

**Symposium 18 (S18): Nursery Crops—Development, Evaluation, Production and Use**

**Monday · August 12**

**Location: Metro Toronto Convention Centre, Room 206D**

**1100–1140**

**S18–0–1**

**ART AND SCIENCE FOR LIFE: DESIGNING AND GROWING VIRTUAL PLANTS**

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Virtual plants are computer models that recreate the structure and simulate the development of plants. Virtual plant modeling represents an interdisciplinary combination of mathematical formalisms, biological knowledge, and computer graphic techniques. An important modeling method is based on the theory of Lindenmayer systems (L-systems). A fascinating aspect of this theory is the contrast between the relative simplicity of model specification and the apparent complexity, intricacy, and visual realism of the resulting forms. At present, L-system models make it possible to: (a) accurately recreate the structure and development of plants; (b) show how the evolution of architectural parameters (branching angles, elongation rates, vigor of branches, etc.) affects the appearance of plants; (c) simulate plant physiology and investigate the effects of manipulations (e.g., pruning) or different external conditions (local light microclimate, water availability, crowding) on plant development; and (d) simulate plants not only in isolation, but also in their ecological contexts. The models are potentially useful as an exploration tool, indicating desirable directions of breeding and manipulating ornamental plants for maximum visual impact. Other applications include research and teaching of botany, and landscape design. Current research problems related to the theory and use of virtual plants include: calibration of the models, detailed simulation of plant physiology, and simulation-assisted studies of the genetic basis of plant form.

**1140–1220**

**S18–0–2**

**UTILISATION OF MOLECULAR TOOLS FOR ROSE GENETICS AND BREEDING**

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Roses are among the most important ornamental plants worldwide. Despite its economic importance little work has been conducted to elucidate the inheritance of important characters yet. Therefore, we begun to analyse morphological characters as well as resistance to two of the most important pathogens, blackspot and powdery mildew, genetically and molecularly. Several morphological traits including single genes and Qtl's were mapped in relative to molecular markers. After the isolation and characterisation of single spore isolates for rose blackspot and powdery mildew, analyses in segregating diploid rose populations revealed the presence of single dominant genes. For each pathogen one resistance gene could be mapped on the rose chromosome map. In addition, for Rdr1 a gene conferring resistance to blackspot high density mapping and the isolation of BAC-clones with closely linked markers led to the identification of a contig carrying several disease resistance analogous sequences and spanning the locus. The structure of this locus and the identification of Rdr1 among the candidate genes are currently under investigation. In parallel, microsatellite markers have been developed to study the structure of blackspot populations. Furthermore, strategies for the marker assisted selection against the genetic background of wild donor species in introgression programs were developed. Within two generations of backcrossing, wild donor germplasm could more effectively reduced by means of molecular markers than by conventional morphological analyses. Data both from the host and the pathogen should lead to the development of strategies for molecular breeding for resistance in roses.

**1220–1240**

**S18–0–3**

**RESISTANCE OF RHAPHIOLEPIS SELECTIONS TO ENTOMOSPORIUM LEAF SPOT**

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Entomosporium leaf spot [*Entomosporium mespili* (DC.) Sacc.] on *Rhaphiolepis* sp. is recognized as a damaging disease in nurseries and landscapes. A study was initiated in March 1996 to evaluate the ornamental characteristics and disease susceptibility of thirteen *Rhaphiolepis* selections to Entomosporium leaf spot in south Georgia. Plants were established in Tifton (USDA 8a) on a Tifton loamy sand. Four replicates were placed on 2.3 meter centers within rows and 3.8 meters between rows. Plants were fertilized in April of 1996–2001 using 16–4–8 + minors at 56 kg N/ha and watered as needed using drip irrigation. Disease and defoliation were evaluated in May and June of 1997, 1998, and 2001. Climatic conditions were not suitable for disease development in 1999 or 2000. Disease and defoliation were visually evaluated on a scale of 1 to 5 where 1 = no disease, 2 = 1% to 25% of the leaves diseased or defoliated, 3 = 26% to 50%, 4 = 51% to 75%, and 5 = >76%. In 1997 and 1998 the selections Gulf Green, Georgia Petite, Olivia, and Georgia Charm demonstrated good resistance to leaf spotting and defoliation. The selection Pink Pearl showed moderate disease and defoliation. Disease development was excessive while leaf drop was fair for Clara. The cultivar Snow White had fair disease ratings but dropped fewer leaves than Clara. The selection Eleanor Tabor received all acceptable ratings in 1997, but had unacceptable disease development in May of 1998 with fair defoliation ratings for both months. The selections Ballerina, Bay Breeze, Cameo, Elizabeth, and Kathy are considered unacceptable due to extensive disease development and defoliation. Ratings in 2001 were similar to those in previous years. Growth and flowering data will also be presented.

