonium nitrate. In control medium without compost, sunflower fresh mass increased linearly with increasing N. In one compost medium (C), growth was stimulated and with N at 6 $mmol \cdot L^{-1}$ was equal to growth with N at 12 $mmol \cdot L^{-1}$ in the control medium. With another compost medium (A), growth was inhibited and did not respond to increasing N. In medium C, saturated media extracts (SME) obtained before and up to 12 days after transplanting had higher concentrations of NH_4 and NO_3 than the control medium. In medium A, NH_4 concentrations were similar to controls, but NO_3 concentrations were lower. Nitrite concentrations were less than 0.2 $mmol \cdot L^{-1}$ and were highest in medium C. Nitrogen derived from compost in medium C substantially reduced the soluble fertilizer N requirement for sunflowers, while N immobilization by compost in medium A was not overcome by increasing fertilizer N.

644 (PS 8)

Ability of Pre-charged Clinoptilolite in a Soilless Root Medium to Provide Potassium and Phosphate during Chrysanthemum Production

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Many soilless root media have limited ability to retain nutrients. Zeolites are minerals that have substantial nutrient buffering capacity and can be precharged with K, and possibly PO_4, and combined with soilless media to provide these nutrients during crop production. The zeolite clinoptilolite was precharged with K and PO_4 at two rates that were estimated from sorption isotherms to result in equilibrium root medium solution concentrations of P at >1 $\mu g \cdot ml^{-1}$ (low rate) and K at 125 $\mu g \cdot ml^{-1}$ (high rate). Precharged clinoptilolite was mixed with a 7 sphagnum peat : 3 perlite root medium to comprise 20% (v/v) and evaluated as the sole source of K and PO_4 during production of *Dendranthema ×grandiflorum* (Ramat.) Kitamura 'Sunny Mandalay'. Phosphate, K, Na, and pH were determined on unaltered bulk medium solutions collected over the course of the cropping cycle, and foliar analyses were determined on tissue collected at mid- and end of crop. Plants that relied on K release from precharged clinoptilolite at the low and high rates and received a N/ P/ - K fertilizer produced growth and tissue K concentrations that were not significantly different than the control which received a complete fertilizer. Plants that relied on PO_4 release of precharged clinoptilolite did not result in growth or tissue P levels similar to those of the complete control. Phosphate levels in the root medium solution were adequate only during the first month of the cropping cycle, but PO_4 release should be taken into consideration when developing a fertilization program using precharged clinoptilolite to provide other nutrients. Using precharged clinoptilolite at the low rate reduced K losses through leaching to 26% of the amount leached from control plants receiving K at 176 $mg \cdot L^{-1}$ at each watering.

645 (PS 8)

A Novel Test for Evaluation of Controlled-release Fertilizers

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Various methods are used to evaluate the release characteristics of coated, controlled-release fertilizers. These methods include measuring the nutrients released into water or remaining in the prills or measuring the growth and nutrient content of the plants grown. Such methods do not show the release mechanism of the fertilizers. A simple test was developed that actually shows how nutrients are released from coated fertilizer prills that contain potassium. When prills of commercial products were placed in 1.5% aqueous solution of sodium tetraphenyl boron, potassium released from the prills combined with sodium tetraphenyl boron and formed a white precipitate. The precipitate patterns revealed that some new prills had large cracks or imperfect coating, thus releasing their nutrients instantly and prematurely. Over time, individual prills within the same fertilizer showed different release behaviors—from no release to release through tiny holes in the coating to release by rupture or bursting of the coating. This test is particularly useful for detecting coating defects during manufacture or subsequent damage to coating, as during incorporation of the prills into growing media. (Provisional patent application filed for this method.)

107 POSTER SESSION (Abstr. 646–653) Crop Protection–Diseases

646 (PS 3)

Controlling Powdery Mildew of Greenhouse Roses Using Quartenary Benzophenanthridine Alkaloids

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There are many naturally occurring substances that have the potential to be adapted to modern pest control chemistry. Azadirachtin, an insect growth regulator, is one such naturally occurring compound that has been widely accepted in insect pest management. Quartenary benzophenanthridine alkaloids (QBAs) are known to be effective in the control of crop damaging fungal diseases. QBAs can be isolated from plants in the Papaveraceae. Extracts of *Macleaya cordata*, a species rich in QBAs, were formulated at 150 $mg \cdot L^{-1}$ QBA for spray application to greenhouse roses infected with *Sphaerotheca pannosa* var. *rosae* (powdery mildew). The QBA formulation was applied at 10-day intervals. Copper sulfate pentahydrate (Phyton27), piperalin (Pipron), and fenarimol (Rubigan) were also applied to mildew infected plants within the same greenhouse at their respective label rates for comparison. One day after treatment, the mildew infection was reduced 50% by QBA, whereas fenarimol, copper sulfate pentahydrate, and piperalin reduced the infection 50%, 75%, and 80%, respectively. Nine days after application, the mildew infection of QBA treated plants was less than 5% of the leaflet surface area. QBAs have the potential to be developed as a biorational fungicide for greenhouse use with both fungicidal and fungistatic activity.

647 (PS 3)

Effect of Silicon on Strawberry Plants

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The effect of silicon (Si) foliar applications on metabolic changes and powdery mildew infection in strawberry plants were determined. Silicon was used in the forms of potassium (K) and sodium (Na) salts. Foliar sprays containing 0, 250, 500, 750, and 1000 ppm of Si were applied. Strawberry plants showed no difference in response to the K or Na salts of Si during the seven weeks of experimental period. Plants treated with potassium and sodium silicate showed reduced severity of powdery mildew, increased chlorophyll content, and increased plant growth. Potassium and sodium silicate treatments also induced metabolic changes such as an increase in citric acid and malic acid levels, and a decrease in fructose, glucose, sucrose, and myoinositol content. The treated tissues also had higher ratios of (18:2 + 18:3)/18:1 in glycolipids and phospholipids and elevated amounts of membrane lipids in leaves and petioles. These results suggest that Si has beneficial effects on strawberry plants and may serve as an alternative to fungicides for controlling powdery mildew.

648 (PS 3)

Performance of Nine Apple Cultivars Grown with Six Fungicide Regimes

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In 1993 a factorial experiment, involving nine apple cultivars on M.9 rootstock and six fungicide regimes, was established. The cultivars included 'Delicious', 'Golden Delicious', 'York Imperial', 'Redfree', 'Freedom', 'Liberty', NY 74828-12, NY 73334-35, and NY 74840-1. The fungicide treatments included early-season sprays of Bayleton or Dodine, separately or combined, and late-season sprays of Captan plus Benomyl alone or combined with early-season sprays of Bayleton plus Dodine. Non-sprayed trees served as a control. In 1995 leaves and fruits were evaluated for disease symptoms. Leaf spot (symptoms caused by black rot or alternaria leaf blotch) was most severe on 'Redfree' and NY 73334-35, and least severe on 'Delicious', 'Golden Delicious', and 'York'. By late summer NY 74828-12 had the most leaf abscission, whereas NY 74840-1, 'Liberty', and 'Delicious' lost the fewest leaves. Early-season fungicide sprays did not reduce early leaf abscission. Sooty blotch and fly speck, but not rots, were nearly eliminated by late-season applications of Captan plus Benomyl. Averaged over all fungicide treatments, more than half of the fruits from 'Delicious', 'Redfree', and NY 74828-12 were free of disease symptoms. Cultivars with <25% of the fruits without infection included 'York', 'Liberty', NY 74840-1 and NY 73334-35. 'York' and 'Redfree' had >25% of the fruits with rots, while all other cultivars had <9% fruits with rots. 'Delicious' and NY 73334-35 had the fewest rotten fruits. Rots were not controlled by any fungicide treatment. 'Liberty' and NY 73334-35 had the most flyspeck and 'Redfree' had the least. 'Liberty', NY 74840-1 and NY 73334-35 had the most sooty blotch and 'Redfree' and NY 74828-12 had the least.

649 (PS 3)

Differential Yield Response Of Melon Hybrids with Monosporascus Root Rot/Vine Decline

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Monosporascus root rot/vine decline (MRR/VD), caused by *Monosporascus cannonballus*, is a serious disease of the major melon production areas of Texas, California, and Arizona. We have previously identified differing levels of tolerance in melon germplasm based on vine disease symptoms. This study was conducted to evaluate the yield response of commercial and experimental cantaloupe

and honeydew hybrids subjected to MRR/VD. Thirty-nine and six cantaloupe and honeydew hybrids, respectively, were transplanted into a field highly infested with *M. cannonballus* in March 1995 in a randomized, complete block with 4 replications. The field was highly infested with *Monosporascus cannonballus*. 'Caravelle' (very susceptible) and 'Deltex' (tolerant) were included as control entries. Fruit were harvested at maturity and sized. Any fruit that did not mature completely due to vine death were counted as culls (unmarketable). Marketable yield of the cantaloupe entries ranged from 26.74% to 67.35%. The most tolerant hybrids were 'SR103654', 'Don Carlos', 'Explorer', and 'Ovation'. Marketable yield of the honeydews ranged from 8.43% to 41.46%, with 'Morning Ice' and 'Creme de Menthe' showing the most tolerance. The best performing hybrids were evaluated again the Fall 1995 and Spring 1996 seasons. In general, genotypes which matured later, and had a more dispersed fruit set, were more tolerant to MRR/VD. This supports previous data showing that high physiological stress (heavy, concentrated fruit load) leads to more severe and rapid vine collapse.

650 (PS 3)

Field Applications of Fungicides Improve Quality and Size of Some Pumpkin Cultivars

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Commercial producers of pumpkin (*Cucurbita pepo*) in the mid-Atlantic region frequently experience losses of fruit size and quality from the fungal diseases powdery mildew (*Erysiphe cichoracearum*) and black rot (*Didymella bryoniae*). In addition to loss of fruit size in some cultivars, the diseases can result in poor quality handles (fruit stems) and pre- and postharvest decay. Since the pumpkins are grown for ornamental use, their appearance, size, and quality are important in marketing strategies. Applications of recommended fungicides during the growing season, although costly, reduce losses in fruit size and quality in susceptible cultivars during years in which the pathogens become established prior to fruit maturity. Larger-fruited cultivars, in general, benefit more from fungicide application than smaller-fruited types in fruit weight, although both benefit in improved handle quality. Cultivars with apparent tolerance to fungal diseases are identified for producers who choose not to use fungicides.

651 (PS 3)

Compound, Surfactant, and Spray Interval Affect Black Spot Control on Rose

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Plants of *Rosa* L. 'Peace' were field planted in Feb. 1995 in order to test black spot (*Diplocarpon rosae* Wolf) control efficacy of several compounds. Plants were protected from fungal infection by black spot with weekly sprays of chlorothalonil (Daconil) from 5 Apr. to 8 June 1995 to allow plant establishment. Spray treatments for efficacy testing were started on 23 June and ended on 1 Nov. 1995. All plants were uniformly weeded, fertilized, and irrigated as needed for the duration of the experiment. Plants were rated for defoliation and disease development on 18 July, 1 Sept., and 10 Nov. 1995. A wettable granular formulation of cyproconazole (Sentinel) controlled black spot significantly better when a surfactant, Latron B-1956, was added to the spray solution at 0.5 $mL \cdot L^{-1}$. Differences between treatments with and without surfactant were greater at lower rates vs. higher rates of cyproconazole. The most effective Sentinel rates with the surfactant were 0.13 $g \cdot L^{-1}$ applied every 14 days or 0.26 $g \cdot L^{-1}$ every 21 days. A formulated combination of chlorothalonil and thiophanate methyl (ConSyst) controlled black spot on a 7-day interval at 1.2 $g \cdot L^{-1}$, but not when applied at 1.8 $g \cdot L^{-1}$ every 14 days. Control was no better than the standard mancozeb (Dithane) treatment. Neem oil (NeemGard) was not effective on the 14-day schedule tested. Tank mixing neem oil with chlorothalonil or thiophanate methyl (Domain) did not significantly improve control. Neither myclobutanil (Systane) or a formulated combination of mancozeb and myclobutanil (RH 0611) was effective in controlling black spot.

652 (PS 3)

Disease Forecasting on Stake Cultured Tomatoes: Defining Decision Thresholds for Use of TOM-CAST in Northern New Jersey

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Fourteen different fungicide schedules for early blight control, including eight variations of TOM-CAST, were evaluated at the Snyder Research and Extension Farm, Pittstown, N.J. Weather data was collected with Sensor Instruments Field Monitors. All calendar-based schedules— weekly, biweekly, grower simulation— reduced foliar disease compared to the untreated control. All forecast generated schedules—TOM-CAST variations, FAST and CUFAST—reduced foliar disease compared to the untreated control. Several of the forecast schedules resulted in disease ratings not significantly different from those following calendar based schedules or from each other. The fourteen different schedules required as many as sixteen to as few as four fungicide applications. Disease control schedule did not affect total yield, marketable yield and postharvest losses. Disease control with a TOM-CAST generated schedule based on weather data from an electronic meteorological service was not different from disease control obtained with a TOM-CAST schedule based on ground station weather data. Potential cost savings of as much as $295 per acre resulting from reduced fungicide schedules were estimated. Chemical name used: tetrachloroisophtalonitrile (chlorothalonil).

653 (PS 3)

Survey of Rooted Plant Material to Determine Source of Root Rotting Pathogen: Introduction into Greenhouses

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With the cooperation of six commercial greenhouses (five in Colorado, one out of state), rooted poinsettia cuttings and bedding plant plugs were collected and analyzed for *Pythium* and *Rhizoctonia*, two common root rotting pathogens in Colorado greenhouses. Samples of plant, soil, and water debris were taken from four greenhouses, as well as samples of growing media ready for use. These were also analyzed for *Pythium* and *Rhizoctonia*. Fungi recovered from the plant, debris, or growing media samples were identified, grown in pure culture, and introduced into susceptible plants (*Vinca minor*) in pathogenicity studies. Neither pathogen was isolated from the rooted poinsettia cuttings tested. *Pythium* was not found in any of the plug material or in growing media. Rhizoctonia solani was found in 16% of the plug samples and 7% of the growing media samples tested. Debris from greenhouse floors yielded four species of *Pythium* as well as *Rhizoctonia* solani. Isolates of each fungus were able to colonize, but not adversely affect, inoculated plants in pathogenicity studies. It appears that disease causing organisms that have potential to decrease plant quality and growth are already present in the greenhouse. Control of root rotting pathogens can best be carried out by relying heavily on sanitation measures.

147 POSTER SESSION (Abstr. 654–657) Crop Protection–Insects

654 (PS 8)

Control of Insects on Ornamental Cuttings by Vacuum Disruption

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Insect infestation of plant material is a serious problem to the greenhouse industry. Nonpesticidal destruction of insects on plant material before they are placed in the greenhouse would supply producers and growers with pest-free plant materials and decrease pesticide usage and exposure of workers and the environment to chemical insecticides. The efficacy of vacuum treating chrysanthemum (*Chrysanthemum morifolium*) and poinsettia (*Euphorbia pulcherrima*) plants for the reduction of insect pests (aphids and greenhouse whiteflies) was investigated. The effects of surfactants on insect elimination was determined. Properly controlled vacuum treatment in conjunction with surfactants was found to disrupt the physical integrity of the insects in all stages of their life cycle.

655 (PS 8)

Field Efficacy of Semiochemical Baits to Control Diabroticine Beetles on Muskmelon

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Semiochemical baits impregnated with cucurbitacin, floral volatiles, and small amounts of carbaryl insecticide have been developed to control cucumber beetles.

Insecticide application of low carbaryl levels with insect attractants offers low risk advantages over conventional insecticides. Experiments determined the effectiveness of different timing schedules of granular semiochemical baits and compared two application methods (i.e., air-blast and standard boom) of flowable semiochemical baits. One concern this study addressed was whether the shearing action of the air-blast applicator affected the physical integrity of the microsphere formulations and therefore its effectiveness. Both granular and flowable formulations reduced cucumber beetle populations. Total number of live and dead beetles in treated plots generally exceeded the total number found in the control plots. This suggests that immigrating beetles were attracted from outside, died, and accumulated in the treated plots. Control plots were treated with floral attractants. Bacterial wilt symptoms were not observed in any plot.

656 (PS 8)

Comparisons of Chemical Controls for Thrips (*Frankliniella occidentalis*) on Greenhouse-grown Gerbera (*Gerbera jamesonii* L.)

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Chemical and physical methods were tested to determine their effectiveness in controlling Western Flower Thrips, *Frankliniella occidentalis* (Pergande), in greenhouses. Comparisons were made between abamectin (Avid); Spinosyn A and D, formulated from the soil Actinomycete, *Saccharopolyspora spinosa* (Spinosad); azadirachtin (Margosan-O); and diatomaceous earth, a physical control aimed at deterring pupation. Results based on the number of thrips counted in gerbera (*Gerbera jamesonii* L.) flowers indicate that the chemical treatments were significantly more effective in reducing populations than the diatomaceous earth. Over time, the population of thrips in both the Avid and Spinosad treatments was reduced to zero. Diatomaceous earth treatments reduced populations almost 50% as compared to the control, while reductions from Margosan-O ranged 50-90%.

657 (PS 8)

Effect of Plastic Mulch, Floating Rowcovers, and Microtunnels on Insect Populations and Yield of Muskmelon

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This work was conducted for evaluate the influence of clear and black polyethylene mulches, used alone or combined with floating rowcover (FRC) and plastic perforated microtunnels, on insect populations, growth and yield of muskmelon. Treatments evaluated were 1) clear plastic + FRC, 2) polyethylene perforated microtunnel, 3) clear plastic + polyethylene not perforated microtunnel, 4) black plastic + FRC, 5) clear plastic, 6) black polyethylene, 7) clear plastic + oil, and 8) bare soil. Aphids and sweetpotato whitefly adults and nymphs were completely excluded by floating rowcovers while the plots covered. The export and national quality fruit yield was major in the mulched beds in relation to control. Clear polyethylene mulch + FRC increased number of fruit and export marketable fruit of cantaloupe (45.2% and 44.8%) with respect to black plastic + FRC, respectively. It is proposed that, under tropical conditions and under high insect stress, mulches combined with floating rowcovers should be selected for their effects on insects in addition to their effects on melon yield. Polyethylene microtunnels were found not economical for cantaloupe production in western Mexico.

108 POSTER SESSION (Abstr. 658–664) Plant/Pest Interaction

658 (PS 4)

Cohesion Transport Theory of Water Movement in Plants: Some Anomalous Results Provided by Xylophagous Leafhoppers

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The Cohesion Tension Theory, first in 1894 introduced by Dixon and Joly is the theory most often invoked to explain water movement in a transpiring plant. The pressure chamber technique has provided the strongest indirect evidence for this theory. However, controversy remains because 1) the necessary pressure gradients in xylem vessels have never been measured directly; 2) it is uncertain how continuous water columns under great tensions could persist in a metastable state for extended periods of time, and; 3) direct pressure probe measurements on individual xylem vessels have not been indicative of the extreme negative pressures obtained with the pressure chamber. Xylem fluid is an energy-limited resource containing the lowest available carbon (energy content = 2 to 15 J/cm3) of any plant tissue. However, many species of xylophagous leafhoppers subsist entirely on this dilute food source, despite the negative pressures thought to occur in xylem vessels. Carbon limitations of leafhoppers were underscored by 1) high feeding rates; 2) an unprecedented assimilation efficiency of organic compounds (i.e., >99%); 3) ammonotelism, and; 4) synchronization of feeding to optimum host nutrient content both seasonally and diurnally. The maximum tension that can be generated by the cibarial pumping mechanism of an insect based on anatomy and biochemistry is about 0.3 to 0.6 MPa, far below the purported xylem tensions occurring during most daylight hours. By contrast, we have shown that feeding has been usually independent of xylem tensions, as measured with a pressure chamber, and instead was a function of the amide content of xylem fluid. Moreover, the calculated net energy gain of insect feeding (or that contained within insect biomass) on xylem fluid of a given composition under a given tension have also been an a paradox. Experiments will be described that provide insight into the energetics of xylem fluid extraction.

659 (PS 4)

Aphids Stimulate Peroxidase Activity but Not ACC Oxidase Activity in Watermelon Plants Inoculated with Anthracnose

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Individually, green melon aphids (*Aphis gossypi*) and anthracnose (*Colletotricum lagenarium*) can cause serious economic damage to watermelons by reducing stands and marketable yields. Greenhouse-grown watermelon seedlings at the third true leaf stage were infected with anthracnose (106 spores/mL) and/or infested with 30 aphids per plant. At the 5th leaf stage (about 7 days after inoculation/infestation), leaf disks were harvested from plants and indicators of stress measured. Peroxidase activity increased from 0.03 to 0.28 absorbance units/mg protein-minute in leaves with anthracnose. When plants were infested with aphids after anthracnose inoculation, peroxidase activity was 0.40 absorbance units/mg protein-minute. Plants having both aphids and anthracnose had more anthracnose lesions when leaves were infested with aphids prior to anthracnose inoculation. The presence of aphids and/or anthracnose stimulated 1-aminocyclopropane-1-caroxylic acid (ACC) oxidase activity from 28 to 44 nL/g-h, indicating enhanced ethylene production. However, aphids had to be present on plants at least 5 days before ACC oxidase activity was stimulated above control levels. Aphids combined with anthracnose failed to elevate ACC oxidase levels higher than either aphids or anthracnose alone. Both peroxidase activity and ACC oxidase activity in watermelon plants increased with anthracnose infection. Thus, watermelon plants stressed by aphids and anthracnose responded differently from plants stressed individually by aphids or anthracnose.

660 (PS 4)

Evaluation of Sesquiterpene Carboxylic Acids as a Mechanism for Resistance to the Tomato Pests *Helicoverpa zea* (Boddie) and *Spodoptera exigua* (Hubner).

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Sesquiterpene carboxylic acids (SCA) are synthesized by leaf trichomes of a wild tomato species *Lycopersicon hirsutum* accession LA 1777 and confer resistance to the tomato pests *Helicoverpa zea* (Boddie) and *Spodoptera exigua* (Hubner). Larvae of both species exhibited a reduction in survival and growth rate with altered feeding behavior when exposed to SCA in choice and no-choice insect bioassays. Larvae of both species were reared on artificial insect diets with SCA added at 0, 10 and 60 mg SCA per g of diet. All larvae perished in the 60 $mg \cdot g^{-1}$ treatment which is comparable to the levels of SCA found on LA 1777. *H. zea* and *S. exigua* showed about 35% and 60% reduction in survival to adult and 38% to 22% increase in life cycle duration, respectively, in the 10 $mg \cdot g^{-1}$ treatment relative to the control. Similar reductions in growth rate and survival were observed when larvae were reared on leaves coated with SCA. Choice bioassays with control (0 mg SCA/g leaf) and 60 mg SCA/g treated leaf tissue demonstrated

2.3-fold increase in larval avoidance and 50% reduction in feeding on treated leaves. Our results suggest that breeding for SCA synthesis in tomato would produce lines with increased resistance to the tomato pests *H. zea* and *S. exigua*. Backcross breeding procedures using LA 1777 have initiated the introgression of the SCA genes into cultivated tomato germplasm. Studies of inheritance of genes coding for SCA synthesis are underway to reveal allelic interactions and facilitate there introgression into the cultivated tomato germplasm.

661 (PS 4)

Identification and Quantification of Damage to Raisins by Pest Insects in Northwestern Mexico

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Caborca, Sonora, is the principal raisin producer area in Mexico. It is estimated that over one-third of the fresh grape production is destined for raisins. There are no studies related to the insects that attack raisins in the fields during drying or in the processing plants where the raisins are stored for several months. The purpose of this study was to identify the insect pests and quantify the extent of the damage. Raisin samples were taken from the fields during drying and from the processing plants. The most abundant and frequent species identified were *Oryzaephilus surinamensis* L., *Lasioderma serricorne* Fab., and *Cryptolestes pusillus* Shoen. Also, *Tribolium castaneum* Herbst, *Alphitobius diaperinus* Panzer, and *Rhyzoperta dominica* Fab were less abundant and had a lower frequency. All these species were found in raisins stored in processing plants and none were observed in the field samples. Damage range was from 25 to 100% and was related to the length of time in storage. The longer the storage time, the higher the percent damage.

662 (PS 4)

Symptom Development and Susceptibility of Dwarf Cherry Tomato to Tomato Irregular Ripening, A Fruit Disorder Induced by Silverleaf Whitefly

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Silverleaf whitefly (SLW) (*Bemisia argentifolii* Bellows and Perring) feeding has been associated with development of tomato irregular ripening (TIR) symptoms. Four dwarf cultivars of cherry tomato *(Lycopersicon esculentum* L.) were infested with adult SLW to observe oviposition preference, tolerance and TIR symptom development. Oviposition preference was observed at low SLW population. Florida Petite was the most preferred and Micro-Tom the least preferred cultivar, with Florida Lanai and Florida Basket intermediate. Each cultivar exhibited TIR symptoms associated with feeding by the SLW. TIR fruit symptoms were expressed as longitudinal red streaks with yellow, green, pink or red blotches externally, and white, yellow or green tissue internally. External TIR symptoms ranged from 32% (Micro-Tom) to 82% (Florida Basket). However, external symptoms disappeared from 34% (Florida Lanai) to 56% (Micro-Tom) of the fruits during ripening. SLW infested plants had 82% (Florida Lanai) to 99% (Florida Basket) of fruits with internal white tissue regardless of external symptoms. Tomatoes with TIR symptoms rarely ripened to a mature red, and sometimes had empty locules, were smaller in size and were seedless.

663 (PS 4)

Pepper (*Capsicum* spp.) Wound Volatiles Suppress the Growth of *Alternaria alternata*, the Causal Agent of Internal Mold of Pepper

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Internal mold of sweet and hot peppers (*Capsicum* spp.) is caused by the pathogen Alternaria alternata. The pepper weevil, *Anthomonus eugenii* Cano (Coleoptera: Curculionidae), is an important pest of peppers in the southern U.S., Mexico, and Central America, and has been implicated in the transmission of the disease. We identified several volatiles released by pepper fruit during wounding by pepper weevils, including (E)-3-hexenyl acetate, linalool, beta-ocimene, and 3,7-dimethyl-1,3,6 octatriene (homoterpene). To study the roles of these volatiles in the interaction of the plant and fungus, we determined their effect on the growth of isolated cultures of *A. alternata*. Fungi were unaffected by any of the compounds when exposed to individual volatiles at 1 ppm; however, a 1 ppm mixture of the four compounds significantly reduced growth. All four compounds were inhibitory individually at 10 ppm, with linalool completely inhibiting fungal growth. These results indicate a role for these volatiles in the plant's response to infection by *A. alternata*.

664 (PS 4)

Transmission of Prunus Necrotic Ringspot into Three Peach Scion Cultivars, Measured by RNA Hybridization following in Vitro Micrografting

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As part of our program to develop transgenic peach cultivars with improved disease resistance, we showed that grafting of in vitro cultured 'Suncrest' peach [*Prunus persica* (L.) Batsch] tips 'onto decapitated stems of Prunus necrotic ringspot virus (PNRSV) infected 'Suncrest' shoot cultures, resulted in consistent transfer of virus across grafts as demonstrated by RNA hybridization analysis, suggesting that such a system could be useful for measuring resistance to PNRSV in peach shoot cultures. We have extended these studies to include grafts of 'Springcrest' and 'Nemaguard' test tips onto 'Suncrest' stocks. RNA hybridization analysis showed that PNRSV persists in shoot cultures for 18 months after initiation from PNRSV-infected 'Suncrest' trees and after 16 weeks of treatment of 4°C in the dark, suggesting that a supply of infected shoot cultures could be maintained for repeated use. Graft success rates for grafts of 'Springcrest' onto 'Suncrest' and 'Nemaguard' onto 'Suncrest', equaled or exceeded success rates for 'Suncrest' onto 'Suncrest'. Virus was transmitted from infected stocks into 'Suncrest', 'Springcrest', and 'Nemaguard' test tips by 2 weeks in most successful micrografts. There was no significant difference in the virus concentrations among the three scions at 2, 4, and 6 weeks after grafting, suggesting that there is equal efficacy of virus transfer through grafts from 'Suncrest' to the three cultivars, and that no differences in resistance to PNRSV exist among these cultivars.

107 POSTER SESSION (Abstr. 665–676) Growth and Development–Floriculture

665 (PS 3)

Diurnal Temperature Alterations Influence Final Height of Herbaceous Perennials

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DIF is the difference between day (DT) and night (NT) temperatures. Temperature drop is a 2-hour temperature reduction at sunrise. DIF and temperature drop, which can be affected by light quality, are effective methods to control final plant height of many greenhouse crops. The effect of DIF and temperature drop on final height was determined for eight species of perennials. Durations for DIF temperatures were 12 hours for both DT and NT. Temperature alterations occurred at sunrise. Temperature treatments (DT/NT) consisted of zero DIF (20/20°C), negative DIF (16/24°C), or positive DIF (24/16°C), and a 2-hour drop (12.7/20.7°C). Long days (LD) were provided from 2200-0200 HR by either cool-white fluorescent (CWF) or incandescent (INC) lights. Data for days to visible bud and anthesis, bud number, and final height were collected. Positive DIF conditions enhanced elongation while negative DIF reduced it in all species. As DIF decreased from positive to negative, plant height was reduced 10%, 30%, 30%, and 20% in *Coreopsis* 'Moonbeam' and 'Sunray', *Delphinium* 'Belladonna', and *Scabiosa* 'Butterfly Blue', respectively. Negative-DIF responses were enhanced under CWF lights for some species. In negative-DIF conditions, *Coreopsis* 'Moonbeam' and 'Sunray' and *Delphinium* 'Belladonna' were 10%, 10%, and 15% shorter, respectively, under CWF lights than INC lights.

666 (PS 3)

Growth Retardants Control Height of Herbaceous Perennials

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Twenty species of perennials were trialed to determine the effectiveness of five growth retardants on final plant height and flowering. Growth retardant treatments consisted of five sprays: 100 ppm ancymidol, 1500 ppm chlormequat, 5000 ppm daminozide, 30 ppm paclobutrazol, or 15 ppm uniconazole. Also included for comparison were two drenches of 15 ppm paclobutrazol or 7.5 ppm uniconazole. Spray treatments consisted of one application every 10 days until

anthesis. Drench treatments consisted of one application only. Data for days to visible bud and anthesis, bud number, and final height were collected. Plant response varied significantly between growth retardant treatments. Sprays of ancymidol, chlormequat, daminozide, paclobutrazol, and uniconazole effectively controlled the height of 4, 3, 13, 4, and 12 species, respectively. Daminozide and uniconazole were the most effective sprays at controlling height on a broad range of species. However, daminozide delayed anthesis compared to control treatments of at least 5 species. Drench treatments of paclobutrazol and uniconazole were effective on 14 and 15 species, respectively. The number of responsive species increased significantly when paclobutrazol was used as a drench rather than a spray. All species tested were responsive to at least one growth retardant treatment.

667 (PS 3)

Influence of Dikegulac and BA in Improving the Quality of Boston Fern

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Two greenhouse studies (1990 and 1991) were conducted to evaluate the effect of dikegulac (Atrinal) and benzyladenine (ProShear) on frond initiation and vegetative growth of Boston fern (*Nephrolepis exaltata* L.). Four weeks after transplanting, fern liners were sprayed with aqueous solutions of dikegulac and benzyladenine (BA). Chemical concentrations of dikegulac were 0, 250, 500, or 750 mg·L^{-1} and those of BA were 0, 50, 100, or 150 mg·L^{-1}. The effect of dikegulac and BA on number of shoots, frond length, leaf area, and dry weight were measured. Dikegulac stimulated shoot initiation and increased leaf area and dry weight without affecting frond length. BA reduced frond length and its effect on shoot initiation, leaf area and dry weight varied from one time to another. This study suggests the potential use for dikegulac in improving the appearance and aesthetic quality of Boston fern.

668 (PS 3)

Effect of Growth Retardants on Production of Containerized 'Barbara Karst' *Bougainvillea*

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The effect of four PGRs on production of 'Barbara Karst' bougainvillea [*Bougainvillea* x *buttiana* (*Bougainvillea glabra* Choicy x *Bougainvillea peruviana* Humb. & Bonpl.) was determined. Liners were transplanted into 3.8-L containers with a soilless substrate on 6 Apr. 1995 and were pruned on 15 May (mean height and width 23.6 and 34.5 cm, respectively). Uniconazole (10 ppm), maleic hydrazide (2808 ppm), daminozide (5000 ppm), and paclobutrazol (50, 100, or 200 ppm) were applied as a foliar spray (to wet) by a compressed air backpack sprayer on 16 May (0 weeks after treatment [WAT]). Daminozide (5000 ppm) was reapplied 31 May and 13 June as described above. Soil drenches of 5, 10, or 20 ppm paclobutrazol were additional treatments. Two nonPGR-treated controls were included: pruned at 0 WAT, and pruned at 0 and 4 WAT. There were eight replications per treatment placed in a randomized complete block design on a container bed under full sun and drip irrigation. At 6, 9, and 12 WAT, growth, flowering, growth habit, number of structural branches (>15 cm long), and level of bacterial spot infection by *Pseudomonas andropogonis* were recorded. Marketability was recorded 12 WAT and phytotoxicity noted 1, 4, 5, 6, 9, and 12 WAT. No PGR treatment effectively suppressed growth, or enhanced quality or marketability of 'Barbara Karst' bougainvillea grown in 3.8-L containers. Furthermore, daminozide reduced the number of structural branches and maleic hydrazide was phytotoxic.

669 (PS 3)

Control of Leaf Senescence of Easter Lily using Plant Spacing and Early Applications of Promalin

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Easter lilies (*Lilium longiflorum* Thunb. 'Nellie White') were placed at three spacings of about 11, 22, or 44 plants per square meter (plants/m^2). Above canopy light intensities, measured weekly at noon, ranged from 107.3 to 704.5 μmol·s^{-1}·m^{-2} and were not significantly different among spacings. Mid canopy light intensities ranged from 16.5 to 229.0, 43.0 to 458.5, and 77.5 to 535.3 μmol·s^{-1}·m^{-2} at spacings of 44, 22 and 11 plants/m^2, respectively. On February 5, 1996, three plants from the 22 plants/m^2 spacing were sprayed with a solution of 0.5 ml·L^{-1} of 1.8% (a.i.) of each of *N*-(phenylmethyl)-1*H*-purine-6-amine and gibberellins A_4A_7; and on March 5, three additional plants from each spacing were similarly sprayed. Beginning 5 Mar., weekly counts were made of yellow and brown leaves on all treated and control plants. Average per plant numbers of brown leaves increased on control plants at all spacings but increased on treated plants only at the 11 plants/m^2 spacing. On 25 Mar., control plants averaged 15.6, 12.1, and 15.3 brown leaves per plant at spacings of 11, 22, and 44 plants/m^2, respectively, while plants treated on March 5 averaged 10.7, 9.0, and 10.7 brown leaves. Plants treated on 5 Feb. averaged 3.5 brown leaves per plant and had an average mid leaf length of 13.8 cm compared to about 10.5 cm for all other plants. Spacing had no effect on average yellow or brown leaves per plant. This study demonstrated that early applications of Promalin can reduce leaf senescence which may occur during forcing time before bud appearance to opening of first bud. Some leaf enlargement may occur on plants treated very early.

670 (PS 3)

Effects of Nutrient and Growth Regulator Treatments on the Growth and Development of Marigolds

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Two cultivars of *Tagetes erecta* Marigolds—Hero Yellow and Safari Tangerine—were grown hydroponically in two different nutrient solutions. The experiment was implemented in the greenhouses on the campus of Alabama A&M Univ., from March to May 1995. The experiment was to assess the effects of growth and development of Marigolds. Heights of seedlings, germinated in grodan (rockwool) cubes were measured and placed randomly in the hydroponic units. Plants were drenched with five rates of either Paclobutrazol (Bonzi) and Uniconazole (Sumagic). The experiment was laid out as a randomized complete block design with either three or four replications of the treatment, which were factorial combinations of variables. After 75 days measurements were made of plants heights, flower bud numbers and dry weights of shoot and root systems. Shoot dry weights were affected by growth regulator treatments, variety, nutrient treatments and a combination of variety and nutrient treatments. Root dry weights were affected by nutrient treatments. Flower bud formation and numbers were affected by the combination of nutrient and variety. Heights were affected by growth regulator treatments, variety and nutrient treatments.

671 (PS 3)

Growth and Development of *Salvia splendens* as Affected by Pot Volume

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Salvia splendens 'Top burgundy' was grown in pots of different sizes (5, 50, 150, and 450 mL) to assess the effect of rooting volume on the growth and development of salvia. Seeds were planted in a peat-lite growing medium and plants grown in a greenhouse during the winter and spring of 1996. Plants were spaced far enough apart to minimize mutual shading and interplant light competition. Plants were harvested at weekly intervals and shoot and root dry mass and leaf area were measured. Relative growth rate (RGR) and net assimilation rate were calculated from these data. Differences in plant size became evident at 25 days after seeding. A small pot size (5 mL) decreased root and shoot dry mass, RGR, and NAR, while increasing the root:shoot ratio. Differences between the pot sizes became more apparent during the course of the experiment. The observation that root : shoot ratio decreased with increasing pot volume suggests that the decreased plant size in smaller pots was not the direct effect of reduced root size. Growth most likely was limited by the ability of the roots to supply the shoots with sufficient water and/or nutrients. Pot volume did not only affect the growth, but also the development of the plants. Salvia flowered faster in bigger pots (about 50 days after seeding in 450-mL pots), while the plants in 5-mL cells did not flower during the 9-week period of the experiment.

672 (PS 3)

Marigold Root Growth in 12-cm Containers Modified with Two or Four Copper-treated Inserts

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This study evaluated the effect of container shape and copper hydroxide on root and shoot development of marigold (*Tagetes patula* 'Little Devil Flame') seedlings. Containers were modified in shape and volume by gluing triangular polycarbonate inserts vertically onto sides of the container. The inserts were either painted with copper or not painted. Inserts decreased container volumes (no insert = 480 cm^3, two inserts = 340 cm^3, and four inserts = 200 cm^3). After 38 days the seedling roots were scanned for computer analysis, and leaf area and dry weights were deter-

mined. Copper effectively prevented roots from growing in contact with copper treated surfaces. Shoot dry weight and leaf area were greater with no inserts, but if inserts were treated with copper the shoot dry weight and leaf area were greater. Root dry weight was reduced 7%–10 % with two inserts and 20% with four inserts compared to no inserts. Copper treated inserts reduced the dry weight further. However, at the insert interface, root length was increased between 15%–20% by all copper treatments, with the greatest increase in the four-insert treatment.

673 (PS 3)

Effect of Benomyl Treatments on Marigold and Indigenous Rhizosphere Bacteria

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The fungicide benomyl (formulated as Benlate 50 DF) has been implicated in damage to several crops grown under warm, moist conditions. Although the target pathogen may be controlled, occurrence of population shifts in rhizosphere bacteria has been documented, with benomyl application. A growth chamber study to investigate the effects of benomyl on marigold (*Tagetes patula*) and subsequent effects on the populations of rhizosphere bacteria of marigold was performed. A one pound per one hundred gallon rate as foliar and drench treatments were applied to marigolds. Plant growth data and rhizosphere bacteria populations were recorded. Repeated application of the benomyl treatments significantly reduced the marigold root and shoot mass, 44% and 67% respectively, compared to controls. Repeated foliar applications of benomyl also resulted in necrotic lesions on marigold leaf margins. Rhizosphere bacteria total numbers differed between treatments, having a greater population for the drench rate than the foliar rate. These results suggest application of benomyl may have harmful nontarget effects, leading to production problems associated with its use.

674 (PS 3)

Evaluation of Vesicular–Arbuscular Mycorrhizal Fungi in Commercial Production of Silver King (*Aglaonema commutatum* L.) Plants

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In the commercial production of silver king plants and other ornate plants, the substrates are treated with fungicides, which affect the vesicular–arbuscular mycorrhizal (VAM) fungi and the plant growth negatively. The restoration of de VAM fungi to the substrate, after its disinfection, might improvement the development. The effectiveness and infectiveness of *Glomus fasciculatum* and *Glomus aggregatum* on silver king (*Aglaonema commutatum*) plants was evaluated in this work. Seedlings of 4-week-old, growing treated with mancozeb, were removed and planted in pots filled with a disinfected mixture of sand soil, cow manure and coconut powder (1:2:2), containing the inoculum of VAM fungi (soil with spores and colonized roots).After 3 and 4 months of the inoculation, plants were removed and dry weight of roots and shoot, number and length of leaves, and mycorrhizal colonization were evaluated. A better development was showed in plants inoculated, resulting highest values in number and length of leaves in relation to control plants. Both VAM fungi improvement the number and length of leaves. The percentage root length colonized (80%) and visual density of endophyte in roots was highest in plants inoculated with *Glomus aggregatum* in both sampling period.

675 (PS 3)

Post-pollination Signaling in Carnation Flowers

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In *Dianthus caryophyllus* flowers the pollinated stigma gives rise to signals that are translocated throughout the flower and ultimately result in corolla senescence. Pollination leads to a rapid increase in ethylene production by the pollinated styles followed by ethylene biosynthesis from the ovaries, the receptacle tissue, and lastly the petals. The accumulation of ACC in these floral tissues also correlates with the sequential pattern of ethylene production. Ethylene production by the pollinated style can be defined temporally by three distinct peaks, with the first peak detected as early as 1 hour after pollination. In a carnation flower with multiple styles it is also possible to detect ethylene production from an unpollinated style on a pollinated gynoecium by 1 hour after pollination. This finding provides evidence for very rapid post-pollination signaling between styles. ACC synthase expression is induced in pollinated styles as early as 1 hour after pollination, but no message is detected in pollinated ovaries. ACC synthase enzyme activity is also absent in the pollinated ovaries despite the accumulation of large amounts of ACC in the ovary after pollination. This indicates that ACC must be translocated between organs after pollination. When a pollinated styles is removed from the flower at least 12 hours after pollination the corolla will still senesce. This indicates that the pollination signal has exited the style by this time. Evidence in carnations suggests that ACC and ethylene may both be involved in aspects of post-pollination signaling.

676 (PS 3)

Impact of Pinching Method and Number of Cuttings on Growth of Eight Florist Azalea Cultivars

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During Fall 1995–Winter 1996, rooted cuttings of eight *Rhododendron Simsii* cultivars—Dorothy Gish, Jacinth, Paloma, White Gish, Friedhelm Scherrer, Gloria, Helmut Vogel, and Inga were transplanted July 1995 into 10.5-cm pots. A treatment consisted of one, two or three cuttings per pot. Cuttings were pinched either mechanically using a hedge clipper (control) or chemically with Off-Shoot-O at rates of 63.5 or 111.1 $mL \cdot L^{-1}$ of water or with Atrimmec at 20 $mL \cdot L^{-1}$ of water. Pinching treatments were repeated three times during the experimental period. New secondary shoots developed more rapidly after a mechanical pinch than after a chemical pinch. Moreover, greater foliage damage was observed on plants pinched with Off-Shoot-O. Growth measurements (height and diameter of plants, top dry mass, number of days to reach anthesis and visual quality) will be presented.

147 POSTER SESSION (Abstr. 677–687) Growth and Development–Floriculture (Flowering)

677 (PS 8)

Flowering in *Primula* as Affected by Day and Night Temperatures

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The growth of *Primula vulgaris* Huds. 'Dania Lemon Yellow' and 'Blue Danova' was evaluated for plants grown at day/night temperature differences of 9, 3, 0, –3 or –9°C. The day temperature was maintained for the duration of the 16-hour photoperiod and the day and night temperatures were selected to provide an average daily temperature of 16°C. The plants were grown at the specific temperatures starting 8 weeks from seeding until flowering. Total daily irradiance was 12 $mol \cdot d^{-1} \cdot m^{-2}$. Time for visible flower bud, flower color and first open flower was recorded. Plant height and flower bud number were determined at the termination of the experiment. 'Dania Lemon Yellow' plants grown with a positive or negative difference of 9°C were significantly ($P < 0.05$) later in reaching a visible bud stage. There were no differences however, in the number of days required for flower color or first open flower for 'Dania Lemon Yellow'. Plants of 'Blue Danova' showed a significant difference only in the number of days required for flowering. The plants grown with a positive or zero difference between day and night required on average 2 more days to reach the stage of first open flower. There were no significant differences in plant height or flower bud number in 'Dania Lemon Yellow' or 'Blue Danova'.

678 (PS 8)

Control of *Ranunculus asiaticus* Flowering by Photoperiod and Temperature

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Three-month-old plants of *Ranunculus asiaticus* L. 'Bloomingdale Mix' were transplanted into 10-cm pots and placed in growth chambers at 12, 16, or 20°C and 8, 12, or 16 hours day length. The irradiance was 12 $mol \cdot d^{-1} \cdot m^{-2}$. The fastest appearance of flower buds and flowering occurred for plants grown at 16 hours day length and 16°C or 12 hours day length and 20°C. At 16°C, plants grown at 8 hours photoperiod required 7–10 more days to reach the stage of visible flower bud than those plants grown at 12 or 16 hours day length. The number of days to flower from the initiation of experimental conditions varied from 53 ±3.7 days (168 days from seeding) for plants at 16-hour days and 16°C

or 12-hour days and 20°C to 74 ± 2.7 days (189 days from seeding) for plants at 8-hour days and 16°C or 12-hour days and 12°C. Largest number of buds and flowers (15 ± 2.2 flower buds) was observed on plants grown at 12 or 16°C and 12-hour photoperiod. Conditions with 8- or 16-hour days at 16°C or 12-hour days at 20°C resulted in a smaller number of buds and flowers (9 ± 3.2 flower buds).

679 (PS 8)

Control of Flowering in Petunia by Photoperiod and Irradiance

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Petunia 'Midnight Madness' plants were grown for 4 weeks starting 3 weeks after seeding, at 8 or 16 hours photoperiod and 3, 7.5, or 12 mol·d^{-1}·m^{-2}. The temperature was 20 ± 1°C throughout the study. The plants were allowed to flower following the 4 weeks photoperiod treatment at 16 hours of 6 mol·d^{-1}·m^{-2}. Petunias grown at long days flowered (first open flower) faster than those exposed to 8 hours day length for 4 weeks. Plants grown at short days required 8 to 10 more days for flowering compared to plants grown at the same irradiance delivered during a 16-hour day. Flowering was first observed 61 ± 0.9 days from seeding for the plants at long days and 12 mol·d^{-1}·m^{-2}. Plants grown at 8 hours and 3 mol·d^{-1}·m^{-2} required on average 84 ± 0.8 days from seeding to reach flowering. The number of flowers and flower buds (10 ± 1.8 flower buds) was lower for plants grown at 12 mol·d^{-1}·m^{-2} independent of day length. There were no significant differences in the number of flower buds (16 ± 2.6 flower buds) at termination of the experiment for the plants grown at the two lower irradiance levels for either 8 or 16 hours day length.

680 (PS 8)

Photoperiod and Irradiance Affect Flowering in Four Cultivars of Pansy

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Plants of four pansy cultivars ('Crystal Bowl Deep Blue', 'Majestic Giant Blue', 'Maxim Deep Blue' and 'Universal True Blue') were grown for 4 weeks starting 24 days after seeding, at 8 or 16 hours photoperiod and 3, 7.5 or 12 mol·d^{-1}·m^{-2}. The temperature was 20 ± 1°C throughout the study. The plants were allowed to flower following the 4 weeks photoperiod treatment at 16 hours of 6 mol·d^{-1}·m^{-2}. The first open flower was observed significantly earlier for plants of 'Majestic Giant', 'Maxim' and 'Universal' exposed to 16 hours at 12 mol·d^{-1}·m^{-2} than any of the other day lengths and irradiance levels for 4 weeks. There was no difference in rate of flowering for plants of 'Crystal Bowl' grown at 16 hours and 7.5 or 12 mol·d^{-1}·m^{-2}. At 3 mol·d^{-1}·m^{-2}, plant development was slowest and an 8 or 16 hours day length did not significantly affect rate of flowering for any of the four cultivars. Plants of 'Crystal Bowl' had on average the fastest flowering (74 ± 2.2 days from seeding with 4 weeks at 16 hours of 12 mol·d^{-1}·m^{-2}) and plants of 'Majestic Giant' the slowest flowering (83 ± 3.4 days from seeding to flower with 4 weeks at 16 hours of 12 mol·d^{-1}·m^{-2}) of the four cultivars.