**1340–1440**

**S18–P–4**

**PROTECTION OF COLLECTIONS OF ORNAMENTAL PLANTS IN THE SOUTHERN AREA OF ROMANIA**

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The ornamental trees and shrubs, together with turf and flowers, make excellent landscaping candidates. The researchers from the Research Station for Fruit Tree Growing-Baneasa, Bucharest, have established six major research thrusts to evaluate both native and introduced species in landscape settings. Specific goals include: preservation of the existing ornamental germplasm; evaluating both native and imported species and cultivars, adaptable to typical conditions of Southern Romania; selection of native flora with landscape potential; using classical methods of breeding to develop new cultivars of landscape plants; optimizing propagation techniques; evaluating plant material under a range of climatic and environmental conditions. The results of the research work to date have identified 115 species and varieties of both deciduous and coniferous plants. The major conifer taxa include: *Thuja*, *Juniperus*, *Chamaecyparis*, *Taxus*. Major shrub species include: *Buxus*, *Euonymus*, *Mahonia*, *Lonicera*, *Cotoneaster*, *Piracantha*, *Sorbaria*, *Ligustrum*, *Spiraea*, *Callicarpa*, *Kerria*, *Budleja*, *Ribes*, *Syringa*, *Forsythia*, *Berberis*, *Sambucus* and *Cornus*. Highlights of this evaluation program will be presented.

**1340–1440**

**S18–P–5**

**THE POTENTIAL OF BREEDING FOR RESISTANCE TO THE INTRODUCED PEST, VIBURNUM LEAF BEETLE (*PYRRHALTA VIBURNI*)**

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The viburnum leaf beetle (*Pyrrhalta viburni*), a European native insect, has now become established in the Northeastern US and Eastern Canada. This beetle

presents a serious threat to both native and non-native *Viburnum* species in the North American landscape. Although all North American native species of viburnum are susceptible to this insect, significant resistance is present in several Asiatic species. These species may be potential sources of resistance to the leaf beetle in breeding programs for new ornamental selections. A segregating F2 population resulting from a wide-cross between the highly resistant *V. carlesii* and the susceptible *V. lantana* was screened for resistance to the leaf beetle. Bioassays consisted of no-choice feeding trials on moistened filter paper in petri dishes using single adult leaf beetles. Feeding was determined by scanning and digitally analyzing the leaf area consumed. This population displayed great variation in leaf beetle resistance/susceptibility, including significant transgressive segregation for this trait. This study indicates that considerable potential exists for the use of interspecific crosses to create ornamental *Viburnum* clones possessing high levels of resistance to *P. viburni*.

1340-1440

S18-P-6

#### COLD HARDINESS EVALUATION OF EIGHTEEN MAGNOLIA TAXA DURING DE-ACCLIMATION IN NORTHERN LATITUDE

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Magnolias are popular ornamental woody plants for landscape in USDA zone 6-7. In the Midwest, cultivation of magnolias is considerably limited due to low temperatures in the winter and de-acclimation in early spring. For this reason, local nurseries often offer "Iron Clad" *Magnolia* such as *M. stellata*, *M. kobus*, *M. x loebneri*, *M. sieboldii*, *M. officinalis* var. *biloba* and *M. denudata*, grown at the Morton Arboretum. This perception is inaccurate. *Magnolia*, including those grown at The Morton Arboretum survived -32 °C (-26 °F) in 1982 and consistently performed well. In spite of the cold hardiness demonstrated by these species, to date there is no scientific research published on these less common species for northern latitudes. The objective of this study is to evaluate the ability of 18 *Magnolia* taxa for de-acclimation and acclimation at the Morton Arboretum for northern latitudes. The stem and bud cold hardiness were evaluated in April 2001 by using artificial freezing test. The LT<sub>50</sub> (the temperature which 50% of the tissues were killed) based on the bud cold hardiness showed that the *M. acuminata*, *M. cordata*, *M. salicifolia*, *M. 'Elizabeth'* and *M. tripetala* had the highest bud cold hardiness (-21 °C to -32 °C). *Magnolia denudata*, *M. kobus* 'Nana Compacta', *M. sieboldii*, *M. x soulangiana* 260-64 and *M. kewensis* 'Wada's Memory' had medium bud cold hardiness (-10 °C to -16 °C). *M. x loebneri* 'Merrill', *M. x soulangiana* 'Liliputin', *M. x loebneri* 'Leonard Messel', *M. stellata* 'Rosea', *M. x proctoriana*, *M. stellata*, *M. x soulangiana* 927-61, *M. kobus* var. *borealis* had the lowest bud cold hardiness (-2 °C to -9 °C). The bud and stem cold hardiness were the same only in *M. acuminata* and *M. tripetala* and the stem cold hardiness was significantly higher than bud cold hardiness in the other 16 taxa during de-acclimation. Dormancy, cold acclimation and midwinter cold hardiness results will be presented.

1340-1440

S18-P-7

#### EVALUATION OF *HYDRANGEA PANICULATA*, *QUERCIFOLIA*, *MACROPHYLLA*, *SERRATA* AND *INVOLUCRATA* CULTIVARS FOR COLD HARDINESS, GROWTH AND PERFORMANCE IN NORTHERN CLIMATES

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Hydrangeas are one of the most popular ornamental shrubs for the landscape. In the Midwest, cultivation of a wide range of hydrangeas is limited due to low temperatures in the winter that damage vegetative or floral buds. *Hydrangea paniculata* and its cultivars have long been mainstays in the nursery industry due to their beautiful late summer flowering. *Hydrangea quercifolia* is a native North American species with a natural range from Georgia to Florida and Mississippi. *Hydrangea serrata*, the mountain hydrangea, is often considered a variety of *H. macrophylla*. A total of 33 taxa were planted on May 3, 1998 at the Morton Arboretum. The plants were 2 gallon from Spring Meadow Nursery Inc. of Grand Haven, Michigan. Stem cold hardiness was evaluated for *H. paniculata* and *H. quercifolia* in February 2001 by using an artificial freezing test. For *H. macrophylla*, *serrata* and *involucrata* cultivars, the flower numbers were used for evaluation.

The LT<sub>50</sub> (the temperature which 50% of the tissues were killed) showed that for the oak-leaved hydrangeas, *H. quercifolia* 'Sikes Dwarf' (LT<sub>50</sub> -40 °C) was the most hardy followed by 'Snow Flake' (LT<sub>50</sub> -25 °C) and 'Alice' (LT<sub>50</sub> -18.5 °C). In panicled hydrangea group, the *H. paniculata* 'Brussels Lace', 'Pink Diamond' and 'White Lace' all were hardy to -40 °C, followed by 'White Moth' (LT<sub>50</sub> -35.75 °C), 'Burgundy Lace' (LT<sub>50</sub> -35.5 °C), 'Unique' (LT<sub>50</sub> -34.75 °C), and 'Kyushu' (LT<sub>50</sub> -32.25 °C). For *H. macrophylla*, flower number counts were taken on August 22, 2001 and showed that 'Coerulea Lace' had the highest mean number of flowers (11) followed by 'Sadie Ray' (9.5), 'Nikko Blue' (7.66), 'All Summer Beauty' (6.33), 'Tokyo Delight' (6) and 'Blue Wave' (5.5). In *H. serrata* group, the 'Blue Bird' (15.33) had the highest flower number followed by 'Preziosa' (1.7). *Hydrangea involucrata* (X=27.33) had the highest flower number of all hydrangea tested. Data on growth and performance will be presented.