681 (PS 8)

Effect of Night-interruption Duration and Cyclic Lighting on Flowering of Obligate Long-day Herbaceous Perennial Plants

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Six obligate long-day species of herbaceous perennials were grown under six night-interruption treatments to determine their relative effectiveness at inducing flowering. Photoperiods were 9 hours natural days with night interruptions provided by incandescent lamps during the middle of the dark period for the following durations: 0.5, 1, 2, or 4 hours; 6 minutes on, 54 minutes off for 4 hours (10% cyclic lighting); or 6 minutes on, 24 minutes off for 4 hours (20% cyclic lighting). Response to night interruptions varied by species, but five of the six species flowered most rapidly and uniformly under 4-hour night interruption. Few or no *Campanula carpatica* 'Blue Clips', *Rudbeckia fulgida* 'Goldsturm', or *Hibiscus ×hybrida* 'Disco Belle Mixed' plants flowered with 1 hour or less of continuous night-break lighting. All *Coreopsis×grandiflora* 'Early Sunrise' flowered, but flowering was hastened as the duration of night interruption increased. *Echinacea purpurea* 'Bravado' flowered similarly across all treatments. In general, the effectiveness of the night-interruption treatments at inducing flowering was 4 hours > 2 hours > 20% cyclic > 1 hour > 10% cyclic > 0.5 hour.

682 (PS 8)

Photoperiod Sensitivity during Flower Development of Opium Poppy (*Papaver somniferum* L.)

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Flower development in opium poppy (*Papaver somniferum* L. 'album DC') is enhanced by long photoperiods (PP ≥ 16-hours). Predicting time to flower in field-grown opium poppy requires knowledge of which developmental stages are sensitive to PP and how the rate of flower development is changed by changes in PP. The objective of this work was to determine when poppy plants first demonstrated developmental changes in response to PP and how long PP continued to influence the time to first flower under consistent temperature conditions. Plants were grown in artificially lit growth chambers with either a 16- (inductive) or a 9-hour PP (noninductive). Plants were transferred at 1 to 3-day intervals from a 16- to a 9-hour PP and vice versa. All chambers were maintained at a 12-hour thermoperiod of 25/20°C. Poppy plants demonstrated developmental changes in response to PP four days after emergence and required a minimum of four inductive cycles before the plant flowered. Additional inductive cycles, up to of a maximum of nine, hastened flowering. After 13 inductive cycles, flowering time was no longer influenced by PP. These results indicate four phases between emergence and first flower: 1) a photoperiod-insensitive juvenile phase (JP); 2) a photoperiod-sensitive inductive phase (PSP); 3) a photoperiod-sensitive post-inductive phase (PSPP); and 4) a photoperiod-insensitive post-inductive phase (PIPP). The minimum durations (days) of these phases under the conditions of our experiment were JP = 4, PSP = 4, PSPP = 9, and PIPP = 14.

683 (PS 8)

Photoperiodic Response of Nine Alternative Hanging-basket Species

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The photoperiodic responses were determined for the following species: *Bacopa speciosa* 'Snowflake', *Bidens ferulifolium*, *Brachycome multifida* 'Crystal Falls', *Helichrysum bracteatum* 'Golden Beauty', *Lysimachia procumbens* (Golden Globes), *Pentas lanceolata* 'Starburst', *Scaevola aemula* 'New Blue Wonder', *Streptocarpella hybrid* 'Concord Blue', and *Streptosolen jamesonii* (Orange Browallia). Each plant species was grown at 8-, 10-, 12-, 14-, and 16-hour photoperiods. Photoperiods were provided by delivering 8 hours sunlight, then pulling black cloth and providing daylength extension with incandescent bulbs. *Bacopa speciosa* 'Snowflake', *Bidens ferulifolium*, *Brachycome multifida* 'Crystal Falls', *Helichrysum bracteatum* 'Golden Beauty', *Scaevola aemula* 'New Blue Wonder', and *Streptocarpella hybrid* 'Blue Concord' were day neutral, i.e., no difference in days to visible bud or days to anthesis in response to photoperiod were observed. *Pentas lanceolata* 'Starburst' and *Lysimachia procumbens* (Golden Globes) were quantitative long day plants, i.e., days to anthesis decreased as daylength increased. No difference in days to visible bud, number of lateral shoots, number of nodes, or internode length were observed for *Pentas lanceolata* 'Starburst'; however, days to anthesis for 14- and 16-hour photoperiods occurred 9 days earlier than 8-hour photoperiods. Days to visible bud for *Lysimachia procumbens* (Golden Globes) occurred 7 days earlier and days to anthesis was 9 days earlier under 14- and 16-hour photoperiods than 8-hour photoperiods. By week 8, only one flower per plant developed in the 8-hour photoperiod while 11 flowers per plant developed in the 14-hour photoperiod. *Streptosolen jamesonii* (Orange Browallia) was a qualitative short day plant. There was no difference in the days to anthesis between 8- and 10-hour daylength, each averaging 36 days from start of photoperiod treatment. Plants under 12- to 16-hour photoperiods did not flower.

684 (PS 8)

Quality, Timing, and Market Potential Vary with Species, Plant and Pinch Number for Hanging Basket Crops

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The objective was to provide options for hanging basket production schedules by varying the number of plants per pot (one to four) and the number of manual pinches per basket (zero to two). Several species were evaluated in Spring 1995 and heat tolerance was assessed throughout the summer. Plugs (82 plugs per flat) were transplanted into 25-cm hanging baskets in a 22/18°C (venting/

night temperature set points) glasshouse. *Bacopa speciosa* 'Snowflake', *Brachycome iberidifolia* 'Crystal Falls', *Helichrysum bracteatum* 'Golden Beauty', *Scaevola aemula* 'New Blue Wonder', and *Streptocarpella* hybrid 'Concord Blue' produced quality baskets with three or more plugs per basket and no pinch. *Pentas lanceolata* 'Starburst' and *Lysimachia procumbens* (Golden Globes) produced quality baskets with fewer than three plants per basket if plants received at least one pinch, however length of growing time was increased. *Pentas lanceolata* 'Starburst', *Scaevola aemula* 'New Blue Wonder', and *Streptocarpella* hybrid 'Concord Blue' proved to be heat tolerant, blooming throughout the summer. *Bacopa speciosa* 'Snowflake', *Brachycome iberidifolia* 'Crystal Falls', and *Lysimachia procumbens* (Golden Globes) were not heat tolerant, i.e., ceased developing flowers in June and resumed flowering in September. *Bidens ferulifolium* did not produce an acceptable quality hanging basket under any experimental treatments.

685 (PS 8)

Photosynthetic Activity of Four Florist Azalea Cultivars

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The photosynthetic activity of four *Rhododendron simsii* cultivars 'Dorothy Gish', 'Paloma', 'White Gish', and 'Gloria' were studied at both the individual leaf level using a portable photosynthesis system (closed), or at the whole-plant level using assimilation chambers (semi-open system). Net photosynthetic assimilation curves in response to light in both systems will be established. The experimental points obtained will be adjusted to a photosynthetic model as described in the literature. The model parameters [original efficiency (α) dark respiration (Rd), maximum photosynthetic capacity to saturated light (Pmax)] will be presented. The evolution of these parameters will be presented as a function of the various stages of development. Also a comparison of the four cultivars will be shown.

686 (PS 8)

Influence of Gibberellic Acid and Long Days on Flowering Time of *Antirrhinum majus* L.

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Gibberellic acid (GA_3) and photoperiod were used in combination in an effort to reduce generation time of *Antirrhinum majus* L. Four commercial inbred lines of *A. majus* were started from seed and grown in a glasshouse in winter 1993-94. GA_3 was applied as a foliar spray every 2 weeks at 0, 144, 289, 577, or 1155 μM starting 5 weeks after seeds were sown. Supplemental lighting (60 $\mu mol \cdot m^{-2} \cdot s^{-1}$) from 0600 to 2000 HR and night interruption from 2300 to 0300 HR was used throughout the experiment. Data were collected weekly on plant height and leaf count from the start of GA_3 treatments through anthesis. Time to flowering was determined as days from seed sowing to anthesis. GA_3 treatment of *A. majus* under a long-day photoperiod increased time to flowering, plant height and leaf count. It would appear that long-days may have overridden the floral induction effects of GA_3.

687 (PS 8)

Changes in Soluble Carbohydrates in Floral Organs of *Lilium longiflorum* during Flower Development

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Easter lily flower buds at five stages of development (stage 1, 3–4 cm in length; stage 2, 6–7 cm; stage 3, 9–10 cm; stage 4, unopened buds, 13–14 cm; and stage 5, open flower one day after anthesis) were harvested, and flower organs were dissected for carbohydrate analysis. Extracting soluble sugars in distilled water at 70°C gave the optimum yield of soluble sugars among the several extraction methods tested including 80% ethanol, and distilled water at various temperatures. Separation of the extracted soluble sugars by alkaline high performance anion exchange chromatography revealed the presence of glucose, fructose, sucrose, and two other sugars of unknown identity. Glucose and fructose concentrations increased remarkably during the flower development in sepal (about 15-fold), style (about 10-fold), and filament (about 5-fold), while sucrose levels remained constant at low concentrations. In stigma, sucrose levels increased parallel to the increase of hexose sugars during development. Ovary had high sucrose levels relative to hexoses that remained constant while hexoses increased gradually. In anther, hexose concentrations increased at the stage 2 and then dropped at stage 3 and 4. Sucrose levels were higher than hexoses in anther, and it increased from stage 1 to stage 2, then dropped at stage 3, and increased thereafter. In addition to these sugars, anthers at stages 2 and 3 had a series of late eluting oligosaccharides. These oligosaccharides could be hydrolyzed to glucose with hot 1 M H_2SO_4 or with amyloglucosidase.

143 POSTER SESSION (Abstr. 688–693) Growth and Development–Small Fruits

688 (PS 5)

Variation in Lowbush Blueberry Fruit Set and Fruit Characteristics

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Twenty stems with four fruit buds were tagged in each of ten lowbush blueberry (*Vaccinium angustifolium* Ait.) clones in a commercial field to assess fruit set and fruit size and weight characteristics. The terminal bud produced the fewest blossoms and fruit but fruit set was equal among all buds (65%–70%). Fruit at bud 4 were slightly smaller in diameter and weighed less than those produced at other buds. Clones with buds producing more blossoms per bud tended to produce more fruit per bud (pearson corr. coeff., $r = 0.49$), but a stronger correlation was found between fruit set and fruit number ($r = 0.81$).

689 (PS 5)

Flower Bud Load Influences Blueberry Vegetative and Fruit Development

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A field experiment was conducted in Gainesville, Fla., with two southern highbush blueberry cultivars, 'Misty' and 'Sharpblue', to investigate the influence of varying flower bud load on the timing and extent of vegetative and reproductive development. Flower bud load was adjusted on three different canes on ten plants by removing none, one-third, or two-thirds of the flower buds. Vegetative budbreak, leaf area, fruit number, and fruit fresh weight and dry weight were measured. Vegetative budbreak was delayed with increasing flower bud load. Vegetative budbreak, leaf area, and leaf area : fruit ratio decreased with increasing flower bud load. Fruit maturity was delayed and average berry fresh weight and dry weight declined with decreasing leaf area:fruit ratio. Responses were similar for both cultivars although 'Misty' was more adversely affected by high flower bud load and low leaf area : fruit ratio.

690 (PS 5)

Fruit Development in Saskatoon (*Amelanchier alnifolia* Nutt.)

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Saskatoon fruits, an emerging horticultural crop across the Canadian prairies, vary greatly in size among cultivars. In this study, we compare fruit development patterns among large, medium, and small fruited cultivars of saskatoon, and assess the role of seed number and pedicel diameter on fruit size. Fruit growth patterns of four cultivars (Thiessen, Northline, Regent, and Smoky) were determined from weekly measurements of fruit diameters and fresh and dry flower/fruit weights during two consecutive growing seasons. The developmental patterns of fruit growth determined using the above criteria were similar among cultivars and between years. At maturity, the largest fruits (fresh weight) obtained were from cv. Thiessen, followed by 'Northline', 'Smoky', and 'Regent', in descending order. Pedicel diameters (one week prior to maturity) correlated linearly with increasing fruit diameter and fresh weight. At maturity, seed number per fruit correlated linearly with increasing fruit weight. Thiessen contained significantly more seeds per fruit (4.6) than 'Northline' (3.7), 'Smoky' (3.2), and 'Regent' (3.2).

691 (PS 5)

Flower Bud Organogenesis and Development in Blackberry Cultivars

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Western trailing blackberries (e.g., 'Boysen' and 'Marion') are grown in Oregon.

USDA-released semi-erect thornless blackberries (e.g., 'Chester Thornless') and erect, thorny blackberries (e.g., 'Cherokee') from Arkansas are grown across the United States from the mid-Atlantic coast region to Oregon. Flower bud development in several blackberry cultivars growing at three sites (Arkansas, Oregon, and West Virginia) was studied. In buds of 'Boysen' and 'Marion' blackberries from Oregon, sepal primordia were first observed in September and November, respectively. Further floral bud development continued into January. Sepal development in 'Cherokee' buds occurred in November in Oregon and in December in Arkansas. At all subsequent sampling dates, the development was more advanced in Oregon than in Arkansas. Buds of 'Chester Thornless' blackberry from all three sites remained undifferentiated until spring. Preliminary findings indicated that the time of flower bud initiation varied considerably among the cultivars examined. The results suggest that floral bud development in blackberry, once initiated, is continuous, but periods of low temperature can arrest bud development.

692 (PS 5)

Early Pruning and Delayed Hydrogen Cyanamide Application Improve Budbreak Uniformity of 'Superior' Grapevines

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Cane pruning of 'Superior' grapevines grown on Hermosillo valley vineyards is normally done between 5 and 10 Jan., with cyanamide application right after pruning. However, hand labor to tie the canes on the wires and rainy days occurring at that time makes it difficult to apply cyanamide right after pruning, resulting in uneven budbreak. Four-year-old 'Superior' grapevines were pruned on 17 Dec. (PD1) and 27 Dec. (PD2) 1994 and 6 Jan. 1995 (PD3), and hydrogen cyanamide (5% Dormex) was applied on 7 Jan. Budbreak was evaluated on three segments of the canes. Total budbreak of vines pruned on 17 Dec. was 71%, 90%, and 80% on the first, second, and third segment of the canes, while on plants pruned on 27 Dec., the response was 39%, 50%, and 79% budbreak on the three segments of the canes, respectively. On vines pruned on 6 Jan., budbreak was 71%, 79%, and 88% on the first, second, and third segment of the canes. Response on cluster number was similar to budbreak, improving when the plants were pruned early (PD1). Number of cluster on PD1, PD2, and PD3 were 7.1, 4.5, and 4.8, respectively. Cluster distribution on PD1 among the canes were 1, 2.4, and 3.7 on the first, second, and third segments; on PD2, 0.3, 2, and 2.2; and on PD3, 0.8, 2, and 2 clusters, respectively.

693 (PS 5)

Date and Intensity of Topping before Spur Pruning Alters Budbreak of Primary Buds in 'Flame Seedless' Grapevines

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In the Sonoran desert, vines are forced to break with early pruning and cyanamide application. Usually topping of the canes (leaving canes 50 cm long) is done on 10 Dec. to facilitate spur pruning and cyanamide application after 20 Dec. However, budbreak is irregular over the years. There is no reason why date and intensity of topping is done that way. The objective of this work was to evaluate budbreak at different dates and intensity of topping. Five-year-old 'Flame Seedless' vines were prune topped on three dates (21 Nov., 1 Dec., and 11 Dec.) and at three different intensities (leaving canes 25, 50, and 75 cm long). A control block was also included without top pruning. Spur pruning and cyanamide application (Dormex 7%) was done on 24 Dec. Budbreak on canes left 50 cm long before spur pruning was 83%, 84%, and 58% on 21 Nov., 1 Dec., and 11 Dec., respectively, while nontop-pruned plants break only 58% of the buds. Number of clusters per plant in the same order were 52, 42, 39, and 26, respectively. There was an interaction of date and intensity of topping with the cluster number, since slight topping (leaving 75 cm long canes) on 1 and 11 Dec. improved the number of clusters per vine up to 47 and 60, respectively.

145 POSTER SESSION (Abstr. 694–707) Growth and Development–Tree Fruits

694 (PS 7)

Determining Vegetative Maturity by Differential Thermal Analyses

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In the past, the laborious and time-consuming method of defoliation was used to determine vegetative maturity (VM) of various deciduous plants. Other methods such as water potential and electrotrical impedence have been explored without a positive response. A change of freezing events of water in plant tissue may be associated with VM. Differential thermal analysis (DTA) was tried to determine if the freezing events of water are related to VM. 'Golden Delicious', 'Gala', 'Red Fuji' and 'Antonovka' apple (*Malus domestica* Borkh.) trees were used to determine VM by defoliation. Different sets of 1-year-old trees grown in pots in the greenhouse were defoliated weekly from 1 Aug. until it was assured the trees had reached VM. Samples from the same trees were taken for DTA. The trees were observed for regrowth 2 weeks after they were defoliated, and the exothermic patterns from DTA were examined for the appearance of an exotherm at about –35 to –40°C. The comparison of regrowth from trees defoliated from a specific date were compared to the exothermic pattern of the same date. An exotherm appeared between –35 and –40°C ≈2 weeks before the apple trees ceased to show regrowth from the defoliation treatment. The exotherm appeared on 30 Aug. for Antonovka and 'Golden Delicious' and regrowth of the trees ceased on 12 Sept. Regrowth ceased on 9 Oct. for 'Gala' and 'Fuji' preceded by the exotherm on 2 Oct. The conclusion was that the appearance of the exotherm at –35 to –40 °C could be used to determine VM.

695 (PS 7)

Sorbitol Dehydrogenase Activity of Apple Fruit is Affected by Defoliation and Girdling

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Following June drop, apple fruit growth depends on sorbitol import as the primary source of carbon. Sorbitol dehydrogenase plays a key role in carbohydrate metabolism by conversion of sorbitol to fructose, which then enters the general carbohydrate pool. Blocking the pathway and eliminating the source of sorbitol to the fruit by girdling the stem and defoliation after June drop resulted in a decline and eventual cessation of fruit growth. The fruit did not abscise however. Fruit sorbitol and starch levels declined while the fructose, glucose, and sucrose pools did not change. SDH activity declined to low levels and was not detectable in many fruit.The decline in SDH activity was evident 1 week after applying the treatments. A few fruit that resumed growth, presumably after the vascular connection was re-established across the girdle, exhibited normal SDH activity. Feeding sorbitol to whole fruit in vitro via the cut stem raised SDH activity in some fruit, although it was still below control levels.

696 (PS 7)

Light Duration Alters [^{14}C] Photosynthate Partitioning into Sorbitol in Apple

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Sorbitol synthesis in apple leaves requires NADPH, a product of photosynthetic light reactions. Light duration directly affects NADPH production, thus, variation in light duration may influence sorbitol synthesis and alter the ratios of sorbitol to other carbohydrates. Our experiments were designed to determine whether light duration altered photosynthate partitioning among carbohydrates and whether longer light durations favored sorbitol synthesis. One-year-old 'Gala' apple plants that experienced a 1-, 4-, 7-, 10-, or 14-hour photoperiod for 7 days were exposed to $^{14}CO_2$ for 15 minutes. Individual carbohydrate concentrations and the activity of newly-fixed [^{14}C] carbohydrates were analyzed during different intervals for 24 hours after labeling. Sorbitol and fructose concentrations increased significantly as light duration increased from 1 to 10 hours, then remained stable at a light duration of 14 hours, whereas starch concentration increased linearly over increasing light durations. Sucrose and glucose concentrations were not significantly altered by light duration. The sorbitol : sucrose ratios increased while sorbitol : starch ratios decreased as light duration increased from 1 to 14 hours. Newly-fixed [^{14}C] carbohydrates varied diurnally. Similar changes during the different light duration periods were found for individual [^{14}C] carbohydrates and unlabeled carbohydrate concentrations. Our results suggest that longer light durations favored sorbitol synthesis over sucrose, and NADPH concentration may become a rate-limiting factor for sorbitol synthesis during short light durations.

697 (PS 7)

Developmental Changes in Carbohydrate Composition of Asian Pear Cultivars Grown in the Southeastern United States

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Changes in sugar composition during maturation and ripening of eight Asian pear cultivars were evaluated. Total soluble sugars (TSS) increased gradually throughout the maturation and averaged 10% to 13% in mature fruit. All cultivars, except 'Shinko' and 'Nijisseiki', had accumulated ≥10% TSS by 100 days after full bloom (DAFB). Starch accumulated during early stages of Asian pear fruit development but decreased as the maturity progressed coinciding with the rise in soluble sugars. Sorbitol, a sugar alcohol, was predominant in immature fruit and accounted for 35% to 60% of TSS fraction depending on the cultivar. Fructose rapidly increased during early maturation. Glucose increased during early maturation, but the increase was much smaller than that of fructose. Sucrose was low (<4%) in immature fruit but accumulated rapidly late in the maturation and continued to increase until harvest. In mature 'Hosui', 'Kosui', 'Nijisseiki', 'Shinsui', 'Shinko', and 'Ichiban' fruit, fructose was the predominant sugar which accounted for 47% to 60% of the TSS fraction. Glucose and sucrose accounted for 13% to 17% and 7% to 12%, respectively, in those cultivars. In mature 'Shinseiki' fruit, sucrose was the predominant sugar (44% of TSS), while fructose and glucose accounted for 33% and 8%, respectively. Sucrose and fructose were present in equal amounts (29%) in mature 'Chojuro' fruit. Late accumulation of sucrose in Asian pear cultivars suggest that sufficient time should be allowed before harvesting to obtain sweeter fruit.

698 (PS 7)

Effect of Shade on Pear Fruit Growth and Quality

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This investigation was undertaken to determine the response of pear fruit growth and quality to shade imposed during development. Whole branches of mature 'Bartlett' trees on *P. communis* L. growing at the Experimental Farm on a sandy loam soil were covered with a 20% transmission black, neutral-density shadecloth from 43 days after full bloom (DFB) to 138 DFB, during the 1995–96 growing season. Two comparable branches on each of five uniform trees were selected for good exposure and one branch of each pair was shaded. Fruit diameters were measured at 2-weekly intervals. Pulp pressure and soluble solids concentration (SSC) were measured at harvest time on 31 Jan. Specific leaf mass (SLM) also was recorded (leaf dry mass was obtained by drying discs at 80°C). Relative fruit growth rates were initially similar between light regimes, becoming lower for the shaded fruit at the subsequent measurements. Light exposure induced a 8.76% increase in final fruit diameter (66.40 mm); this increment would appear to depend on carbohydrate availability, since highly significant differences at $P \leq 0.01$ emerged in the spur SLM of the exposed and covered branches (7.68 vs. 5.79 $mg \cdot cm^{-2}$, respectively). SCC was similar for the two light environments, while flesh firmness was 8.80% higher in the shaded fruit. Our results indicate that solar radiation deprival had clearly detrimental effects on fruit growth and maturity, and they provide a basis for improving pruning and training practices in the future.

699 (PS 7)

The Advances in the Study on Mycorrhizas of Fruit Trees in Dry Tropics of Mexico

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The productivity of marginal soils frequently found in the arid tropics might be improved by using VAM fungi as "biofertilizer" and as a tool of sustainable agricultural systems. Study of mycorrhizas of fruit trees was performed in 1987 in western Mexico. More progress has been made in resources, taxonomy, anatomy and morphology, physiology, ecology, effects, and application of mycorrhizas in fruit trees and ornamental plants production. Currently, five genera has been identified and inoculated plants showed significant difference in respect to plants not inoculated with mycorrhizal fungi. Citrus trees were highly dependent on mycorrhizae for normal growth and development, while the banana plants showed lower levels of root colonization by different strains of VAM fungi. The added endomycorrhizal inoculum significantly increased root fungal colonization in fruit trees and reduce the time in nursery. The current status and research trends in the study of fruit tree mycorrhizas in western Mexico are introduced, and the application prospects in sustainable agriculture also are discussed.