1340-1440

S18-P-8

#### INTEGRATED APPROACHES FOR MANAGING THE BOXWOOD LEAFMINER, *MONARTHROPALPUS FLAVUS* (SHRANK)

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The boxwood leafminer, *Monarthropalpus flavus*, is a serious pest of boxwoods in landscapes and nurseries. Studies conducted in the laboratory and field examined the ability of boxwood cultivars to serve as hosts for the leafminer. A survey of nine cultivars of *Buxus* at the United States National Arboretum revealed significant differences in levels of infestation by the boxwood leafminer. An analysis of larval survival confirmed high levels of susceptibility in *Buxus sempervirens* 'Myrtifolia' and *Buxus microphylla* 'National' while *B. sempervirens* 'Handsworthiensis' and *B. sempervirens* 'Vardar Valley' exhibited high levels of resistance. To rule out the possibility that colonization was responsible for differences in levels of survivorship, we enclosed ovipositing flies on several cultivars and measured larval survival. *Buxus sempervirens* 'Vardar Valley' continued to demonstrate high levels of resistance to the leafminer. Laboratory studies indicate that the mechanism of resistance is antibiosis rather than antixenosis. We described the life cycle of boxwood leafminer in the mid-Atlantic region of the United States in relation to growing degree-day accumulations. Using life cycle information we evaluated the efficacy of three systemic insecticides (avermectin, imidacloprid, acephate) for control of this pest. Avermectin and imidacloprid applied at adult flight provided excellent control. Imidacloprid applied in the summer gave good control of larvae. Avermectin and acephate were ineffective when applied in the summer. Planting pest resistant cultivars greatly reduces the need for pesticides. A single well-timed pesticide application with a systemic insecticide eliminates the need for multiple applications. While both approaches help to preserve biological diversity and contribute to the development of sustainable landscapes, the use of highly resistant plant materials may provide a durable and environmentally superior strategy for dealing with this pest.

1340-1440

S18-P-9

#### THE CHARACTERISTICS LINKED TO THE SHAPE OF SEPALS IN *HYDRANGEA MACROPHYLLA*

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The inflorescences of most species of *Hydrangea* are composed of decorative and non-decorative florets. The decorative florets are sterile and their sepals are large and colored. Non-decorative florets are fertile and their sepals are small and inconspicuous. In this study, the characteristics of decorative florets were compared with those of non-decorative florets for the purpose of investigating the characteristics linked to the type of sepals, using several cultivars of *Hydrangea macrophylla*. In the shape of stamens, no differences were obvious between both types of florets. There were no significant differences in pollen fertility between both types of florets, estimated by in vitro germination tests and acetic carmine staining tests. The locules and placentas of decorative florets were much smaller than those of non-decorative florets. The inflorescences of *H. macrophylla* often have several semi-decorative florets which have both large sepals and small ones in a floret. In the semi-decorative florets, the ovary developed normally on the side adjacent to small sepals. The non-decorative florets were pentamelous and

the number of their flower organs was stable. On the other hand, most decorative florets were tetramerous, and the number of their flower organs was unstable. From these results, it was suggested that the development of the pistil and the number of flower organs were linked to the shape of sepals.

**1340–1440**

**S18–P–10**

**BIOLOGICAL CHARACTERS AND APPLICATION OF 47 VARIETIES OF CLIMBING PLANTS**

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In order to restore the ecological landscape of special terrains and landforms and to improve the environmental quality of the urban landscape, a study was initiated evaluating the adaptability of different native climbing plants. We selected 64 taxa from 174 climbing plants collected. This list was further reduced to 47 taxa based on their adaptability in Shenzhen (31 evergreen and 16 deciduous taxa). Observations were recorded on the growth rate, blooming and fruiting habits, and related phenology. 17 varieties had a yearly net growth length of over 3 metres and could be useful to revegetate slopes, barren hills and motorway interchanges. 11 varieties had large colourful flowers; some of them blooming more than once per year (e.g., *Passiflora alatocaerulea*, *Pseudocalymma alliaceum* and *Pharbitis india*, etc.). There were a variety of different vining and climbing methods observed [leaf stalks (1), tendrils (21), tendrils with adhesive pads (3), adventitious roots (8), twining stems (13), trailing stems (1)]. These characteristics need to be considered when selecting plants for revegetation projects. Results of a planting experiment suggest that evergreen types with strong drought-hardiness (e.g., *Macfadyena unguis-cati*, *Pueraria montana* and *Bauhinia corymbosa*, etc.) were very useful to revegetate the stony slopes and barren hills. Indigofera enephylla was useful in replanting barren soil. The selection of a variety of plants, such as *Pharbitis india*, *Pyrostegia venusta* and *Thunbergia laurifolia* with *Parthenocissus heterophylla* and *Ficus pumila*, could not only make the motorway interchange green but also beautify it.