700 (PS 7)

Abnormal Anther and Pollen Development in Sweet Cherry Cultivars Resulting from Lack of Winter Chilling

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Lack of pollen dispersal was noted in various sites and cultivars of sweet cherry (*Prunus avium*) following one of California's warmest recorded winters (≈550 hours @ 7°C in the Central Valley). 'Bing' cherry is thought to require 850 to 880 hours for adequate budbreak and bloom development. Cross pollination is required by most sweet cherry cultivars for fruit set, including 'Bing'. Complete anther dehiscence averaged 13% in 'Bing' trees sampled, compared to 52% in 'Rainier', 65% in 'Brooks', 84.5% in 'Burlat', 33% in Van, 23% in 'Larian', and 86% in 'Black Tartarian'. A range of degree of dehiscence from none to half-open was widely apparent, again by cultivar. Many partially dehiscent anthers did not shed pollen normally but appeared to have the mass of pollen completely adherent inside the pollen sacs. 'Black Tartarian', 'Larian', and 'Burlat' shed pollen readily, however, pollen from dehiscent anthers of other cultivars generally appeared to stick together on the everted locule walls and required direct manipulation to be withdrawn from the pollen sac. Anther morphology ranged from normal size to half normal size, anthers appearing to be without pollen altogether that shriveled on drying, and lobes that were aborted. Pollen germination was low overall: 19% 'Bing', 18% 'Rainier', 20% 'Brooks', 57% 'Burlat', 14% 'Van', 48% 'Larian', and 48% 'Black Tartarian'. Poor fruit set in low chill years is often attributed to lack of bloom overlap with pollenizers, however, inadequate chilling also may contribute to low fruit set by inhibiting anther and pollen growth and development. The implications of a critical chilling requirement for normal floral differentiation are that in cherry-growing areas where low chill years are common, pollen may not be viable or transferrable from pollenizers and female gametophytic development also may be impaired.

701 (PS 7)

Endogenous Hormone Contents in Standard and Dwarf Persimmon (*Diospyros kaki* Linn. cv.)

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'Xiao Fang Shi' is a rare, dwarf cultivar of persimmon (*Diospyros kaki* Linn cv.) recently found north of Shanghai, China. The tree starts to bear fruit at2 years of age, while standard trees start fruiting at 5or 6 years of age. Dwarf and standard cultivars have about equal spring shoot growth, but the dwarf cultivar has little fall growth. To determine the mechanisms of dwarfness and early fruiting, enzyme-linked immunosorbant assay (ELISA) was used to analyze the endogenous indoleacetic acid (IAA), gibberellic acid (GA_{1+3}) and abscicic acid (ABA) contents in leaves and shoot tips of dwarf ('Xiao Fang Shi') and standard ('Da Fang Shi' and 'Zhu Sha Hong') persimmon. The measurement was done during the entire growing season. The results showed that IAA, GA_{1+3}, and ABA contents were influenced by cultivars, ages of trees, and phenophases. The dwarf cultivar 'Xiao Fang Shi' has lower IAA and GA_{1+3} but higher ABA contents than the two standard cultivars during the growing season. These correlations are especially evident when the fruit is ripening. The correlation coefficiency between contents of IAA and GA_{1+3} and tree height was 0.9704, while that between ABA content and tree height is –0.9697. The low IAA and GA, and high ABA contents may be responsible for little shoot growth of the dwarf cultivar in the fall.

702 (PS 7)

Seasonal Fluctuations of the Firmness and Cell Wall Polysaccharides of *Citrus* Fruit Rind

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To compare to two types of Citrus fruit rind [i.e., soft type (satsuma mandarin, *Citrus unshiu* Marc.) and firm type (Hassaku, *C. Hassaku* Hort. Tanaka)], rind firmness and contents of cell wall polysaccharides were measured from August to January. In August, firmness was measured by a puncture test and found to be ≈3000g in both species. Firmness of satsuma mandarin decreased drastically with time from August to September and decreased slightly thereafter. In contrast, Hassaku firmness increased slightly from August to September, decreased from September to November, and fluctuated. Hassaku firmness, therefore, was significantly higher than satsuma mandarin firmness after September. We measured sugar content in each fraction after fractionalizing cell wall polysaccharides. In flavedo tissue, sugar content in cellulose fraction was the highest, fol-

lowed by hot-water and EDTA fraction; hemicellulose fraction was the lowest. Although both species were almost the same in sugar content in cellulose and EDTA fraction in August, satsuma mandarin was significantly higher than Hassaku in January. These data showed that changing of rind firmness in citrus was related to the sugar content of cellulose and EDTA fraction in flavedo tissue. In albedo tissue, sugar content in the cellulose fraction was the highest, followed by hemicellulose and hot-water fraction, and EDTA fraction was the lowest. However the extent of seasonal fluctuation in albedo tissue was smaller than that of flavedo tissue, not having any relation to the changing of the firmness.

703 (PS 7)

Seasonal Carbohydrate Fluctuations in 'Hass' Avocado

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Monthly samples were taken from 9-year-old 'Hass' avocado trees on Duke 7 rootstock grown at the UC Southcoast Research and Extension Center in Irvine, Calif. Changes in starch and total soluble sugars were monitored from fine and coarse roots, trunk (above the bud union), small diameter stems, leaves, and fruit. When possible, seasonal carbohydrate changes were compared to root and shoot flushing patterns. In all of the vegetative plant organs monitored, total soluble sugars accounted for most of the carbohydrate. Starch accounted for ≈10% of the sample dry weight, whereas the total soluble sugars accounted for ≈18%. D-mannoheptulose and perseitol, both C7 sugars, were the predominant soluble sugars throughout the year. Fructose, glucose, and sucrose accounted for <5% of the total soluble sugars. During fruit development, soluble sugar content of the exo- and mesocarp tissues >25% of the dry weight. The significance of these findings will be discussed in relationship to tree phenology and carbohydrate partitioning.

704 (PS 7)

Root System Characteristics of Papaya Plants Grown on a Slope

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'Red Lady' papaya transplants were planted on a slope with a 30% to 35% grade and grown for 5 months. Excavation was used to determine root distribution on the uphill and downhill sides of the plants. Roots were separated into the taproot system and lateral roots on the uphill and downhill sides. The line intersect method was used to determine length of the lateral roots, and length of the taproot system was measured directly. All roots were dried at 70°C. The taproot system accounted for 2% of the total root length and 66% of the total root mass. Of the 130-m of lateral roots, 71% were located on the downhill side. Similarly, 69% of the dry mass of the lateral root system was located on the downhill side. Primary lateral roots on the uphill side of each plant developed horizontally, but some secondary lateral roots developed against gravity to maintain a portion of the root system close to the surface of the slope. Some of these lateral roots developed at angles of 55° to 60° above the horizontal.

705 (PS 7)

Partial Root Volume Irrigation of Papaya Plants in Split Root Containers

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The influence of partial root volume irrigation on water relations and expansion of roots and leaves of papaya plants was determined using split root containers. In one study, 'Tainung #1' and Solo #8 seedling roots were trained into four compartments until well-established, then water was withheld from 0, 1, 2, or 3 quadrants. Mid-morning stomatal conductance and predawn relative leaf water content were not affected by the irrigation treatments. Similarly, relative root water content in the dry quadrants was not different from that in the watered quadrants. In a second study, 'Red Lady' seedling roots were trained into four compartments which contained a 13 × 13-cm plexiglass observation window. After the plants were well-established, watering was continued in one of 4 (1:4) or four of four (4:4) quadrants. Leaf midrib and root extension were measured at 06:00 and 18:00 HR each day. Daily growth of roots in the dry quadrants was reduced 25% below that in the watered quadrants, and midrib extension of the 1:4 plants was reduced ≈10% below that of the 4:4 plants. Irrigation treatments did not influence the percentage of growth occurring during the diurnal and nocturnal periods. The dry quadrants of 1:4 plants were almost devoid of fine roots. The number of root tips on the observation windows of the 1:4 plants was reduced 43% in the dry quadrants and increased 22% in the wet quadrant compared with that for the 4:4 plants.

706 (PS 7)

Root and Stem Extension of Young Papaya Plants

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'Red Lady' and 'Tainung #1' papaya plants were grown in nursery trays with cells 5.1 cm in diameter. After 10 weeks, mean height of the 'Red Lady' plants was 10.1 cm and that of the 'Tainung #1' plants was 9.3 cm. Each of five plants per cultivar was planted between two root observation windows, one at 45 cm and the other at 95 cm. Roots reached the 45-cm observation window in 30 days, when mean height of the 'Red Lady' plants was 18.7 cm and that of the 'Tainung #1' plants was 13.0 cm. Roots reached the 95-cm observation window in 55 days, when mean height of the 'Red Lady' plants was 55.4 cm and that of the 'Tainung #1' plants was 40.6 cm. Thus, root extension during these initial 55 days was 17 to 18 mm per day for both cultivars, and stem extension during this period was 8.7 $mm \cdot d^{-1}$ for 'Red Lady' and 5.5 mm per day for 'Tainung #1'. Root extension declined for both cultivars to ≈12 $mm \cdot d^{-1}$ by the initial bloom period, then further declined to ≈4 $mm \cdot d^{-1}$ during and after the initial fruit set stage. Stem extension increased to about 19 $mm \cdot d^{-1}$ after the plants were established and remained at this rate until well into the stage of heavy fruit set and growth, when it declined to about 8 $mm \cdot d^{-1}$. The amount of fruit set influenced root characteristics more than cultivar.

707 (PS 7)

Growth, Foliar Mineral Relations, and Gas Exchange of *Mammea americana* as Influenced by Salinity

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Whole plant growth, foliage mineral content, and leaf gas exchange were measured on *Mammea americana* seedlings exposed to salinity ranging from 0 to 8 $dS \cdot m^{-1}$ to determine relative tolerance of this species. In one study, growth measured as leaf area, trunk cross-sectional area, and total dry mass was reduced by 23 weeks of exposure to salinity. Growth of plants exposed to 8 $dS \cdot m^{-1}$ was ≈30% below that of control plants. Leaf gas exchange was reduced by salinity to a greater degree than the growth variables. Stomatal conductance of plants exposed to 8 $dS \cdot m^{-1}$ was ≈70% below that of control plants. Plants exposed to 8 $dS \cdot m^{-1}$ exhibited a seven-fold increase in leaf chloride and 13-fold increase in leaf sodium compared to the control plants. In a second study, 8 weeks of exposure to 8 $dS \cdot m^{-1}$ reduced net CO_2 assimilation and apparent quantum yield to ≈50% of the values for the control plants. Dark respiration was not influenced by salinity. The results indicate that *Mammea americana* is moderately sensitive to salinity stress.

108 POSTER SESSION (Abstr. 708–715) Growth Regulators—Fruits

708 (PS 4)

Residual Effects of Chemical Induction of Branching of Apple Trees in the Nursery on Their Performance after Transplanting

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One-year-old trees of three apple selections [NY73334-35 (A), NY75414-1 (B), and NY75413-30 (C)] from the Geneva Breeding Program were transplanted into an orchard. While at the nursery, the trees were treated with Promalin and Accel, by themselves or in combination, to promote lateral branch formation (feathering). After trees were transplanted, no growth regulators were applied to the trees. One year after transplanting, treated trees of B and C had produced more feathers than the controls. This was particularly pronounced with the very difficult-to-branch selection C. No differences between chemical treatments were found. Regardless of selection, each chemical treatment significantly influenced increase in total extension growth compared to the control and contributed to rapid build up of tree structure. There were no differences between the treatments in tree height, tree caliper, or the number of spurs.

709 (PS 4)

Chemical Control of Spininess with Apple Rootstocks

Tadeusz Jacyna,* and *James N. Cummins,* Cornell University-NYSAES, Geneva, NY 14456

Spininess is characteristic of many *Malus* species, especially American crabapple and *Malus baccata* L. Spininess often is present on rooted stoolshoots of commercial apple rootstocks (M.9, M.26, MM.111, and MM.106) and some rootstocks from the Geneva Breeding Program. This undesirable characteristic makes liner production costly and laborious. It is estimated that the cost of manual removal of spines amounts to ≈20% to 25% of total production costs. To counteract spininess, the stoolshoots of excessive spiny rootstock selections [74R5M9-760 (T/1), 74R5M9-707 (T/2), and 75R5M9BR-521 (T/3)] were chemically treated while growing at stoolbed. Chemical treatments consisted of single sprays of nontranslocated growth regulators Tamex (a.i. butralin) or Tamex AG (a.i. butralin + fatty alcohols C8 - C10), and commercial auxin formulation (Tre-Hold A-112). Tamex AG and A-112 at applied rates brought about some phytotoxicity effects while Tamex did not. On average, Tamex application (1000, 2000, and 4000 ppm) reduced spine number to ≈80%, 68%, and 84% of T/1, T/2, and T/3 control plants, respectively. However, Tamex at 4000 ppm reduced the number of spines to 57% and 60% of control T/2 and T/3 plants, respectively, without any detrimental side effects. A parallel greenhouse experiment is being performed using commercial M.26 and Geneva 30 apple rootstocks.

710 (PS 4)

Drop Control and Fruit Quality Effects of AVG on McIntosh Apples

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Aminoethoxyvinylglycine (AVG) was used in two experiments to control preharvest drop and to improve fruit quality of 'McIntosh' apples. AVG application at 25 g a.i./acre (26 ppm) and 50 g a.i./acre (52 ppm) to mature 'McIntosh'/M.7 apple trees delayed drop between 1 and 2 days. In another experiment where AVG was applied to 'Marshall McIntosh'/Mark apple trees at concentrations between 30 and 120 ppm, drop control also was good. The response was linear. NAA had little or no effect on retarding preharvest drop. In both experiments, AVG increased fruit flesh firmness, retarded ripening, and delayed red color development. The commercial potential of AVG will be discussed.

711 (PS 4)

The Effects of Nephtaline Acidamid (NAD) on Preharvest Drop of 'Golden Delicious' Apples

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To determine the effect of NAD on prevention of preharvest fruit drop of 'Golden Delicious' apples, a range of studies were conducted for 2 years in the Kamalabad area in Karaj City-Iran. In this experiment NAD at 10 and 15 ppm concentrations were applied in two intervals of 2 and 3 weeks before harvesting (131 and 138 days after full bloom) and at the same time nontreated trees were used as control plants.The results indicate that applying NAD reduces the preharvest fruit drop percentage and then is followed by the yield increase. Fruit drop percentage, fruit weight, length, diameter and volume changes, amount of soluble solid material, total sugar content, total acid content, fruit juice pH, and flesh firmness were measured and analyzed in this experiment. According to the results of this experiment using NAD not only prevents the preharvest fruit drop of 'Golden Delicious' apples, but any unsuitable changes on the qualitative property of the fruit are avoided and there even is quality improvements in some cases compared to control trees.

712 (PS 4)

The Effect of Accel and Carbaryl on the Fruit Set, Yield, Quality, and Leaf Mineral Composition of Apples

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Experiments were performed to determine the effect of Accel and carbaryl on the fruit set, yield, quality, and leaf mineral composition of three apples cultivars: 'Empire', 'Jon-A-Red', and 'Braeburn'. The treatments used were Accel at 25, 50, and 75 ppm; carbaryl at 0.05%, 0.1%, and 0.2%. There were significant increases in length : diameter ratio, weight of fruit per tree, pH, and percent red color. Mean fruit weight, percent N, K, and Mg as the rates of Accel and carbaryl increased. Sugar content in the fruit and the levels of P, Ca, Mn, Fe, Cu, and Zn in the leaves were not affected. We conclude that the increased fruit weights were due to increased cell numbers and the few fruit that remained after thinning, thereby leading to increased amounts of assimilates directed to the developing fruit. The increase in percent red color is indicative of the effect of the treatments on the degree of ripening.

713 (PS 4)

Changes in Kinetic Characteristics of the ABA Binding Protein(s) of the Grapevine Fruit during Different Stages of Fruit Development

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By using the micro-volume radio-ligand binding essay, the changes in the kinetic characteristics of the abscisic acid (ABA)-binding protein(s) of the Kyhoh grapevine (*Vitis vinifera* x *V.labrusca*) fruit during the different stages of fruit development have been studied. The changes in the berry volume growth, concentration of sugar, organic acids, and ABA in fruit mesocarp have been surveyed, especially for studies of ABA-binding protein. The dissociation constant (Kd) and ABA binding maximum (Bmax) were determined by the Scatchard plots for ABA binding in microsomes of the fruit. They are Kd = 17.5, 50.0, 6.3, 13.3 $nmol \cdot L^{-1}$; Bmax = 98.6, 523.0, 41.6, 85.4 $\mu mol \cdot mg^{-1}$ protein, respectively, for the fruit developmental phase I, II, veraison, and phase III. The Scatchard plots showed a rectilinear function for all of the developmental phases including veraison, which suggests the sole ABA-binding site of high affinity for ABA in the fruit microsomes, but this site could either be only one kind of the same protein or consist of more kinds of different proteins for different developmental stages. The binding affinity of ABA-binding protein(s) for ABA was shown to be higher at veraison time than during other developmental phases; this binding affinity increased nearly by 10 times from phase II to veraison, while the concentration (Bmax) of the ABA-binding protein(s) decreased to the minimum at veraison. The very low concentration of ABA at veraison may be able to trigger the onset of fruit ripening due to the increase of the binding affinity of ABA-binding protein(s) for ABA at this time. The possible functions of the ABA-binding protein(s) for fruit development during the different developmental stages were discussed, and it is suggested that the protein(s) detected could be the putative ABA receptor(s) or transporter(s) for the action of this plant hormone in grapevine.

714 (PS 4)

Behavior of Red Roomy Grapevines to Cycocel and Some Micronutrients: I. The Effect of Buds Behavior and Growth

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Our objectives were to investigate the effect of spraying cycocel at effect of spraying cycocel at 0.0, 500, 1000, or 500 ppm starting immediately after pruning and ending at 30 days after berry set and/or the application of a mixture containing Mn, Zn, Cu, and Fe at 0.3 per each element. Data on buds behavior end growth characteristics (i.e., number of internodes and laterals, leaf area, cane thickness, and weight of pruning) were tabulated. Results showed that three sprays of 1000 ppm cycocel immediately after pruning, 15 days before first bloom, and at 30 days after berry set combined with using the micronutrients together at 0.3% substantially raised burst and fruiting buds and all the studied characteristics, while reducing dormant and vegetative buds. Three sprays of 1000 ppm cycocel plus 0.3% of a mixture containing the four micronutrients caused a positive influence on the behavior of buds and growth aspects of Red Roomy vines.

715 (PS 4)

Behavior of Red Roomy Grapevines to Cycocel and Some Micronutrients:III. The Effect of Physical and Chemical Properties of the Berries

A.M Akl, Ahmed F. Faissal, and *S. Youssef William,* Hort. Dept., Fac. Agric. Minia., Univ. Egypt

Physical and chemical properties of Red Roomy grapes in response to spraying cycocel and some micronutrients were investigated through two consecutive seasons. One spray 15 days before first bloom, 30 days after berry .set, or all of the three previous dates together and/or using Mn, Zn, Cu, and Fe in combination at 0.0% or 0.3% in sulphate form were applied. Three sprays of cycocel at 1000 ppm in combined with the four micronutrients together at 0.3% exerted a lower percentages shot and cracked berries and total acidity and a greater total soluble and total sugars percentages. The adverse effect of cycocel can be dimin-

ished by spraying the micronutrients with it together at 0.3%. The most pronounced effect on berries quality was obtained as a result of spraying Red Roomy vines with cycocel at 1000 ppm plus the application of Mn, Zn, Cu, and Fe at 0.3% three times.

145 POSTER SESSION (Abstr. 716–729) Growth and Development–Vegetables

716 (PS 7)

Flow Rate as a Major Physiological Factor Influencing Calcium Content on Six Commercial Cultivars of Snap Beans (*Phaseolus vulgaris* L.)

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Flow rate, Ca content, and Ca concentration of sieve sap were measured at four developmental stages (flowering and 1, 2, and 3 weeks after flowering) in six commercial snap bean cultivars to better understand physiological factors associated with genetic differences for pod Ca concentration. Sampling began 5 weeks after greenhouse planting and consisted of 1) decapitation of the plant at the first node; 2) covering the stem with preweighed dry cotton; and 3) removing the cotton, reweighing it, and saving it for Ca determination. Flow rate was defined as the difference in cotton weight (expressed as milliliter) per 12 hours. Ca determinations were made using an atomic absorption spectrophotometer. Calcium content was defined as milligram of Ca per total volume of sieve sap after 12 hours. Concentration of Ca was the quotient of Ca content by flow rate (expressed as milligrams Ca per milliliter sap). A positive correlation between flow rate and total Ca content of sieve sap ($R^2 = 0.83$), flow rate and Ca concentration of sieve sap ($R^2 = 0.36$), and Ca content and Ca concentration ($R^2 = 0.80$) were found. Maturity appeared to be an important factor affecting flow rate and Ca influx in snap bean plants. Significant differences between genotypes for Ca content and flow rate were observed. High Ca genotypes reflected a high flow rate regardless developmental stage.

717 (PS 7)

Comparison of Root Characteristics of Conventionally Grown Cowpeas and Cowpeas Grown without Added Nitrogen Fertilizer

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Field experiments were conducted in Oklahoma in 1993 and 1994. Cowpeas [*Vigna unguiculata* (L.) Walp.] were grown using either non-inoculated seed and 23 kg·ha^{-1} of preplant nitrogen fertilizer (conventional) or inoculated seed and no preplant nitrogen fertilizer (reduced input). Sample plants were excavated at first pod set and analyzed for nodulation and root morphology. Additional plants were excavated at the green-shell stage and were analyzed for nitrogen concentration. Conventional and reduced input cowpeas did not differ in nodule distribution among root morphological components, total nodule fresh weight, total root dry weight, or nitrogen concentration. Most nodules generally were located on the basal and lateral roots. Results indicate that cowpea root characteristics are not necessarily altered by differing cultural systems at a given location.

718 (PS 7)

Effect of Mycorrhizal Fungi and Phosphorus Stress on Gas Exchange, Growth, and Development of *Capsicum annuum* L. cv. San Luis (Chile Ancho pepper)

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Seedlings of *Capsicum annuum* L. cv. San Luis were grown in pots containing a pasteurized mixture of sand and sandy loam soil inoculated or noninoculated with the V-A mycorrhizal (VAM) fungus *Glomus intraradices* Schenck et Smith. Long Ashton nutrient solution (LANS) was modified to supply P at 0, 11 or 44 μg·ml^{-1}. Diurnal gas exchange measurements were taken 15, 30 and 50 days after the experiment was initiated. Plant growth, leaf elemental content, and mycorrhizal development were assessed 52 days after transplanting. Gas exchange and net photosynthesis were enhanced by mycorrhiza and full strength LANS fertilization (44 μg·ml^{-1}). The symbiosis increased leaf nutrient content of P, K, Mg, S, Fe, Mn, Zn, Cu, B, Mo, and Al. Mycorrhizal plants had higher shoot dry weights, leaf number, leaf area, and fruit primordia than nonmycorrhizal plants with P at 0 and 11 μg·ml^{-1}. Root colonization (arbuscules, vesicles, and internal and extraradical hyphae development) were higher with P at 0 and 11 μg·ml^{-1}. The quantity of spores recovered in soil was independent of P treatments.

719 (PS 7)

Phenology of Four Melon Hybrids Cultivated in the Lara State Conditions in Venezuela

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Phenologycal studies of melon hybrids (Chando, Concorde, Explorer, and Durango) were made through the parameter days to enmergency, type of flowers, days to initiate flowering after sowing, flowering period until first fruit appeared, first cycle fruit formation until new cycle, and days from sowing until the first and final harvest. Chando and Concorde hybrids germinated 4 days after sowing, and Explorer and Durango hybrids germinated 1 day later. All hybrids presented andromonoic flowers. The first flower bottom was present at 25 days after sowing, especially in the hybrid Concorde, while for Explorer and Durango hybrids, it was 26 days. The period of time from flower initiation until the first fruit appeared for Concorde and Chando was 5 days, while for Explorer and Durango hybrids, it was 7 days. Fruit formation occurred in the first cycle and had a duration of 9 days from Concorde. For Chando, Explorer, and Durango, the formation of first fruit group (first cycle) was 12 days. The period of time from sowing until first harvest was 61 days for Concorde and 69 days for the final harvest and from 63 to 72 days, respectively, for the Chando hybrids. For Explorer and Durango, it was 67 to 78 days, respectively.

720 (PS 7)

Stalk Senescence, Sugars, Proteins, and Minerals in Stalks of a Supersweet Corn at Developmental Stages

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Senescence and levels of minerals, sugars, and proteins were determined in stalk internodes of corn (*Zea mays* L.) cv. Illini Gold, a *shrunken2* hybrid, from from mid-whorl (V9; internodes completely juvenile) to fresh-market maturity (FM; internodes exhibiting stages of senescence). Senescence was rated in internodes near the base of the stalk (I7), below the ear (I9), and between the ear and tassel (I11). Tissues were extracted and analyzed by carbon-nuclear magnetic resonance spectroscopy (C-nmr) and SDS-PAGE electrophoresis. Senescence rating increased from V9 to FM. Through silk emergence (R1) C-nmr carbohydrate spectra were similar, regardless of internode, with chemical shifts between 61 and 104 ppm, mostly of glucose, fructose, and sucrose. At FM, additional lines were found that were not associated with a saccaride. The highest concentration of sucrose was at R1, fructose at tasseling (VT), and R1, and for glucose from VT to FM. The protein profile present through R1 in I7 was not present at FM. In I9, the protein profile was similar throughout. In I11, numbers, or density, of protein bands decreased through FM. Mineral concentrations did not change, decreased, or fluctuated. Levels of N, Cl, or Na at VT, R1, and FM, respectively, were negatively correlated with senescence. In I7 and I9, senescence ratings were negatively correlated with levels of Mg, NO_3^-, or SO_4^{2-}. Senescence appears to be associated with concentrations of some minerals, a reduction in levels of sucrose, and with the presence or absence of some proteins; however, cause and effect remains to be established. This research was hosted by USDA/SCARL at Lane, Okla., and made use of NMR equipment provided through USAF/AFOSR Grant F49620-95-1-0316 and NIH/NIGMS Grant GM 08003.

721 (PS 7)

Reduced 5'-Methylthioadenosine Nucleosidase and 5-Methylthioribose Activities and Ethylene Biosynthesis in Nonripening Tomato Mutants *'Rin'* and *'Nor'* Relative to Ripening Tomato 'Rutgers'

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5'-methylthioadenosine (MTA) nucleosidase (EC.2.2.2.28) and 5-methylthioribose (MTR) kinase (EC.2.7.1.100) activities were evaluated in *'rin',*

'nor', and 'Rutgers' tomato fruit during development and ripening. Changes in the activities of these enzymes were compared to ethylene biosynthesis. MTA nucleosidase and MTR kinase activities in *'rin'* and *'nor'* were ≈30% and 22%, respectively, lower than 'Rutgers' during the first 2 weeks of fruit development. In 'Rutgers', activities of these enzymes declined sharply until fruit maturity. Shortly before climacteric rise in ethylene synthesis, MTA nucleosidase, and MTR kinase activities increased, reaching a maximum level before peak ethylene synthesis then declined when fruit started to approach senescence. Whereas, *'rin'* and *'nor'* mutants exhibited no climacteric rise in ethylene synthesis and no change in MTA nucleosidase or MTR kinase activities, following their decline after 2 weeks of growth. A rapid increase in ethylene synthesis was observed when mature green *'rin'* and *'nor'* fruit were wounded. This increase in ethylene was paralleled by an increase in MTA nucleosidase and MTR kinase activities. However, increase in wound ethylene, MTA nucleosidase, and MTR kinase activities in *'rin'* and *'nor'* was ≈40% less than what we had previously reported in 'Rutgers'. Relationship of MTA and MTR kinase activities to fruit growth, development, ripening, and natural and wound ethylene biosynthesis will be described.

722 (PS 7)

Fruit Ripening and Quality of Experimental and Commercial (*rin* and *nor*) Tomato Hybrid Lines

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Sinaloa tomato growers continuously evaluate new varieties, looking for better quality and long shelf life. Mutant fruit with the genes rin and nor offers both possibilities when crossed with normal fruit. Our study presents results of 16 tomato hybrid lines harvested from the field at the "turning" stage and stored under simulated marketing conditions (20°C and 80% RH). Twelve experimental hybrids were from the *rin* type, one from the *nor* type, two commercial hybrids were normal, and one commercial line from the *rin* type. Sampling was done every 2 days up to 16 days. Evaluations done included physical, chemical, and physiological determinations. Line S69 (*nor* type) had higher firmness compared to the others, while normal lines (S121 and S123) were the softest. S69 was the only hybrid that did not completed a red external color development. Experimental lines of the *rin* type presented acceptable development of red color, however, only normal lines (S121 and S123) reached the characteristic red color of tomato. Lines of the *rin* type (S172 and S200) lost more weight during marketing than normal ones. Pulp pH was higher on the experimental *rin* lines than on the commercial ones (BR84, S121 and S123). Not difference on the sugar : acid ratio among the lines was found. Only normal lines showed a climateric CO_2 and C_2H_4 peak.

723 (PS 7)

Tomato N Metabolism with Root Zone Temperature that Is Constant, In Phase, or Out of Phase with Shoot Temperature

*Yong-Zhan Ma** and *Martin P.N. Gent,* Dept. of Forestry and Horticulture, Connecticut Agr. Expt. Station, New Haven, CT 06504-1106

Tomato (*Lycopersicon esculentum* Mill) seedlings were grown with air temperature of 28°C light/12°C dark (12/12 hours), and either a constant, 20°C, root-zone temperature (RZT), or in-phase with air temperature, 28°C in the light and 12°C in the dark, or out-of-phase, 12°C in the light and 28°C in the dark. These treatments were applied from 17 to 25 days after germination, with 200 M NO_3^- in flowing nutrient solution. The relative growth rate of leaves was the greatest with constant RZT, 0.33/d, and least with out-of-phase RZT, 0.29/d. The concentration of free amino acid and protein in leaves was least for out-of-phase RZT. The NO_3^- concentration in leaves was the highest in the dark, intermediate in the middle of the light period, and the lowest at the end of the light period. In roots, NO_3^- concentration showed a similar trend. This variation was greatest when RZT was varied out of phase, and least with constant RZT. At the end of the light period, NO_3^- concentration in roots was 246, 180, and 162 $\mu mol \cdot g^{-1}$ dry weight for constant, in phase, and out of phase RZT, respectively. In the light, leaves of seedlings grown with out-of-phase RZT had 5 $mmol \cdot g^{-1}$ NO_3^- compared to 16 $mmol \cdot g^{-1}$ with in-phase RZT Availability of NO_3^- in the light may be the factor limiting plant growth with out-of-phase RZT. This research was supported in part by grant number 93-37100-9101 from the National Research Initiative Competitive Grants Program/USDA.

724 (PS 7)

The Role of Auxin in Enhanced Root Growth of Trichoderma-colonized Sweet Corn

Lisa M. Blanchard and *Thomas Björkman*,* Dept. of Horticultural Sciences, NYSAES, Cornell Univ., Geneva, NY 14456

Sweet corn roots colonized with the T-22 strain of the common rhizosphere fungus grow substantially faster than roots of plants not so colonized. We tested whether this growth enhancement was a consequence of the fungus affecting auxin regulation of cell elongation. In corn roots, auxin acts an inhibitor of growth, maintaining the rate below its short-term maximum potential. The first hypothesis was that the fungus secretes an auxin inhibitor, and thereby reduces the auxin limitation of growth. Apical segments (5 cm) were incubated in media conducive to elongation, supplemented with 0.1 μM indole acetic acid (IAA), a T-22 culture filtrate (5%), or both. IAA inhibited growth by 69%, and the culture filtrate inhibited by 16% with no interaction. The action of T-22, therefore, is not through a secreted antiauxin. The second hypothesis was that the fungus metabolizes or otherwise reduces the effectiveness of auxin, which was tested by measuring growth of colonized and uncolonized seedlings after a half-hour incubation of the root tips in 0.1 μM IAA. Auxin inhibited growth by 42%, whereas colonization increased growth by 27%. Again, there was no interaction, a result inconsistent with the antiauxin model. The third experiment further tested the antiauxin hypothesis by maximizing acid growth (normally regulated by auxin) by incubating the root tips in 1 μM fusicoccin (FC). Colonization increased growth by 10% without FC but by 42% with it. FC alone increased growth by 11%. The significant positive interaction is not consistent with a change in the auxin sensitivity but is consistent with an increase in the maximum sustainable growth rate.

725 (PS 7)

Kinematic Analysis using a Novel Method of Marking Roots with the Fluorescent Dye Calcofluor

*Robert C. Ebel** and *Jonathan P. Lynch*, Dept. of Horticulture, The Pennsylvania State Univ., University Park, PA, 16801

Kinematic analysis allows accurate description of physiological changes along root axes by additionally taking into account changes due to dilution as cells expand. In previous studies using kinematic analysis, roots have been marked with ink by fine-tipped pens or single hair brushes. These methods have occasionally reduced root growth and limited resolution to the width of the marks, usually 1 mm. We describe a new method of marking roots with the fluorescent dye calcofluor which does not reduce root growth. The terminal 7 mm of bean root tips were grown vertically in a glass chamber into which a constant flow of aerated nutrient solution was passed. A 0.001% calcofluor solution was pulsed through the chamber for 1 min. Excess calcofluor was removed rapidly by a high rate of nutrient flow ($200\ ml \cdot h^{-1}$) for 3 min. after which flow was reduced to 20 ml/hr. Roots were magnified 11.5× under a microscope mounted horizontally and five digitized images captured every 5 min. Imaging software allowed determination of fluorescence of individual pixels along the length of the root. Fluorescence decreased in the zone of cell elongation due to dilution as cells expanded. This method may improve resolution of kinematic analysis to the length of individual pixels, which was 18 microns at 11.5× magnification.

726 (PS 7)

Comparison of Root Death in Common Bean (*Phaseolus vulgaris*) grown in Sand Culture and Field Conditions

Maria Fisher, David Eissenstat,* and *Jonathan Lynch,* Intercollege Program in Plant Physiology and Dept. of Horticulture, The Pennsylvania State Univ., University Park, PA 16802

In annual plant species, root death has been assumed to be closely correlated with shoot senescence. However, in a preliminary study with common bean grown in sand culture beyond physiological maturity (114 days), no root death occurred. We investigated whether the incidence of bean root death was higher under field conditions than in sand culture. Root death was defined as root disappearance. The sand culture consisted of silica sand and P-loaded alumina. Plants in this system were fertigated twice daily with complete nutrients supplied in adequate amounts. The field planting was on a Hagerstown silt loam in central Pennsylvania. Roots were observed using minirhizotrons every 1 to 3 weeks after planting. In sand culture, incidence of root death was monitored on a population of 170 roots from three plants between 25 and 88 days (shoot senescence) after planting Root death was 10%. In the field study, 55% of the 53 roots examined died between 32 and 93 days (shoot senescence) after planting. Biological factors present in the field and not

present in sand culture appeared to contribute to root death. The persistence of roots in sand culture suggests a lack of programmed root senescence in contrast to shoot senescence. This has interesting implications for resource allocation during reproduction and in face of belowground herbivores and pathogens.

727 (PS 7)

Distribution of Horseradish Peroxidase in Horseradish Plants

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Peroxidases are an enzyme family that displays a wide range of forms, functions, and distribution in the plant kingdom. Peroxidase extracted from horseradish is one of a few enzymes that had been widely used in industrial and clinical research. Horseradish peroxidase (HRP, EC 1.11.1.7, donor : hydrogen-peroxide oxidoreductase) has been used to estimate the levels of other enzymes, in immunoassay, bio-bleaching processes, and in lignin degradation for fuel production. Despite its extensive use, little is known about HRP distribution in horseradish plants. Four commercial horseradish cultivars (IL-647, IL-1069, IL-1573, and IL-1590) were evaluated for HRP activity in the main root, lateral roots, leaves, and leaf blades. HRP activity was highest in the main root followed by lateral roots. However, only a trace amount of HRP activity was detected in leaf blade and leaf petiole. IL-1573 has the highest HRP activity, while IL-647 has the lowest activity. Site of HRP synthesis and its distribution during horseradish plant growth and development will be described.

728 (PS 7)

The Effect of Plastic Mulch Color on Growth and Development of Cucumber and the Response of Cucumber Beetles to Mulch Color

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Field experiments were performed to verify the influence of polyethylene mulches (red, blue, gray, black, and yellow) on the development and yield of two varieties of cucumber (*Cucumis sativus*), a hybrid, 'Turbo' and an open-pollinated, 'Marketmore 76'. The influence of the mulches on the population dynamics of the adult striped cucumber beetle (*Acalymma vittatum*) was also observed. Rhizosphere temperature, reflected surface temperatures, reflected wavelength, vine length, leaf number, leaf area, total fruit produced, and number of marketable fruit were some of the characteristics measured. A split plot experiment in a randomized blocks design with three replications was used. In relation to plant growth and yield, plants grown on red mulch showed the best growth and yield overall compared to blue, gray, black, and yellow colored mulches, The incidence of the cucumber beetles was highest in the yellow colored mulch. The 'Turbo' variety had the highest fruit number in almost all of the colors of mulch compared to the open pollinated 'Marketmore'. It is suggested that the differential growth and development of cucumbers was influenced by the rhizosphere temperature as well as the light spectrum reflected from the plastic. The response of the beetles to the mulch was mainly attributed to the different wavelengths reflected from the various mulches.

729 (PS 7)

Essential Oil of Leaves and Flowers of 'Sweet Dani': A Lemon Basil (*Ocimum basilicum*)

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Hydro-distilled essential oils from fresh and dry leaves and fresh and dry flowers of 'Sweet Dani', a new ornamental lemon basil (*Ocimum basilicum*) cultivar with potential as a source of natural citral, were analyzed by GC and GC/MS. The essential oil contents were 0.18%, 0.19%,0.30%, 0.28% w/w on a fresh weight basis of fresh and dry leaves, and fresh and dry flowers, respectively. Oils from leaves and flowers differed significantly in content and composition. The major constituents in dry leaf oil were neral 21.8% and geranial 33.5%. The major constituents in dry flower oil included: nerol 11.5%, neral 12.9%, geraniol 7.6%, and geranial 17.7%. Nerol (1.6%), and geraniol (0.4%) were very low in dry leaf oil. As citral is a combination of neral and geranial, the relative leaf and flower citral content is 55.3% and 30.6% of the total oil, respectively. Linalool and octanol were detected in flower oils only.

104 POSTER SESSION (Abstr. 730–733) Growth and Development–Woody Ornamentals/Landscape, Turf

730 (PS 1)

Root Pruning Influences Level of Embolism during Posttransplant Growth of *Corylus colurna*

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Two-year-old, bareroot, *Corylus colurna* seedlings were grown in 7.5-L containers from 15 Mar. to 23 June 1995. Plants were grown in a glasshouse using pine bark media. Temperatures were maintained at 30/20°C. Plants received no fertilization or Osmocote 18–6–12 top-dressed at 14 or 28 g/container. Additionally, plants were pruned to remove 0%, 25%, or 50% of the root system based on root length. Height, diameter, branch number, leaf area, and root and shoot dry weight increased linearly as rate of fertilization increased. Percent embolism was not influenced by rate of fertilization. Plant height, branch number, leaf area, and root and shoot dry weight were not influenced by rate of root pruning. Plant diameter increased linearly as rate of root pruning decreased. Percent embolism increased linearly as rate of root pruning increased.

731 (PS 1)

Changes in Ultrastructure of Bark Cells and Slippage of Bark in Poplar Plants when Grown under Short-day Photoperiods

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The development of bud dormancy in poplar plants is initiated by short-day photoperiods (SD). During the development of bud dormancy, there was a gradual increase in the force required to peel off the bark from the stems. We measured the force required for bark peeling and investigated the cellular changes associated with this phenomenon. Stem samples were collected from plants which had been grown under SD for different period of time up to 10 weeks. At each sampling date, the forces required to peel off the bark were measured by a tensiometer. At the same time, samples were fixed to examine ultrastructural changes by transmission electron microscopy. We have observed that there was a significant increase in the force (in Newtons) required to peel off bark from poplar stems when the development of dormancy was initiated by SD treatment. Many ultrastructural changes were observed, including the accumulation of bark storage proteins, the break down of the central vacuole to form many small vacuoles, thickened cell walls, etc. Efforts have been made to relate ultrastructural alterations to changes in the force required for bark peeling.

732 (PS 1)

Changes in Protein Profiles in Poplar Trees during the Induction of Bud Dormancy by Short-day Photoperiods

Zoran Jeknic and Tony H.H. Chen,* Dept. of Horticulture, ALS 4017, Oregon State Univ., Corvallis, OR 97331.

In poplar (*Populus deltoides* Bartr.ex Marsh), the development of bud dormancy is initiated by short-day (SD) photoperiods. The degree of bud dormancy, expressed as days to budbreak, increased from ≈10 days for plants grown under long-days to >200 days after 10 weeks of SD exposure. We investigated quantitative and qualitative changes in protein fractions extracted from terminal buds, lateral buds, bark, and leaves of poplar plants during the induction of bud dormancy by 2-D PAGE. While total protein contents(as milligrams per gram fresh weight) in leaves, terminal, and lateral buds did not change significantly during SD treatment, bark protein content increased about five-fold in 10 weeks. The results of 2-D PAGE analysis indicated that there was a significant change in protein profiles in terminal and lateral buds, leaves, and bark. The results suggested that SD treatment in poplar plants causes substantial changes in protein profiles during the induction of bud dormancy.

733 (PS 1)

Quantitative Analysis of Turfgrass Plots

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A system for the digital analysis of photographic prints of turfgrass plots is being developed. The 3-year-old turfgrass plots included Meyer zoysiagrass,

Midlawn bermudagrass, Prairie buffalograss and Mustang tall fescue. The plots were photographed by a camera with a small dual bubble level on the camera back and a 28-mm-wide angle lens. Photographs were digitized with flatbed scanners. The images can then be analyzed in a variety of ways. For example, a series of photographs were taken from mid-Sept. through late Oct 1995 and spectral analysis of the resultant digital images were made. The initial RGB (red-green-blue) format of the images was converted to HSI (hue-saturation-intensity) for analysis. The results indicate, obviously, that hue changed from 104 (i.e., green) to 75.7 degrees (i.e., brownish) between the beginning and end of Oct. 1995. Similarly, intensity changed from ≈0.12 to ≈0.16 during the same time period, indicating that the images became darker over time. These phenomena were observed in all four species examined. However, the saturation value evoked a significant species * date interaction. The three warm-season species showed a decrease in saturation, while Mustang had no significant decrease during Oct. Spectral as well as textural analysis are likely the two most useful techniques in the digital analysis of turfgrass plots. Examples of both will be presented.

34 WORKSHOP 3
Wetlands and Horticulture: Problems and Solutions

734

Selenium in Water Management Wetlands in the Semi-arid West

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The discovery in 1983 of deformities, reproductive failures, and high waterfowl mortality rates at Kesterson National Wildlife Refuge, western San Joaquin Valley, Calif., due to selenium (Se) -contaminated drainage water, raised concerns that these problems may be occurring in the >600 wetlands and National Wildlife Refuges being utilized to collect irrigation drainage waste water in 17 western states. The waterfowl problems were traced to ingestion of organic Se present as Se-amino acids. Plants assimilate soluble Se into Se-amino acids and release them upon decomposition. Aerobic plant residue decomposition studies showed that 50% of the assimilated Se was mineralized to soluble Se, while the remaining organic Se persisted. This means that each growth cycle results in a steady decrease of soluble Se and an increase in organic Se levels. To test the effect of plant growth on Se accumulation, two types of evaporation ponds were evaluated, one with prolific plant growth, and the second relatively devoid of plant growth. Soil Se analysis showed that plant growth dramatically increased Se accumulation in the surface layers. Evaluation of additional Se-contaminated sites showed that Se accumulation followed an exponential function and accumulated rapidly above a 2% soil organic C content. Without plant growth, the Se remains mobile and diffuses to low concentrations in the underlying soil, suggesting that plant residue cycling is an important factor in Se accumulation and toxicity.

735

Wetlands of the Colorado River Delta Maintained by Agricultural Drainage Water

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The delta of the Colorado River in Mexico historically contained 780,000 ha of riparian, marsh, and gallery forest habitat. Similar to other desert river deltas, such as the Nile and Indus, the lower delta of the Colorado River has been severely affected by the upstream diversion of water for human use. However, several large marsh areas of conservation interest still occur below the agricultural fields in Mexico. They are supported by flood water, agricultural drainage water, and municipal sewage effluent, as well as by seawater in the intertidal zone. The main anthropogenic marshes are the Rio Hardy wetland, maintained by geothermal discharge and Mexicali irrigation return flows in the western delta, and Cienega de Santa Clara, maintained by local irrigation return flows and by discharge of Wellton-Mohowk Valley drainage from the United States, imported via a 80-km canal to Mexico. These wetlands provide valuable habitat to resident and migratory waterfowl, shorebirds, mammals, and endangered species, including the Yuma Clapper Rail and the Desert Pupfish. Both wetlands are currently threatened by water management actions that do not take the wetland value of agricultural drainage into consideration. If agricultural drainage water and other available waste streams were explicitly managed to support wetlands, the Colorado River detla could potentially contain 50,000 ha or more of permanent, high-quality brackish wetlands below the agricultural fields.

736

"Green" Water Treatment for the Green Industries: Opportunities for Biofiltration of Greenhouse and Nursery Irrigation Water and Runoff with Constructed Wetlands

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Constructed wetland biofilters have been widely used in recent years to provide secondary or tertiary water treatment, effectively reducing BOD, TSS, nitrate and ammonium, and some organic pollutants from municipal, industrial, and agricultural waste sources. The greenhouse and nursery industries, like all agricultural enterprises, have found themselves under increasing pressure to reduce or eliminate discharge of contaminated wastewater. In response, many greenhouse and nursery operators have installed, and are using, a variety of runoff containment and recirculating irrigation systems. While effective in reducing or eliminating wastewater discharge, these systems can become contaminated themselves and require treatment of the water before it can be reused in the irrigation system. Further, if the water should become contaminated and unusable, environmental discharge of this spent water from a recirculating irrigation system is perhaps even more problematic than simply allowing the excess irrigation water to be dumped in the first place. Potential contaminants in a recirculating irrigation system could include pesticide and other organic residues, excess fertilizer and non-fertilizer salts, and plant pathogens. The primary concern in greenhouse and nursery discharge wastewater is usually fertilizer salts, although pesticide and other organic chemical residues may also be of concern. Biological filtration using constructed wetlands may be a simple low-cost method for greenhouses and nurseries to treat these contaminants.

737

Best Management Practices Enable the Coexistence of Agriculture and the Everglades Environment.

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Situated at the northern end of the historical Florida Everglades is the 280,000-ha tract of land called the Everglades Agricultural Area (EAA). This land was diked, canalized, and drained in the early 1900s to encourage the production of primarily sugarcane, vegetables, sod, and rice on its Histosols. The phosphorus in drainage water from the EAA is believed to be causing undesirable changes to the ecosystem in areas subject to legislated environmental protection. Phosphorus (P) load reduction "Best Management Practices" (BMPs) are being developed and implemented in the EAA to reduce agricultural production impacts on the wetland areas. The BMPs can be categorized as fertilizer, water management, or particulate control related, and can be applied effectively across the EAA. Ten farms, representative of the EAA soils, rainfall, crops, farm size, geographic location, and water management practices, were used in the study. The farms were monitored under pre-BMP conditions for 1 to 3 years. By Jan. 1995, seven of the 10 farms were operating under project-designed BMP packages that included only the fertilizer and water management options. Depending on the method used for adjusting for hydrologic variability between years, calculated P load reductions ranged from 25% to 60% between 1994 and 1995.

53 WORKSHOP 6
Issues in Postharvest Biology

738

Climacteric Fruit Produce a Diminished Respiratory Climacteric When Ripened on the Plant

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Respiration (i.e., carbon dioxide production and oxygen consumption) increases as ripening is initiated in a group of harvested fruit called climacteric. This group includes many horticulturally important fruit crops, such as apples,

avocados, bananas, melons, peaches, pears, and tomatoes. Other fruit, which includes cherries, citrus, and strawberries, do not exhibit an increase in respiration as they ripen and are called nonclimacteric. Measurements of carbon dioxide production by ripening apples, melons, and tomatoes revealed a well-defined climacteric, but only in harvested fruit. The respiratory climacteric was greatly diminished or absent from these fruit when they ripened while attached to the plant. Fixation of respired carbon dioxide through photosynthesis or into organic acids was insufficient to account for the diminished amount of carbon dioxide evolved from ripening attached climacteric fruit. Unlike the respiratory climacteric, an increase in ethylene production occurred in both attached and harvested climacteric fruit. Ethylene stimulates respiration in most plant tissues. The rapid rise in respiration as soon as attached ripening climacteric fruit were harvested or abscised suggests that an inhibitor of ethylene-stimulated respiration may be translocated from the plant and prevent the climacteric rise in respiration in attached ripening fruit.

739

To PG or Not to PG?

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The absence of endo-α-1,4-D-galacturonanase (PG, EC 3.2.1.15) in some fruits and the molecular suppression of PG in tomato fruit have collectively provided evidence that this protein is neither required nor sufficient to achieve normal softening in fleshy fruits. On the other hand, initial claims that down-regulation of PG was without effect on tomato softening were overstated. The influence of PG on softening does appear to be minimal during the initial stages of ripening, during which time changes in the locule tissues can significantly alter texture as monitored in whole fruit. Enzymes, including pectinmethylesterases, cellulases, rhamnogalacturonanase, and glycosidases may also play pivotal roles in softening. β-galactosidases have attracted much attention as potential determinants of fruit texture; however, conclusive evidence for this role is lacking, and increased levels of β-galatosidase (and net cell wall galactosyl residue loss) have been noted in senescing vegetative and floral organs as well as in fruit. Apoplastic pH, ionic activity, and composition are likely to contribute to tissue and whole-organ texture through weakening of polymer aggregates and/or through modulation of cell wall enzyme activity. During the latter stages of ripening and overripening, the role of PG is apparent from the persistent structural integrity of fruit transformed with PG antisense constructs. Patterns of softening and deterioration in normal tomato fruit suggest that the catalytic activity of PG in vivo is initially queued and does not parallel the accumulation of PG protein. Developmental changes in membrane permeability, physical injury, and other stress conditions can alter the apoplastic environment, releasing constraints on PG action.

740

Determining Fruit Maturity in Research and Industry Applications

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The reasons for knowing the maturity of fruit center around controlling fruit quality after harvest. Farmers are usually concerned with trying to determine harvest date to fit their labor, storage, and marketing needs, whereas research scientists are typically trying to account for the effects of maturity as a variable in experiments. Specific goals for farmer and researcher will, in part, govern what maturity indices are used and what values are acceptable. Restrictions in time and equipment will also affect choice of maturity assessment methods. In some instances, internal or external characteristics might be more important. Because changes in a number of characteristics comprise ripening, there is no single criteria or method that can be termed "best." However, for each situation, an optimal choice of criteria or method may exist. The logic and information necessary to reach those optimal choices, from the perspective of the researcher and the commercial horticulture operation, is presented and contrasted.

741

Are the Effects of Heat on Physiology Due to Heat Shock Proteins?

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Production of heat shock proteins (HSP) in response to high temperatures are a highly recognizable feature of plant and animal systems. It is thought that such proteins play a critical role in survival under supraoptimal temperature conditions. The use of heat treatments has been examined extensively, especially for disinfestation of fruit and disease control. Heat treatments can affect physiological responses, such as ethylene production, softening, and other ripening factors, as well as reducing physiological disorders, including chilling injury. HSPs have been implicated in a number of stress responses, but the extent that they are involved, especially in amelioration of chilling injury, is a subject of debate. In a number of cases, heat shock proteins do not appear to be involved, and HSPs do not explain long-term adaptation to heat; other systems for which we do not have models may be at work. Resolution of these issues may require the use of transgenic plants with modified heat shock responses.

54 WORKSHOP 7
Alternative Production and Protection Practices for Tree Nut Crops

742

Alternative Production and Protection Practices for Tree Nut Crops

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California walnut farmers compete with pests and diseases to produce an economically viable crop. Current control strategies work reasonably well for most pest and diseases. However, the future of these techniques is a matter of speculation. This presentation describes current production practices and potential alternatives to "traditional" pest and disease control. Codling moth, walnut husk fly, mites, navel orangeworm, aphids, and scale are typical insect pests that have an impact on California walnut production. Spray decisions using Integrated Pest Management, beneficial insect releases, mating disruption, insect growth regulators, and orchard sanitation offer potential alternatives. Major diseases include: Phytophthora crown and root rot, crown gall, oak root fungus, and walnut blight. Control options include careful site selection and orchard management, resistant rootstocks, competitive bacteria for crown gall control, and copper compounds for walnut blight suppression. Weed growth is related to the amount of light reaching the orchard floor. Mature trees often shade the orchard floor, subsequently reducing the need for weed suppression. Herbicides are typically used for vegetation control. Choice of irrigation system, cultivation, mowing, cover crops, and flaming offer potential alternatives either alone or in combination with conventional herbicides.

743

Alternative Production and Protection Practices for Pistachios

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Pistachios are the single most-successful plant introduction to the United States in the 20th century. Part of this success is due to the alternative production practices that have made this crop more economical to grow. Controlled deficit irrigation (CDI) can produce 25% savings in irrigation water with no adverse effects. Reclaimed drainage water can be used for in-season irrigation up to 6 dS/m. Nitrogen applications can be adjusted for crop load and alternate bearing. Foliar sprays of boron, copper, and zinc can replace heavy ground applications to alleviated these micronutrient deficiencies. Some early season insect damage can be tolerated due to the tree's ability to compensate for the damage by filling a higher percentage of the remaining nuts, Maintaining a clean orchard floor can limit some insect pests. Mechanical pruning has been demonstrated to be cheaper and cause no loss in yield. Foliar fungal diseases can be partially controlled by limiting trajectory angle, frequency, and duration of irrigation or by using buried drip irrigation systems. Soil-borne fungal diseases and nematode damage are controlled by using resistant rootstocks.

744

Alternative Practices for Almond

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Improving almond orchard management by integrating cultural practices, pest and disease controls, and vegetation management has been a goal of Univ. of California research and extension efforts for more than 25 years. Alternative cultural practices related to orchard floor management, fertilizer applications, and pest and disease control are currently important components of the almond production system. Nontillage, with or without a seeded cover crop, has improved

potassium uptake and reduced pest problems. In-season fertilizer applications reduced the potential for nitrate pollution of groundwater. Minimizing dust, early harvest, and destruction of overwintering refugia are all cultural practices that reduce crop damage caused by pests. New methods of pest and disease monitoring using pheromone traps, egg traps, or a better understanding of disease life cycles have reduced unnecessary chemical applications. Degree-day phenology models have improved the timing of needed sprays. Expanded use of selective spray materials, such as narrow-range oils and *Bacillus thuringiensis*, reduce impacts on non-target species while natural predators and parasites are encouraged. Augmentative releases of beneficial insects are currently being evaluated as an additional alternative to in-season spraying. Cultivar and rootstock choices for new plantings present alternatives that can help avoid pests or diseases. Planting pattern affects productivity and is another factor to consider when evaluating alternative production practices for almond as new orchards are established.

745

Alternative Production and Protection Practices for Hazelnuts

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Oregon's Willamette Valley is home to 99% of the U.S. domestic production of hazelnuts, *Corylus avellana*. There are currently around 30,000 acres of hazelnuts in Oregon. Hazelnuts are a relatively low resource input crop when compared to other orchard crops. They require few pesticide applications, and are harvested mechanically. Oregon State Univ. (OSU) developed an Integrated Pest Management (IPM) program for hazelnuts in the middle 1980s that is widely adopted in the industry today. Sampling schemes and action thresholds have been developed for the filbertworm (the most important insect pest), as well as: obliquebanded leafroller, filbert leafroller, and filbert aphids. In an example of classical biological control, a filbert aphid parasite, *Trioxysis pallidus*, was imported from Europe in 1984. Trioxysis has successfully established itself throughout the industry. As a result, the need for aphid control sprays has been significantly reduced. Current research in hazelnut IPM is focused on a "soft pesticide" program that features an insect growth regulator for filbertworm control. Recent research with isotopically labeled nitrogen seeks to improve the efficiency of nitrogen fertilization in the industry. The northern portion of the industry is affected by Eastern Filbert Blight. OSU research has secured registrations of effective fungicides and refined the control program for the blight. Work is being completed on a predictive model to quantify the extent of spore dispersal, based on accumulated rainfall.

746

Alternative Production Practices for Pecan

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Several new management tools and management practices are being developed for pecan. Major insect pests of pecan are pecan nut casebearer, hickory shuckworm, and pecan weevil. Sex pheromone attractants are being developed for each of these pests that improve monitoring. Also, a pecan weevil trap (Tedder's trap) was introduced recently that is more sensitive to weevil emergence than the previous trap. New models that predict critical periods for pecan scab infection are being tested. Certain legume ground covers are being tested to increase beneficial arthropods in the orchard for aphid control, and to supply N. Mulches are being investigated as an alternative to herbicide management for young trees. A mechanical fruit thinning method has been developed that increases fruit quality and reduces alternate bearing as well as stress-related disorders.

57 WORKSHOP 8
Use of Molecular Markers in Germplasm Management

747

Molecular Markers for the Detection of Genetic Drift: The Case of Pea and Ryegrass

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Maintenance of genetic resources within the National Plant Germplasm System includes preserving the genetic constituency of accessions as close to the original sample as possible. Genetic changes that can arise during seed regeneration include both an overall loss of genetic diversity within heterogenous accessions and changes in the gene frequencies within accessions. Two germplasm collections are being examined with molecular methods at the Western Regional Plant Introduction Station (WRPIS) for evidence of such genetic change. In the case of pea, gross observation of seed and plant characters indicate that vigorous plant culling during a comprehensive Pea Seedbourne Mosaic Virus eradication program a decade ago resulted in the overall loss of genetic diversity in some heterogenous accessions. Isozyme data has corroborated these observations. Molecular markers are beginning to be used, both to quantify possible genetic changes in accessions as a result of the eradication process, and to document success in reintroducing diversity by repeating the eradication process with additional seed from archival seedlots. In the case of ryegrass, the practice of bulking the seed harvested from regeneration plots may bias the seedlot toward genotypes that are more fruitful. Isozyme analysis after two regeneration cycles showed that balanced sampling (equal seed no./plant) maintained allele frequencies close to the original seed sample. A bulk harvest sample and a sample with an equal number of spikes harvested from each plant showed some significant change in allele frequency, but no significant changes were seen in the allelic richness of accessions, or in the level of an accession's overall heterozygosity. A regeneration sample with an equal number of seed/plant will therefore best preserve gene frequencies within accessions, but loss of an accessions overall diversity will not diminish as a result of less than ideal sampling methods in ryegrass.

748

Management of *Vitis* and *Brassica* Germplasm

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We discuss a series of studies in our units employing molecular genetic markers in collection management, primarily for identity and diversity assessment and partitioning of genetic variation. Isozymes, random amplified polymorphic DNAs (RAPDs), and simple sequence repeat DNAs (SSRs) have been used for these purposes. We analyzed a range of *Brassica oleracea* accessions at six isozyme loci. Unique isozyme profiles (or fingerprints) were found for 40% of the individual genotypes within accessions. While isozymes were extremely valuable for partitioning genetic variability between and among subspecies, they failed to identify accessions and subspecies. Furthermore, relationships found did not correspond to those predicted by taxonomy. In a study of three species of Chinese vegetable brassicas using 112 RAPD markers, we were able to unambiguously distinguish all 52 accessions studied, despite some intra-accession variability. In addition, cluster analysis correctly grouped all individuals of the same species, but below that rank, taxonomic groupings occasionally broke down. RAPD profiles were found that unambiguously distinguished the three *Brassica* species from one another, but, for subspecies, no such profiles were found. In another RAPD study of *B. oleracea* subsp. *capitata* (cabbage), a closely related set of cultivars were not distinguishable, although more distantly related cultivars were. We had disappointing results with a RAPD study of *Vitis* accessions. DNA was extracted from the leaves of 23 greenhouse-grown and 52 field-grown vines. Twelve of the 23 greenhouse vines were rooted cuttings collected from 12 of the field-grown vines. Unfortunately, the RAPD profiles of all vines grown in the same location (whether greenhouse or vineyard) were more similar to one another than were profiles from the same clone grown in the two different locations. We are studying whether this result is due to physiological differences in plants growing under different conditions, to differences between PCR reagent lots, to pathogen infestation, or to DNA sample contamination. In a study of 23 accessions representing 15 *Vitis* species and three species hybrids, we used six different SSR markers to identify individual genotypes. We were able to unambiguously distinguish all genotypes, except two that were identical at all six loci. Review of planting records revealed that the two genotypes were probably the same grape clone. SSR results were not congruent with known taxonomic relationships or geographic origin of genotypes. The SSR polymorphisms found in even this small subset of the *Vitis* collection in principle make possible the identification of more than 130 trillion different genotypes. This high level of polymorphism, however, makes our particular SSR loci of limited use for identification of species and for the determination of genetic relationships. Molecular genetic markers offer a powerful, efficient approach to assessing questions of identity, relationship, and diversity in germplasm collections, but markers need to be selected based on their suitability for the particular task.

749

Molecular Markers and Germplasm Enhancement: A Case Study in Tomato

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The C.M. Rick Tomato Genetic Resources Center (TGRC) is a genebank of wild relatives, monogenic mutants, and miscellaneous genetic stocks of tomato. The wild species group includes representatives of all nine *Lycopersicon* spp., as well as four related *Solanum* species. One of the roles of the TGRC has been to foster the use of the widest available gene pool for tomato researchers. The wild nightshade *Solanum lycopersicoides* possesses a number of potentially useful traits, but has been untapped by breeders because of sterility and incompatibility barriers. We are using molecular markers to identify alien chromosomal segments introgressed from *S. lycopersicoides* into tomato. This project involves development of RFLP, RAPD, and isozyme marker linkage maps and their use in selection of homozygous segmental substitutions in backcross inbred progenies. In this fashion, a large proportion of the *S. lycopersicoides* genome has been integrated into the cultivated tomato. This study has also provided information on the nature of sterility and novel variation in hybrid derivatives.

81 WORKSHOP 10
Health Functional Fruits and Vegetables

750

Health Functionality of Blueberries

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Fruit extract of the European blueberry, or bilberry (*Vaccinium myrtillus*), is a major component of a great number of pharmaceutical and food supplement products. Compared to most small fruits, bilberry has a high concentration of anthocyanin pigments. Anthocyanins are of biomedical interest due to their properties as antioxidants and protein cross linkers. The major clinical applications for anthocyanins are in ophthalmology, blood vessel and connective tissue disorders, and diabetes. Bilberries are harvested from wild stands throughout Scandinavia, Eastern Europe, and at higher altitudes in southeastern France. Because they are wild, a wide array of genotypes make up the commercial product. As part of an investigation of the nutraceutical components of North American wild lowbush blueberries (*Vaccinium angustifolium*), we are comparing the anthocyanins and other phenolic components from fruit of commercially available *Vaccinium* species. We are particularly interested in the variation in composition among *Vaccinium* clones and species.

751

Melon (*Cucumis melo* L.) Fruit Nutritional Quality and Health Functionality

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Within the Cucurbitaceae are two genera, *Cucumis* and *Citrullus* (muskmelons and watermelon, respectively), with sweet-tasting fruits. Per-capita consumption of these two genera rank melons (11.6 kg) second only to bananas (12.6 kg) as the most-consumed fruit in the United States. Consumption of melons, especially muskmelon and honey dew fruits, is significant from the standpoint of their nutritional benefits to humans. Orange-fleshed melons provide a person with 100% of their daily requirement of vitamins A and C. Melons also are a significant source of nutrients: sugars, dietary fiber, calcium, iron, potassium, and "phytochemicals." Phytochemicals are compounds not presently recognized as having nutrient value. Thirty-eight known phytochemicals are in melons and have preventive properties in addition to anti-cancer attributes. Use of beta-carotene-rich melons is important in chemopreventive trials. Melon production and genetic factors may affect human health-beneficial nutrient and phytochemical quality attributes.

752

Health Functionality in Grapes and Wine

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The moderate consumption of red wine, grapes, raisins, and grape juice has a demonstrably positive effect on human health. Scientifically conducted surveys have shown that the effects of moderate intake of red wine reduces circulatory disease. Legislative efforts on labeling red wine to show the scientific evidence of this statement are receiving favorable attention. The antioxidant resveratrol, present in the skins of the grape in any of its various forms, is believed to be the agent primarily responsible for the healthful benefits demonstrated. It has been shown to affect lipid metabolism in higher mammals. Studies of resveratrol content in a variety of wine grapes are being performed at the Univ. of Arkansas, as well as at other institutions. Red wine (in contrast to white wine and other alcoholic beverages) reduces clotting ability and increases levels of high-density lipoproteins ("good" cholesterol), which diminishes the risk of coronary problems. Grape skin extract, red wines, and red juice appear to enhance the ability of blood vessels to resist vasoconstriction and to contribute to antithrombotic activity. In laboratory tests, several known antioxidants in wine out-performed vitamin E, the current best-known dietary antioxidant.

753

Misconceptions of Fruit and Vegetable Nutritional Quality

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Many concepts of the nutritional value of fruit and vegetables generally accepted in the past, in the light of more knowledge, today are considered "misconceptions." For example, the tomato, once considered poisonous, then shown edible, later proved to be a "good" food and a valuable source of minerals and vitamin C, today shows the potential for significant anti-cancer activity. Results of a 6-year study of the dietary habits of 47,000 men reported up to a 45% reduction in the incidence of prostate cancer of those who ate 10 or more servings per week of tomato-based products. Other misconceptions to be discussed include nightshade vegetables and arthritis, apples after meals to clean the teeth and gums, and "if a little is good for you, a lot must be better." Today's nutritional ideas about many fruits and vegetables may become tomorrow's misconceptions as our knowledge of the composition (e.g., phytochemicals) of fruits and vegetables increases. Examples of this are include the use of muscadine pomace and the nutritive value of strawberries.

754

Nutritional Losses in Fruits and Vegetables as a Function of Postharvest Handling and Storage

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Present dietary recommendations for fruits and vegetables should be based on the bioavailability of essential nutrients at the time of optimum harvest. Few people, however, are fortunate enough to have available freshly harvested produce all year. With the development of improved postharvest technology, shelf life has increased dramatically in many parts of the world. How does the nutritional quality of fruits and vegetables change with increasing storage time, changes in storage atmosphere, different postharvest processes? Do these changes have an impact on dietary recommendations? Apples are capable of being stored for up to 12 months with properly managed temperature and storage atmosphere. Because information regarding this subject is lacking for apple (and many other fruits and vegetables), perhaps a model can be developed based on work with other commodities to help us understand the nutritional changes associated with different postharvest treatments.

84 WORKSHOP 11
Teaching Horticulture in Changing Times

755

Survival in the '90s: How a Non-land-grant School Maintains Its Horticulture Program

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With the current climate of consolidation in academia, maintaining viable discipline-oriented curricula requires concerted effort. In the past 8 years, the horticulture program at Texas Tech reduced the number of degree programs and faculty while it increased the course offerings available and quadrupled the enrollment in horticulture courses. This increase in productivity and program secu-

rity came about through the efforts of the College and the Department. The designation of the Introductory Horticulture course as a core curriculum lab science elective dramatically raised enrollment. The introduction of horticulture as a minor within the College and across the University resulted in many of the horticulture courses being accessed by students previously not reached. In addition, efforts to create articulation agreements with and actively recruit students from 2-year institutions are beginning to show some success. The greatest future impact appears to be in the creation of mutually beneficial distance education alliances with other 2- and 4-year institutions. Areas of continued concern include balancing faculty teaching and research loads, frequency of upper level course offerings, and identifying large classroom facilities during peek hours. Support facility space utilization, pressing time constraints and "faculty burn-out" are also current problem areas associated with increased faculty productivity levels.

756

The Horticulture Curriculum at Michigan State University

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The Dept. of Horticulture changed its curriculum prior to 1992 to conform to the change from the quarter to the semester system that took place in Fall 1992. As a result of changes in our student body, their interests, and new accounting procedures for determining productivity in our college and the university, another revamping of our curriculum was accomplished beginning in Fall 1992 and our curriculum was changed again to take effect in Fall 1994. Our students now have a choice of a Landscape, Design, Construction Management option or Horticulture. Students all take a two-semester sequence of an Introductory Horticulture course—they must choose a production and management course from three out of four commodity areas (floriculture, landscape, pomology, or vegetable crops), and three out of five upper-division courses in applied physiology or genetics. They must also take a course in Greenhouse Structures and Management and a senior-level capstone course in Horticutural Management. This curriculum has broadened our students' exposure to horticulture to a much greater degree than was present in our old curriculum. In addition, they have about 20–21 credits (out of 120) for electives.

757

Accommodating Change in a Diverse Horticulture Curriculum

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The Dept. of Horticulture and Landscape Architecture offers majors in Horticulture with four concentrations (Floriculture, Horticultural Business Management, Horticultural Food Crops, and Horticultural Science) and Landscape Horticulture with three concentrations (Landscape Design and Construction, Nursery and Landscape Management, and Turf Management). A third major in Landscape Architecture is also offered. The department maintained the concentrations in past years of low enrollment by switching courses to alternate years, dropping nonmajor courses, and through hiring part-time staff. Currently, increasing enrollments, with limited additional funding and the need for broadened general requirements, increased career guidance, and capstone courses have increased pressures on consolidation of concentrations. Faculty have refocused senior courses to create capstone courses in several concentrations, moved the senior seminar to sophomore status for career enhancement, and are currently discussing other options.

96 WORKSHOP 13
New and Exciting Advances in the Breeding of Ornamental Plants

758

Breeding of *Lupinus harvardii* as a Specialty Cut Flower Crop

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The Big Bend bluebonnet, *Lupinus havardii* Wats., is a showy winter annual native to a narrow geographical range in southwestern Texas with blue, fragrant 0.5–1.0-m-long racemes. The *L. havardii* raceme has considerable potential in the floral industry, because there is a need for high-quality, durable, raceme-type cut flowers. We began a research and breeding project in 1991 aimed at evaluating the potential for this species as a specialty cut flower. Breeding strategies included the development of selfed populations as well as random pollinations among selected individuals with the aim of improving flower color, uniformity, yield, and postharvest performance. Recurrent phenotypic selection has resulted in the development of blue, pink, and white color lines. Concurrently with the breeding efforts, research on seed germination, greenhouse culture for year-round production, postharvest handling, and shipping requirements have been conducted. Trials have indicated that *L. havardii* is adaptable to greenhouse culture and that individual plants can produce 15–25 marketable racemes within 4–5 months from sowing. Two years of commercial greenhouse trials have been completed. Blue and white cultivars will be released by Texas A&M Univ. within the next year.

759

In Vitro Breeding Techniques for *Alstroemeria*

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Alstroemeria, also known as Lily-of-the-Incas, Inca Lily, or Peruvian Lily, has been bred at the Univ. of Connecticut since 1985. In vitro procedures have been integrated with traditional breeding techniques to create new and exciting cultivars. Embryo culture has been used to generate interspecific, intraspecific, and intergeneric hybrids that would not have been possible with traditional breeding. Somaclonal variation has been used to create new plants from spontaneous and induced mutations, but, in most cases, the plants have not been acceptable commercially. Chromosome doubling with colchicine has been used for fertility restoration of sterile diploids. Somatic embryogenesis has also been studied quite extensively; somatic embryos are easily obtained from zygotic embryos of *Alstroemeria.* In vitro fertilization procedures are currently being studied in order to hasten embryo development after hybridization has occurred. Because *Alstroemeria* plants are slow to propagate by traditional rhizome division, micropropagation is used to multiply new cultivars rapidly. Because the production of pathogen-free plants is one of the goals of our breeding and new plant introduction programs, meristem culture and thermotherapy are also being studied. All of these techniques will be described during the workshop.

97 WORKSHOP 14
Preharvest Apple Abscission and AVG

760

Aminoethoxyvinylglycine (AVG): Past, Present, and Future

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Aminoethoxyvinylglycine (AVG) is a naturally occurring plant growth regulator that was first patented in 1973 (US patent #3,751,459). AVG has been shown to competitively inhibit ACC (1-aminocyclopropane-1-carboxylic acid) synthase (Yu et al., 1979, Arch. Biochem. Biophys. 198:280–286), which is the enzyme responsible for the conversion of *S*-adenosylmethionine (SAM) to ACC, the immediate precursor of ethylene in plants. Because of this unique mode of action, AVG has been tested over the years on a wide array of plant tissues. Studies on plants of horticultural interest have included cut flowers (e.g., Baker et al., 1977 HortScience 12:38–39), greenhouse crops (e.g., Saltveit and Larson, 1981, J. Amer. Soc. Hort. Sci. 106:156–159), and tree fruits (e.g., Bangerth, 1978, J. Amer. Soc. Hort. Sci. 103:401–403). AVG is currently being developed by Abbott Laboratories for use on apples (e.g., Shafer et al., 1995, Proc. 22nd Annu. PGRSA Mtg, pg 11–15). This presentation: a) briefly reviews prior literature regarding the effects of AVG on apples, b) provides an update on Abbott's commercial development program, and c) outlines some near-term research objectives for the use of AVG on apples.

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AVG Effects on Preharvest Apple Fruit Drop and Maturity in Virginia

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AVG applied 2 to 6 weeks before the optimum harvest date for several cultivars dramatically reduced pre-harvest fruit drop. The loss of fruit firmness and starch loss after the optimum harvest date was reduced by AVG sprays. The development of watercore in 'Starkrimson Delicious' and 'York' and maturity crack-

ing in 'Rome' and 'Golden Delicious' were delayed and/or prevented by AVG. Color development was slightly delayed for most red cultivars and 'Golden Delicious'. Soluble solids concentration was generally unchanged. Airblast applications of 123 g·ha^{-1} AVG was no more effective than a standard rate of NAA (28 to 56 g·ha^{-1}), but rates of 248 g·ha^{-1} AVG and above were more effective than NAA for most cultivars. When fruit were left on the tree for periods of 3 to 5 weeks after the optimum harvest date, NAA hastened the loss of fruit firmness and starch and NAA increased watercore of 'Delicious' and maturity cracking of 'Golden Delicious' and 'Law Rome'. Soluble solids and red color were generally unaffected by NAA. Ethephon sprays hastened the rate of fruit drop. When NAA was tank mixed with ethephon, NAA delayed fruit drop caused by ethephon, but AVG did not. The use of superior oil or Regulaid surfactant did not affect NAA or AVG responses; however, the silicone surfactant Silwet L-77, in one experiment, promoted the effectiveness of AVG. Tank mixing NAA or AVG with pesticides (Guthion + Lannate + Captan) did not affect the responses of AVG or NAA on fruit drop.

122 WORKSHOP 16
Quality and Management of Tree Root Systems: Current Status and Future Directions

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Coating of Nursery Containers to Improve Tree Root System Quality and Transplant Establishment

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Interest in chemical modification of root systems of container-grown trees has increased in recent years with more widespread recognition of implications of root system architecture of container-grown trees on subsequent landscape performance. Initial research on Cu-based latex materials for application to interior container surfaces to avoid circled, matted, and kinked roots at container wall : media interfaces began with small forest tree liners in the late 1970s and early 1980s. Transfer of this technology to horticultural crops followed from the mid-1980s to the present. Testing has spread to a wide range of temperate and tropical landscape trees, shrubs, herbaceous annuals and perennials, interior foliage plants, and vegetable transplants. Inhibition of root elongation after contact with treated container surfaces is via a mild Cu toxicity, frequently resulting in a stimulation of lateral root proliferation proximal to the inhibited root tip, but responses vary with species, cultivar, media composition and pH, and Cu concentration and formulation. Early reports on root architecture effects were predominantly qualitative in nature. Quantitative studies on root architecture within treated containers have been less consistent in responses among species. Improvements in root regeneration, shoot growth, and water relations during post-transplant field establishment of trees grown in Cu-treated vs. non-treated containers have been documented for several species. Ecological (Cu leaching potential), technological (new applications), and economic (profitability) questions have arisen with increased use and availability of Cu-based container treatments and will be discussed.

134 WORKSHOP 20
Reevaluating Tissue Culture Techniques for Generating Useful Variation and for in Vitro Screening

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In Vitro Selection and in Vitro Screening for Disease Resistance in Fruit Trees

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One approach for obtaining useful genetic variation is to select for somaclonal variants generated by tissue culture techniques. Increased levels of resistance to bacterial leaf spot (*Xanthomonas campestris* pv. *pruni*) have been observed in toxin-selected and unselected peach regenerants in vitro, in the greenhouse and under field conditions. Peach regenerants have also demonstrated increased levels of bacterial canker (*Pseudomonas syringae* pv. *syringae*) and root-knot nematode (*Meloidogyne incognita*) resistance. Random amplified polymorphic DNA (RAPD) primers have been used to study genetic variation at the DNA level among the somaclonal variants. Sixty RAPD primers (10-mers) were screened and 10 proved useful as markers to detect polymorphisms, thus establishing a genetic basis for somaclonal variation. These studies demonstrate the feasibility of using tissue culture techniques to generate fruit trees with increased levels of disease resistance.

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Development of Insect-tolerant Plants with Somaclonal Variation

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The potential value of somaclonal variation for economically important plants is well-documented. The process of somaclonal variation can arise from a controlled or a random source of variation. Variability can be obtained by applying cellular pressures and selection. Valuable resistance to diseases and nematodes has already been accomplished with somaclonal variation; now, plant tolerance to pests has been realized. *Tetranychus urticae*, the two-spotted spidermite, and *Trialeurodes vaporariorum*, the greenhouse whitefly, were disinfected and introduced to aseptic shoot cultures of *Torenia fournieri*. These pests were allowed to feed until such time that their populations decreased due to the absence of food. The plant cells that remained after feeding were induced to form adventitious shoots and plantlets. These regenerated plantlets were acclimated to greenhouse conditions and evaluated for tolerance to the pest to which they were subjected in vitro. Highly significant differences were found in somaclones for both the two-spotted spidermite and greenhouse whitefly when compared to control plants. A wide range of variability was observed among the somaclonal population. There were significantly fewer mite eggs laid on plants regenerated from in vitro cultures screened with two-spotted spidermites than on seed-sown controls. Regenerants from cultures screened with whiteflies in vitro had fewer eggs, immatures and live adults than controls. The potential for somaclonal variation to be used as a method to develop insect resistant plants will be discussed.

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Selection and Characterization of Resistance in Mango Embryogenic Cultures to *Colletotrichum gloeosporioides* Penz. Phytotoxin

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Anthracnose, caused by *Colletotrichum gloeosporioides*, is the most serious production and postharvest problem of mango. Most mango cultivars are highly susceptible to this disease. Embryogenic nucellar cultures of two cultivars, 'Hindi' and 'Carabao', were recurrently selected with either the purified phytotoxin or the crude culture filtrate produced by the fungus. Mycelium growth was suppressed in dual cultures involving the recurrently selected lines. Enhanced extracellular production of proteins was observed in the embryogenic cultures and in regenerants, including a newly expressed acidic chitinase isozyme ('Hindi') and greater expression of two other chitinase isozymes ('Hindi' and 'Carabao'). Activity of α-1,3-glucanase was also substantially increased in the recurrently selected lines. Resistant lines were characterized using RAPDs on the basis of polymorphisms generated by eight different primers. In most cases, the differences involved the absence of RAPD markers in resistant lines.

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Embryo Rescue Techniques to Generate Variation in Citrus Crops

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Although no longer as glamorous as it was a few decades past, the routine application of embryo rescue techniques, leading to plant recovery, is a valuable tool for citrus cultivar improvement. Embryo rescue approaches can be used to generate useful variation or to capture various kinds of spontaneous genetic variation. Embryo rescue, by in vitro culture of undeveloped, and presumably unfertilized, ovules in colchicine-supplemented media is a practical method of producing tetraploid clones, which are used then in crosses with diploids to produce

seedless triploid hybrids. This same approach, i.e., in vitro culture of undeveloped ovules, is also used to recover plants from chimeric sectored fruit exhibiting economically important mutations for fruit characteristics, and for producing potentially variant somaclones. Seedlessness is an important objective for fresh citrus fruit cultivar improvement, and triploidy following 2x × 4x hybridizations is one approach being exploited for this objective. When monoembryonic diploid seed parents are crossed with tetraploid pollen parents, however, normal seed development is not usually possible. Embryos must be excised from abortive seeds fairly early in development and cultured appropriately to ensure the recovery of sufficient numbers of 3x offspring from these crosses, to increase the likelihood of identifying superior seedless hybrids. These applications will be described in some detail, and progress toward breeding objectives are highlighted.

135 WORKSHOP 21
Non-chemical Pest Management Techniques

767

Flame Cultivation for Controlling Weeds

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Flame "cultivation" for weed control was developed about 50 years ago. The practice was very popular with Southern cotton farmers through the 1950s and 1960s, but lost favor when petroleum prices rose drastically in the 1970s. There is now a new interest in the practice of flame cultivation as a partial or total replacement for herbicides in vegetable crops. This interest is fueled by three factors: 1) an increasingly negative public perception of herbicides on vegetables, 2) a very limited selection of herbicides labeled for vegetables, and 3) limited efficacy of some of the herbicides that are registered. Flame cultivation, in combination with mechanical cultivation, can replace or supplement herbicides in some vegetable crops. The mode of action of flame cultivation is the bursting of cell walls in the weeds as the weeds are heated by a carefully directed LP gas flame. With most vegetable crops, the crop plants must be protected in some manner. This can be done with a water shield (flat fan water spray), height differential between weeds and crop, physical shield, etc. Much of the early work on flame cultivation of vegetables was done with sweet corn. Work is now underway on flame cultivation of lima beans and southernpeas, where multiple flame cultivations have proven effective at controlling weeds for which no herbicide is available.

35 COLLOQUIUM 1
Enhancement of Horticultural Crops for Improved Human Health

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Enhancement of Horticultural Crops for Improved Health

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Fruits and vegetables are being recommended more strongly than ever for improving human health, but, in some parts of the world, supplies are inadequate and, even when supplies are abundant, some segments of the population eat far less then recommended amounts. This divergence suggests that careful analysis and multiple approaches are needed to maximize the benefits of horticultural crops to human health. Information about the specific health benefits of certain crops and the value of diversity in the diet to get benefits not yet understood may stimulate increased usage. An attractive, appetizing, and economical supply seems essential, and may require efforts ranging from breeding for resistance, flavor, appearance, and holdability, through production and harvesting methods, to postharvest handling and processing.

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Subsequent Generation "Functional Foods"—Production of Candidate Oral Vaccines in Transgenic Plants

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The concept of "Functional Foods" is becoming a commonly used term in discussions of human nutrition. Consumer awareness of natural food constituents and their role in cancer and cardiovascular disease prevention has done much to increase health consciousness with respect to plant products. The Plants and Human Health Program of the Boyce Thompson Institute uses molecular techniques to create transgenic plants with modified food composition; our goal is to devise strategies for production of pharmaceuticals or "nutraceuticals" in plants. Our initial focus has been genes encoding the antigenic proteins of human infectious agents such as hepatitis B and the causal agents of diarrheal disease. Areas of research include; 1) methods to increase production of foreign proteins in transgenic plants, and 2) utilization of engineered edible plant tissues for animal feeding studies. We have found that transgenic foods orally immunize test animals; these findings portend many new and exciting possibilities for plant medicinal chemistry.

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Cancer Chemoprotective Effects of Cruciferous Vegetables

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High fruit and vegetable consumption is associated with a striking reduction in susceptibility to malignancy. In addition to other health benefits (e.g., high levels of vitamin C, carotenoids, and dietary fiber), cruciferous vegetables contribute significantly to this chemoprotective effect. Cruciferous vegetables (e.g. *Brassica* sp.), contain glucosinolates, water-soluble secondary metabolites that are converted to highly reactive isothiocyanates as a defense response to predation or injury. When fed to mammals, isothiocyanates induce Phase 2 enzymes such as glutathione-*S*-transferase and quinone reductase, that detoxify xenobiotics. Phase 2 enzyme induction potential was assessed for fruits and vegetables from a wide variety of plant families and the *Brassica* vegetables were particularly rich in such activity. Tremendous variability in glucosinolate content and Phase 2 enzyme induction potential was found between commercial broccoli cultivars (n = 12) and between sites (n = 7) growing transplants produced at the same time, from the same seedlot. Broccoli (*B. oleracea* var. *italica*) cvs. Green Comet and Excelsior had an almost identical spatial distribution of Phase 2 enzyme induction potential that varied by position on market-stage plants. Fertilization regime also affected Phase 2 enzyme induction by these two cultivars. Additionally, induction of detoxication enzymes and glucosinolate profiles have been evaluated in primary and axillary shoots of two greenhouse-grown broccoli cultivars (Broccolo Natalino and a proprietary hybrid), harvested over the duration of a 2-month period of side-shoot production. This approach to evaluating the germplasm, positional, temporal, and cultural effects on levels of inducers of mammalian detoxication enzymes should lead to development of cultivation strategies to enhance the chemoprotective effect of Cruciferous vegetables.

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Nutritional Improvement of Horticultural Crops through Plant Breeding

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Fruits and vegetables are rich sources of the micro mineral elements and vitamins often lacking in diets based on cereals, grain legumes, and starchy roots and tubers, but void of animal products. When embarking on a breeding program to improve nutritional compounds, the way the fruit or vegetable is consumed in mixed diets must be considered. To alleviate nutritional problems, the nutrients must not only be present in the plant parts consumed, but also absorbed efficiently in the body. In some cases, it may be necessary to modify compounds to improve absorption as well as increase the concentration. Breeding to improve nutritionally related traits can be approached in a manner similar to that for other traits; i.e., identification of genetic variability, selection for enhanced levels using either individual phenotype or family mean values, and testing for field performance. In addition to improving amount and availability, avoidance of undesirable correlated responses due to genetic or physiological linkages between the trait of interest and other traits deleterious to either plant growth or the consumer is critically important during selection. The growing number of molecular marker-based linkage maps should prove especially useful for identifying genes of interest and employing marker-aided selection. When insufficient variability for amount or type of compound is present in the gene pool, strategies using transgenic plants may be useful.

772

Changes in Nutritional Value of Horticultural Food Crops Affected by Handling, Storage, and Processing

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Postharvest handling, storage, and processing greatly affect retention and bioavailability of nutrients in horticultural food crops. Although there are a few exceptions, concentrations of most nutrients are reduced by all postharvest operations. Losses of certain nutrients may range from 5% to 100%, depending on their chemical stability, solubility, and postharvest treatment. Therefore, the amount of a particular nutrient in a horticultural food at the time of harvest may not reflect the amount present when the raw or cooked food is consumed. Most vitamins are susceptible to oxidation catalyzed by enzymes, light, pro-oxidant metals, and active oxygen species. Also, nutrient retention and stability are affected by heat, leaching, and certain preservatives, such as sulfites. Physical injuries during handling, processing, and preparation for consumption accelerate vitamin degradation. Therefore, nutrient losses may be very large in minimally processed and food service products that are marketed in peeled, sliced, or shredded forms. Other processing methods, such as dehydration, fermentation, freezing, and canning usually result in significant losses in nutrient concentrations. Although processing generally contributes to loss of nutrient content of foods, certain processing methods improve the bioavailability of some minerals and vitamins, which may increase the actual nutritional value of the food. Methods to reduce inhibitors and antagonists of nutrient availability should receive major emphasis in efforts to improve nutritional value, along with efforts to improve the amount and retention of nutrients in horticultural food crops.

44 COLLOQUIUM 2
Issues and Applications of Computer Technology to Horticulture

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Integrating Digital Multimedia, Computer-based Instruction, and the World Wide Web into an Introductory Biology Curriculum

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During the past 6 years, the General Biology Program at the Univ. of Minnesota has been exploring the use of computer-based multimedia to improve the quality of undergraduate instruction in large undergraduate courses. Our project has created an image library of about 3500 computer graphics, animations, and digital video sequences for lecture support, as well as the software to present and manage this image library. During the past 3 years, students have used computers for modeling, simulation, and problem-solving activities in the laboratory of our evolution and ecology undergraduate course. Most recently, we have begun to integrate the World Wide Web into our curriculum in a variety of ways. This presentation demonstrates the comprehensive way in which our Program has combined these "new" information technologies into our introductory courses. The general applicability of this approach to any discipline will be discussed.

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The Chalkboard-less Classroom

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Classrooms are radically changing across the nation's campuses. Rooms that were once dominated by bright lights, chalkboards, and overhead projectors are being transformed into multimedia "Master Classrooms," complete with task lighting, video projectors, visualizers, laserdisk and videotape players, soft boards, and computers. What are these pieces of equipment, how much do they cost, and how can they be implemented into horticultural curriculum? Just as our college students teethed on television programs such as *Sesame Street* when they were toddlers, they now are continuing to learn through a combination of audio, video, and kinesthetic stimulation in the classroom. Computer hardware and software empowers today's educator with a multimedia development studio on his/her desktop to create simple "slide" presentations or complex, interactive multimedia applications. However, it is not multimedia itself, any more than it was the chalkboard, that makes a powerfully educational presentation; rather it is the educator's creativity, utilization of instructional methods, and delivery. Interactive, multimedia development software allows the educator to address different styles and paces of learning as he or she develops a lesson. Through on-screen hot spots, movable objects, buttons, etc., the educator engages the learner's attention and provides the opportunity for the learner to rehearse a concept as often and repeatedly as necessary to encode the information for later retrieval and application to new concepts. Given the power of this new medium to visually and audibly present information, how does the educator avoid overloading the learner? Although multimedia applications readily engage the learner, it takes careful programming by the educator to maintain and direct the learner's attention to ensure transfer of the information from short- to long-term memory.

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Applications of Computer Programming to Specific Horticultural Research Problems

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The personal computer has become a standard research tool and is used in the research process from data collection to publication of results. The volume of computer software increases as personal computers proliferate. Most tasks are accomplished with off-the-shelf products available at any computer store. More specific needs are usually met with commercial software packages supplied by the company providing the research equipment or from a specialized software provider. However, there are specific research needs that are best fulfilled with a custom computer program. An interface between data collection and storage that is more comfortable to the user or a model developed with a narrow scope might be better served with software developed for that application. The development of software for the MARYBLYT fire blight system is presented.

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Information Technology and the Law

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This paper explores fundamental doctrines of law which increasingly constitute the rules of commerce in deploying the National Information Infrastructure (NII). Particular attention is given to efforts made within the U.S. government to ensure that an appropriate regime of intellectual property law is in place in promoting U.S. leadership in the information-based marketplace. The direct relationship between U.S. copyright law and the networked dissemination of software, audio, graphical and textual works is consequently explored. Also described is the effect of developments in information technology upon the frequently opposing interests of freedom of speech, right to privacy, and governmental regulation.

82 COLLOQUIUM 3
Municipal Waste Compost Production and Uses for Horticultural Crops

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Compost Regulations: Overview of the Status in the United States

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State and federal regulations relevant to compost marketing and end use can greatly affect the success of a compost distribution and marketing program. Typically, regulations are feedstock-specific and they vary from state to state. They address health, safety, and environmental issues, as well as other concerns of the general public and professional end users. This presentation reviews regulatory approaches adopted by states that are leaders in compost production. It provides insight as to regulatory trends and discusses how they have affected market development to date. Suggestions regarding the improvement or modification of environmental regulations and USDA Acts are also provided.

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Composting Systems

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During the past decade, numerous commercial composting systems have been developed. Time, as well as economics, are determining which of these

systems are feasible. Systems that take time but can operate at low cost are surviving, as are more costly systems capable of producing a mature compost in the shortest possible time. Which system to use can be determined by the amount of space available and the amount of feedstock to be composted. Where space is limited and the volume of feedstock is high, more intensively managed systems are necessary. When space is not a limiting factor, more passive systems may be adequate. Of the more costly system developed, those systems with the least amount of down time and with a high degree of versatility appear to be surviving. Although it is possible to optimize the rate of composting through good engineering and management, there exists a given time period, depending on the feedstock necessary to produce quality mature compost. Minimizing production time to the point where the quality of the compost is jeopardized will result in wide-spread rejection. As horticulturists, we must stand firm in demanding compost standards with qualities based on our needs. Based on the diversity of our industry, the horticultural industries are likely to be the largest potential users of commercial compost.

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Plant Nutrition and Heavy Metal Aspects of Compost Use

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Depending on the materials used to produce a compost, it will contain lower or higher levels of nutrients and metals. If composts have been appropriately matured, nutrients are in plant-available forms for crop production, and the compost pH will be near neutral. After 25 years of research and development of regulations and advice for biosolids and compost utilization, pretreatment of industrial wastes allows biosolids composts, and composts prepared from biosolids mixed with municipal solid wastes or yard debris to contain levels of microelements needed for plant nutrition but not high levels that could cause phytotoxicity. Composts can supply N, P, K, Ca, Mg, Fe, Zn, Cu, Mn, B, Mo, and Se required by plants or animals. When used in potting media, supplemental N fertilization is usually required, depending on crop requirements. Use of compost can replace other forms of microelements used as fertilizers in media or fields. Detailed evaluation of potential food chain transfer of Cd, Pb, and other elements in composts clearly shows that consumption of 60% of garden foods produced on pH 5.5 soils with 1000 t compost/ha would not comprise risk over a lifetime of consumption, nor would ingesting the composts at 200 mg/day for 5 years. Potentially toxic organic compounds are either destroyed during composting, or bound very strongly by the compost so that plant uptake is trivial. Compost use can be a safe and wise choice for both home and commercial use to replace peat or uncomposted manures, etc. Many states have developed regulatory controls to assure that pathogenic organisms are killed during composting, and that product quality standards are attained that allow marketing for general use in the community.

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Biological Control of Plant Diseases with Composts

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Compost offers the potential to suppress root rots and vascular wilts caused by soilborne plant pathogens, as well as plant diseases affecting aerial plant parts. Many factors affect the degree of control obtained. They include the decomposition level (stability) of the compost, the types of microorganisms colonizing the organic matter after peak heating of the compost, plant nutrients released by the compost (fertility), its salinity, loading rates, and other factors. Biocontrol agents in composts induce suppression through various mechanisms, including competition, antibiosis, hyperparasitism, and the induction of systemic resistance in the plant (roots as well as foliage) to pathogens. Examples of each of the effects are reviewed.

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Weed Control Consideration in Compost Production and Use

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A rapid increase in municipal solid waste (MSW) production (2 kg/person per day), combined with a decreasing number of operating landfills, has increased waste disposal costs. Composting MSW can be an alternative method of waste disposal to traditional landfilling or incineration. Weed control methods using waste materials such as bark, straw, and sawdust were used in commercial crop production for many years before the advent of chemical weed control. Weed growth suppression by mulching can often be almost as effective as conventional herbicides. A 10 to 15 cm-deep mulch layer is needed to completely discourage weed growth in these systems, and best results are obtained with composted materials. In recent years, composts made from a large variety of waste materials have become available on a commercial scale. Preliminary investigations into the use of MSW compost as a weed control agent have shown that compost, especially in an immature state, applied to row crop middles reduced weed growth due to its high concentration of acetic, propionic, and butyric acids. Subsequently, compost can be incorporated into the soil for the following growing season to potentially improve soil physical and chemical properties. Integrated pest management programs that incorporate biological control should be adopted wherever possible because some weed species with persistent seeds can escape chemical control.

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Use of Compost Products for Ornamental Crop Production: Research and Grower Experiences

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Horticultural growing medium components must be selected with regard to their influence on properties such as cost, availability, ease of mixing, appearance, pH, nutrient levels, soluble salt levels, exchange capacity, aeration, particle size distribution, bulk density, water-holding capacity, and consistency. Over the past several decades, various types of compost products made from urban waste materials have been evaluated as components in horticultural growing mixes. The highest-quality compost products tested have frequently compared favorably with peat as one of the organic components in growing mixes. The lowest-quality compost materials tested have retarded plant growth and, in extreme cases, contributed to plant mortality. Occasionally, compost products that performed well in research trials did not prove to be satisfactory when used in commercial nursery crop production because of the lack of repeatable consistency between batches produced in large-scale municipal composting operations. One of the major reasons for the lack of consistency in compost quality is the highly variable nature of organic feedstocks accepted by many large-scale composting operations. The highest-quality composts tend to be produced in composting operations in which facility management decisions are made with consideration on their impact on the economic, physical, and chemical parameters of the end product.

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Compost Utilization for Vegetable Crops: Research and Grower Use

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Utilization of municipal waste composts on vegetable crops may be advantageous if research can determine appropriate product maturity and quality standards, application methods and rates, application timing, and supplemental nutrient requirements. Experiments using compost for seed germination and seedling growth indicate that mixtures of compost with amendments such as perlite and vermiculite result in acceptable growth rates, but often require additional N and K for optimum growth. In the field, compost generally improves soil characteristics for vegetable crop growth. Tests using compost rates from 12 to 336 $t \cdot ha^{-1}$ either increased or did not change yields of vegetable crops. Highest yields are often produced from a combination of composts with additional nutrient sources. When the composts were used as mulches, vegetable crop growth and production were generally higher than from plants in unmulched plots, but lower than those from plots with polyethylene mulches. If growers are to accept the use of composts, the compost must be a consistent product, and yield increases must be high enough to justify the costs of transporting and applying the compost.

123 COLLOQUIUM 4
The Impact of Biotechnology on the Environment

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Impact of Biotechnology on the Environment: Challenges and Opportunities

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The major challenge facing society in the 21st century is to feed and provide

shelter for increasing numbers of people while protecting human health, our natural resource base, and the environment. To accomplish this, we must combine traditional technologies that stress conservation with modern technologies that rely heavily on biologically based solutions. Biotechnology, by its historical definition, has play an important role in environmental clean-up, but the contemporary practices of biotechnology will lead to more-sophisticated approaches. These technologies will allow clean-up of existing contamination and even prevention of contamination through more-sensitive and accurate monitoring systems. One of the most important advances is in bioremediation, in which microorganisms and plants remove contaminants from the soil or water and concentrate of volatilize them. In addition, plants are being modified through the changing of single genes so that they are less susceptible to pathogenic microorganisms, viruses, or insects, and more efficient in nitrogen utilization. The use of such modified plants, in concert with good agricultural practices, should lead to reductions in chemical inputs of pesticides and fertilizers. Strategies have also been developed that permit the "manufacture" in plant "pharms" of industrial products that are now produced through the use of nonrenewable resources. These biological approaches are part of the cadre of tools that we need to solve the problems of the next century. In addition, these tools will be instrumental in understanding the basic biological systems upon which the solutions to many of these challenges will come. Biotechnology is not a technological fix, but it should form part of the mind-set from which we design our strategies.

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Toxic Mercury Reduction and Remediation using a Modified Bacterial Gene in Transgenic Plants

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The use of plants to stabilize, reduce, or detoxify aquatic and terrestrial pollution is known as phytoremediation. We have employed a molecular genetic approach for the development of potentially phytoremediative species using a bacterial gene for ionic mercury detoxification. One gene of the bacterial mercury resistance operon, *merA*, codes for mercuric ion reductase. This enzyme catalyzes the reduction of toxic, ionic mercury to volatile, elemental mercury having far lower toxicity. Early attempts to confer Hg^{++} resistance to plants using the wildtype *merA* gene were unsuccessful. We hypothesized the highly GC-skewed codon usage was ineffective for efficient plant gene expression, and sequence modification would be necessary to confer *merA* gene activity and ionic mercury resistance in plants. A directed mutagenesis strategy is being used to develop modified *merA* gene constructs for transformation and analysis in plants species. Transgenic *Arabidopsis* and yellow-poplar plants having modified *merA* codon usage display Hg^{++}-resistance. *Arabidopsis* plants with modified *merA* were observed to evolve ≈4 times the quantity of Hg^0 from aqueous Hg^{++} in controlled experiments. In contrast, plants with unaltered *merA* coding sequences display unstable and inactivated gene expression. Our progress towards further *merA* modification and transgenic plant development will be reported. Additionally, the theoretical phytoremediative benefits and potential advantages of *merA*-expressing plant species will be discussed as part of our long-term goals.

786

New Proteins for the Control of Insects in Transgenic Crops

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Genetically modified potato and cotton crops that express insecticidal proteins from *Bacillus thuringiensis* (Bt) have recently been commercialized. These crops display autonomous resistance to specific insect pests, and thus offer major agricultural and environmental benefits. We have implemented a microbial screening program to discover new types of insecticidal proteins for use in transgenic crops. New proteins with diverse modes of action offer opportunities to control insect pests that are not susceptible to Bt insecticidal proteins and to delay or prevent the potential occurrence of resistance of insects to crops genetically modified with Bt genes. Cholesterol oxidase emerged from our screen as a new insecticidal protein with potent activity against the cotton boll weevil. Cholesterol oxidase was acutely toxic to boll weevil larvae, with an LC50 of 2–6 parts per million when ingested in artificial diet feeding assays, and caused marked reductions in fecundity when ingested by adult boll weevils. Cholesterol oxidase also exerted significant, though less severe, toxicity against several lepidopteran pests. The insecticidal action of cholesterol oxidase appears to be due to oxidation of midgut epithelial membrane cholesterol followed by membrane disruption. A cholesterol oxidase gene was cloned and expressed in transgenic tobacco plants to yield plant tissue that exerted potent activity against boll weevil. Expression of this cholesterol oxidase gene in cotton plants may offer significant protection against the cotton boll weevil and may also aid in the mitigation of resistance of cotton lepidopteran pests to Bt proteins.

787

Biotechnology for the Treatment of Pesticide Waste

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The use of microbes and/or microbial processes for the bioremediation of soils contaminated with pesticides is an idea that has enjoyed considerable interest over the past several years. Many microbes with specific pathways for the degradation of particular pesticides, or classes of pesticide, have been isolated and characterized. Unfortunately, most sites that are heavily contaminated with pesticides contain a mixture of the many different types of pesticides that have been used over the last 5 decades. This complex mixture of compounds may inhibit microbial degradation or may require multiple treatments to assure that all the chemicals are degraded. Treatment of wastes before they contaminate the environment is one way to avoid the problems associated with mixed wastes. We have isolated a number of microorganisms that detoxify insecticides, such as carbaryl of parathion via the action of hydrolase enzymes. These enzymes can be used to treat waste pesticide solutions before disposal. A system was developed for the disposal of one high-volume organophosphate insecticide waste by treatment with parathion hydrolase, followed by ozonation to yield harmless products that were readily degraded by other soil microorganisms. A second method for disposal of this waste involves altering the environmental conditions in the waste to stimulate the growth of microorganisms naturally present in the material utilizing the pesticide as a carbon source. This accomplishes degradation of the material over a 2-week period. Many, if not all, pesticides are degradable to some degree by microorganisms, and this fact can be exploited to provide cost-effective methods for the safe disposal of pesticide wastes.

788

Exploiting Tissue Culture-generated Variation and Natural Plant Population Diversity for Wetland Creation

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Several salt marsh functions were found to be directed by the genotype of the vascular plant. Tissue culture regenerants of *Distichlis spicata* and *Sporobolus virginicus*, along with plants from natural populations of these species, were compared in a common garden study. Significant differences among genotypes were found in several characteristics of importance in the functioning of the salt marsh food web. Specifically, potential detritus production, belowground organic matter production, and canopy structure were affected. Selections from five morphologically distinct populations of *Spartina patens*, including one tissue culture regenerant, also maintained differences in a common marsh setting. In a newly created salt marsh near Lewes, Dela., three populations of short-form *Spartina alterniflora* from different latitudes (Massachusetts, Delaware, and Georgia) were planted. After 5 years in the new site, the plants maintained distinct morphologies characteristic of plants at their site of origin; e.g., aboveground biomass, canopy structural characteristics, and root and rhizome biomass, composition, and distribution. The magnitude of marsh functional processes associated with the latitude of the population source persisted in the created wetland. The edaphic algal community, the activity of the aerial microbial decomposers, and the edaphic community respiration were significantly influenced by vascular plant genotype in the created marsh, and they reflected the values characteristic of these functions at the latitude of origin of the vascular plants. Indications are that higher trophic levels may also be affected. In creating new wetlands, this plant genetic variation can be used to accentuate different functions, thus optimizing wetland values on the specific site and at the landscape ecology scale.

56 COLLEGIATE BRANCH POSTER SESSION (Abstr. 789–792)

789

Evaluation of Eight Species for Suitability as Seasonal Cut Foliage

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The Aquifoliaceae and Magnoliaceae families play an important role in sea-

sonal holiday arrangements. For florists, floral designers, and seasonal gift shop owners, there is a great need to find cut foliage species suitable for use in floral displays. Foliage cuttings that retain their appearance, stay green, and do not drop leaves or berries are desired characteristics for greenery used in these displays. Because of their attractive foliage, the following species were chosen: *Ilex* x *attenuata*, *Ilex vomitoria*, *Ilex cornuta* 'Rotunda', *Ilex cornuta* 'Burfordii', *Ilex opaca*, *Osmanthus heterophyllus*, *Ilex latifolia*, and *Magnolia grandiflora*. For each species, cuttings were taken, fresh weights for these cuttings were obtained, and chlorophyll levels were measured. Measurements forweight and chlorophyll levels were then taken once a day for 5 days. After the five daily measurements, the measurements were taken once a week for 3 weeks. Based upon slow rate of water lost, chlorophyll retention, and visual rating of appearance, the two most suitable species were *Osmanthus heterophyllus* and *Ilex latifolia*. The *Ilex vomitoria* was unsuitable because of the tendency to drop leaves. The *Ilex opaca* was also unsuitable because of leaf drop and unattractive leaf curling.

790

Mortality of First-year Plantings of Selected Asian Pear in Northern Alabama

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The growing popularity of Asian pears in the open market has generated a need for more information about their fireblight resistance and stress tolerance. In 1994, Alabama A&M Univ. established a large research planting of 10 cultivars of Asian pear on three different rootstocks. The cultivars included Kosui, Korean Giant, 20th Century, Hosui, Shinko, Ichiban Nashi, Shinseiki, Chojuro, Okusankichi, and Shinsui. The three rootstocks used were *Pyrus betulaefolia, Pyrus calleryana,* and Old Home x Farmingdale 333. The planting was arranged as a randomized complete block replicated 10 times with a total of 300 trees planted. Mortality was scored in late 1995 and data was subjected to Chi-square analysis. Rootstock did have a significant effect on mortality. *P. betulaefolia* had the lowest frequency of mortality of 11%, with Old Home and *P. calleryana* at 24% and 31% respectively. Cultivars also had a significant effect on mortality. Korean Giant and Shinseiki had the lowest mortality of 3.33% and 6.67%, respectively. Kosui and Hosui had the highest mortality of 46.67% and 36.67%. Stress conditions that occurred during 1995 and environmental factors that contribute to the development of fireblight were responsible for the mortality of the Asian pear.

791

Determining Consumer Interests and Preferences in the Consumer Horticultural Industry: Results of a Consumer Interest and Market Survey of Garden Show Attendees

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Consumer interest and market surveys play an important role in determining what consumer wants and needs are from an industry. These surveys can also serve the role of preparing students for their future jobs in the industry. The horticulture industry is no different. Companies need to know what consumer interests and needs are so they can serve them better. Likewise, students need to know what areas of horticulture are receiving the highest demand by consumers so they can prepare themselves better. A consumer preference study was conducted at the Topeka, Kan., "Lawn, Garden, and Flower Show" by members of the Kansas State Univ. Horticulture Club. The objectives of the survey were to determine: 1) the specific gardening interests of the respondents, 2) the demand for educational materials on specific gardening areas by the respondents, 3) what the respondents' garden buying habits were, and 4) what the respondents' plant selection preferences were. Survey respondents indicated that, when selecting plant material, plant quality was the most important criterion used, while plant packaging was of least importance. Plant size and price were only given some importance in the plant selection decision. Other results of the survey will be presented.

792

The Shepherd's Field, a Wholesale Greenhouse Facility Development and Phased Expansion: A Case Study

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Development of a business plan, facility development, and phased expansion for a multi-faceted horticulture operation will be discussed.The company, The Shepherd's Field, presently consists of fruit and vegetable production distributed through farmers' markets. The owner wants to expand the operation to include bedding plant production, also to be sold at farmers' markets. The objective of this project was to develop a case study for use in greenhouse management courses that would facilitate making management decisions. The present owner has limited resources available. Through researching facility and system costs, the case study will present the owner and students with choices to be made on the development and expansion of the facility. Ultimately, both the owner and students will make decisions. The process of case development will be discussed and the case presented.

36 COLLEGIATE BRANCH ORAL SESSION (Abstr. 793–x803)

793

Delaying Flowering using Ethephon during New Guinea Impatiens Production

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Flowering of *Impatiens hawkeri* Bul. during production results in an accumulation of dead plant material and directs energy away from vegetative growth. Ethephon is currently used at 500 ppm during the production of cuttings to eliminate flowering on stock plants. In this study, the timing and rate of ethephon application during production was examined. Two cultivars were used: 'Innocence' and 'Shadow'. Ethephon was adjusted to pH 5.0 and applied at planting (0), or 1, 2, 3, or 4 weeks after planting at 0, 250, or 500 ppm. An additional control of water adjusted to pH 5.0 was also included. Five replications were used in a completely randomized experimental design. The experiment was conducted twice—26 June 26 and 7 Oct.1995—each lasted 10 weeks. The number of branches, plant size, fresh:dry weight ratio, and days to first flower were recorded. 'Innocence' did not significantly respond to the treatments, except for branch number and fresh:dry weight ratio, which decreased when treated with ethephon. In 'Shadow', a treatment of ethephon at 250 ppm 1 or 3 weeks after transplanting provided the best control of flowering with a minimal delay in production and high plant quality.

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Controlling *Rhizoctonia solani* using Quartenary Benzophenanthridine Alkaloids

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There are many naturally occurring substances that have the potential to be adapted to modern pest control chemistry. Azadirachtin, an insect growth regulator, is one such naturally occurring compound that has been widely accepted in insect pest management. Quartenary benzophenanthridine alkaloids (QBAs) are known to be effective in the control of crop-damaging fungal diseases. QBAs can be isolated from plants in the Papaveraceae. Extracts of *Macleaya cordata*, a species rich in QBAs, were formulated for drench application to *Cucumis sativa* 'White Wonder' seedlings. The seedlings were grown in a peat-lite medium using 10-cm plastic pots and inoculated with *Rhizoctonia solani*. Test formulations were prepared with and without QBAs and applied at 75, 150, and 300 ppm QBAs as a 100 ml/pot drench. The QBA formulations that provided effective control of *Rhizoctonia solani* lost 20% or fewer seedlings compared to the formulation without QBA, which lost more than 60% of the seedlings. Treated plants were evaluated confirming *Rhizoctonia solani* infection.

795

New Pest Control Strategies and Effects on Pollination of Cucumbers

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Cucumbers are susceptible to the bacterial wilt organism that overwinters in the gut of cucumber beetles. This disease is transmitted in feces via open feeding wounds and plugs xylem vessels of water conductive tissues. Insecticides can be applied to control cucumber beetles. Adios, a semiochemical bait impregnated with cucurbitacin is combined with the insecticide carbaryl, which can be applied after plant emergence to control cucumber beetles. However, the method of ap-

plication for giving the maximum control is unknown; thus, this was the purpose of this project. This study evaluates the rate of application, number of applications, methods of application using pressure and airblast sprays, and compares two Adios formulations. Also studied were the effects of Adios on bee fertilization and the quality of the fruit, since carbaryl is toxic to bees, and therefore can affect pollination. Adios was also compared to a foliar insecticide, Asana.

796

Effects of Paclobutrazol and Uniconazole on the Growth and Development of Miniature Kalanchoes (*Kalanchoe blossfeldiana*)

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An experiment was conducted to determine the effect of plant growth regulator, application concentration, and time of application on five cultivars of Kalanchoe (Stromboli, Majestic, Heirloom, Keepsake, and Revelry). Kalanchoe cuttings were propagated in 5.2-cm-diameter containers under a short-day photoperiod, then placed into a greenhouse maintained at 20C. Spray applications of paclobutrazol (25 or 50 ppm) and uniconazole (1 or 5 ppm) were made prior to visible flower bud (VB), after VB, or before and after VB. Across all cultivars and spray application dates, paclobutrazol applied at 25 and 50 ppm reduced total plant height by 20% and 29%, respectively, while uniconazole applied at 1 and 5 ppm reduced total plant height by 16% and 24%, respectively. Plant height was reduced by 13% with the pre-VB application, 23% with the post-VB application, and 32% with the pre- and post-VB applications. In general, the greater the treatment effectiveness at reducing plant height, the greater the increase in time to flower. For example, a post-VB Bonzi (50 ppm) application caused a 6-day delay in time to first open flower. With the appropriate plant growth regulator application, all five Kalanchoe cultivars tested could be used for commercial production in 5.2-cm-diameter pots.

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Cultivar Specificity of Jujube using *Agrobacterium rhizogenes*

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Jujube (*Ziziphus jujuba*), is valued for its fruit, its ornamental quality, and for its use in reforestation. Jujube is considered to be very difficult to root. Five strains of *Agrobacterium rhizogenes* were tested on eight cultivars of jujube for the induction of roots. Strains of *A. rhizogenes* used were A4, TR105, AR WT, MT232, and 50. Cultivars of jujube included 'Sherwood', 'Sugar Cane', 'So', 'Li', 'Silver Hill', 'Tiger Tooth', 'Lang', and 'Contorta'. 'Sugar Cane' had the lowest callus rating of the cultivars and 'Li' the highest of the cultivars, followed closely by 'Tiger Tooth'. 'Sugar Cane' consistently had the lowest number of primary and secondary roots, and did not have any tertiary roots. 'Li' consistently had the highest number of primary, secondary, and tertiary roots of the cultivars, followed by 'Lang'. 'Li' had more, longer roots than any of the other cultivars, followed by 'Contorta'. 'Li' had the best root grade rating of the cultivars. The highest percentage of rooting occurred in 'Li' and 'Contorta'. 'Sugar Cane' had the lowest percentage of rooting. There was no significant effect of strain on any of the rooting parameters measured. Overall, 'Li' rooted the best of the cultivars tested in response to *Agrobacterium rhizogenes*. 'Sugar Cane' performed the worst.

798

Biostimulants can Increase Growth of Greenhouse-grown Ornamental Annuals

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Three biostmulants, Grow-plex (Menefee Mining Corp., Dallas, Texas), Roots 2 (LISA Product Corp., Independence, Mo.), and Root n' Shoot (Natural Organic Products International, Mount Dora, Fla.) were applied to transplanted plugs of *Salvia splendens* 'Empire Red' and *Begonia semperflorens-cultorum* 'Varsity Pink' and 'Varsity Brite Scarlet'. Root n' Shoot drench (0.78%) solutions at transplant increased root weight, but a 1.56% solution decreased root weight of salvia; however, shoot growth was unaffected. Root n' Shoot decreased shoot growth of begonia, but did not affect root growth of begonia. Roots 2 treatments (0.25% or 2.00%) increased shoot weight of salvia, but did not affect salvia root growth or root or shoot growth of begonia. Spraying Grow-plex (0.78% or 1.56%) to runoff at transplanting and 2 weeks after transplanting did not affect root or shoot growth of salvia or begonia.

799

Physiological and Molecular Changes in Aeroponically Grown, Phosphate-starved Tomatoes

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We are interested in understanding the molecular changes that occur in response to phosphate starvation in the roots of tomato plants. Aeroponics offers a unique way to study the changes that occur in the roots of plants. Tomato plants were grown in an aeroponic system developed by L.A. Peterson at the Univ. of Wisconsin. Aeroponically grown tomato plants were treated with various concentrations of phosphate (Pi) ranging from 0 to 250 μM. Plants were harvested at different times after the initiation of Pi deficiency treatments for nutrient analysis and gene expression studies. Several changes in essential nutrient content were observed. A differential accumulation of magnesium between the root and shoot tissue of phosphorus-starved plants was noticed. The expression of a recently cloned phosphate starvation induced gene (TPSI1) increased with decreasing concentration of Pi in the growth media. There is a strong correlation between the concentration of the Pi in the growth media and expression of the gene. The effect of Pi starvation on the gene expression in different parts of the plant, including old and young leaves, will be discussed.

800

Chemical and Physical Evaluation of Tofu from Vegetable Soybean Cultivars

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Soybean, *Glycine max* (L.) Merril is an annual self-pollinated diploid legume (sub-family Fabaceae). In the 1990s, soybean production in the far east, as in ancient times, was primarily for food consumption. Today, vegetable soybean is the dominant soyfood in Asia and is gaining popularity in the United States because of its versatility and nutrient value. Dozens of different forms of food have been developed from it. Tofu is one of the most important of these. Twenty four cultivars of vegetable soybean from two regional tofu tests (Alabama A&M and Virginia State Univ.) and 10 cultivars from the Alabama A&M Univ. soybean breeding project were evaluated for the physical and chemical characteristic of the resultant tofu. Data on protein, tofu yield, moisture content, tofu texture, and structure were recorded. Shear-force (used to evaluate texture) was determined with a Kramer Shear cell and micro-structure was examined using a scanning electron microscope. Seed protein content ranged from 30 to 54%. Tofu yield ranged from 41.9 to 83.0 g and texture of tofu ranged from 10 to 62.3 lb.

801

Response of New Guinea Impatiens to Various Water Qualities in a Subirrigation System

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With the rising concern for the environment and an increase in governmental regulation, greenhouse growers must find alternative methods for irrigation that will avoid ground and surface water contamination. Subirrigation is one of these alternatives, but subirrigation is more sensitive to water quality than traditional systems and many growers are faced with poor water quality. This experiment tested seven different water sources from across the state of Texas. Each source was replicated twice using New Guinea impatiens 'Illusion'. Leaf count, plant height, and plant width were measured at 2-week intervals. Plants were harvested at 8 weeks and measured for shoot fresh weight, shoot dry weight, and overall quality. Electrical conductivity of the upper, middle, and bottom layers of the container medium was measured. Compared to the reverse osmosis control, fresh weight was reduced by 12% to 30%, average leaf number by –7% to 56%, quality evaluation by –8% to 61%, average width by –5% to 27%, and the average height by 8% to 34%. The results will be explained based on differences in analysis of the various water and media samples.

802

Germination of Selected Turfgrass Seeds under Saline Conditions

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The influence of NaCl concentration on seed germination in blue grama grass (*Bouteloua gracilis*), salty alkaligrass (*Puccinellia distans*) and Kentucky bluegrass (*Poa pratensis*) were investigated. When seeds were germinated in petri

dishes containing 0, 2.5, 5.0, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, 25, 27.5, and 30 g • liter^{-1} NaCl at 22 C for 4 weeks, blue grama grass was most salt-tolerant with 50% germination at 17.5 g • liter^{-1}. The salt concentrations that provided 50% germination for salty alkaligrass and Kentucky bluegrass were 5 and 1.5 g • liter^{-1}, respectively. The upper limits of salinity that allowed any germination were 30 g • liter^{-1} (1%) for blue grama grass, 27.5 g • liter^{-1} (1%) for salty alkaligrass, and 5 g • liter^{-1} (2%) for Kentucky bluegrass. Germination was quickest in blue grama grass (90% germination in 1 week) followed by salty alkaligrass (50% in 3 weeks) and Kentucky bluegrass (50% in 4 weeks). The tissue contents of Na^+ and Cl^- as influenced by increasing levels of NaCl were also determined.

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Wiley–Boone Aviary: A Bird Garden

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The Wiley–Boone Aviary is a collection of domestic/exotic birds established at the Morgan Poulty Center at Clemson Univ. in the mid-1970s. The area receives 3000 visitors per year, mostly school children. To make the site more aesthectically pleasing and conducive to educational programs, a new design was necessary. The Aviary was selected for redesign as an independent project in Fall 1995. Objectives of the design were: 1) creating an area conducive to housing, attracting, and viewing birds; 2) educating visitors through interactive display areas; 3) creating a bird garden that will attract and educate the public while providing natural food sources, cover, and nesting sites. Plants such as *Pyracantha coccinea*, *Amelanchier arborea*, and *Juniperus virginiana* provide winter berries and protection from predators. Final plans feature: 1) individual aviary structures for exotic, game, and domestic birds; 2) open habitats for mallards and song birds; and 3) an amphitheater for educational purposes. Project steps included research, site analysis, preliminary design, and final master plan. As part of fund-raising activities, the master plan was displayed at the spring festival of the South Carolina Botanical Garden. This, combined with publications, will stimulate community awareness and participation as we approach the implementation phase of the project.