**1440–1500**

**S18–O–11**

**RESISTANCE TO THE BIRCH LEAFMINER (*FENUSA PUSILLA*) WITHIN THE *BETULA* SECTION *COSTATAE* IS RECESSIVE AND DISPLAYS A GENE DOSAGE EFFECT**

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The birch leafminer (*Fenusa pusilla*) is a common and often serious pest of ornamental birches throughout much of the temperate regions of North America. Of the five *Betula* species resistant to this insect pest, none possess ornamental white bark. Interspecific hybridization promises to combine leafminer resistance and ornamental white bark in a single genotype. Twenty-two interspecific crosses within the genus *Betula* were performed and the progeny assayed for resistance to *F. pusilla*. Two leafminer resistant species within the section *Costatae*, *B. alleghaniensis* and *B. costata*, were successfully hybridized to white-barked species. All progeny resulting from diploid x diploid crosses of highly resistant individuals of *B. costata* with white-barked species were susceptible to leafminer. Offspring of the diploid x hexaploid cross *B. turkestanica* x *B. alleghaniensis* displayed a broad range of resistance levels. While the progeny of this cross closely resemble the hexaploid *B. alleghaniensis* parent in most phenotypic characters, the majority of individuals in this population displayed leafminer resistance that is intermediate between the two parents, with some plants possessing the susceptibility of the diploid *B. turkestanica*. This suggests segregation of alleles contributed by the hexaploid parent. These results indicate that the leafminer resistance mechanism utilized by these members of the *Betula* section *Costatae* is inherited as a recessive trait with gene dosage effect.

**1500–1520**

**S18–O–12**

**INTERSPECIFIC HYBRIDIZATION IN *ABELIA***

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For nearly a century, *Abelia xgrandiflora* has been a staple in southern United States landscapes. *Abelia xgrandiflora* is one of only two interspecific hybrids ever developed and released within the genus. *Abelia* contains approximately 30 species that vary widely in a number of traits including flower color, flower size, growth habit, and cold hardiness. Despite the potential for interspecific hybridization, breeding work in the genus has been limited. Intra- and interspecific compatibility was assessed among 12 taxa of *Abelia*. Seed set was generally higher among interspecific hybrids than intraspecific hybrids. *Abelia chinensis* ranked as the best maternal and paternal parent in both intra- and interspecific crosses. Interspecific hybrids varied in percent seed set, dependent on the parentage. Previously unrecorded interspecific hybrids were obtained between *A. chinensis* x *A. engleriana*, *A. chinensis* x *A. spathulata*, *A. chinensis* x *A. serrata*, and *A. chinensis* x *A. zanderi*.

**1520–1540**

**S18–O–13**

**SELECTION AND BREEDING OF EUCALYPTS FOR ORNAMENTAL HORTICULTURE**

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Eucalypts have wide appeal throughout the world for ornamental horticulture. The genus is known for its unique flowers and bud forms, which are popular for floriculture, and its hardy disposition, making many species favorable for parks and gardens. Development of *Eucalyptus* species for ornamental horticulture uses a combination of selection from established plantations and natural populations. In order to select superior individuals from the large number available, a list of essential characters was devised, and these characters prioritised. These characters, or selection criteria, have been divided into Primary and Secondary criteria. Criteria of Primary importance relate specifically to bud and flower characters, although fruit and general tree characters can be of importance for more unique individuals. The characters are viewed in combination; there is no one character that can be selected for at the first stage. The second stage relates to performance characters; response to cultivation practices and clonal propagation techniques as well as the postharvest vase life of the buds and flowers are assessed. These characters are viewed singly, and poor response to any will result in the culling of that genotype from the breeding program. A breeding programme has been underway at Adelaide Univ., Waite Campus, for over 10 years, producing interspecific hybrid eucalypts through controlled pollination. The breeding programme has over 550 hybrid individuals currently being assessed for their floricultural and horticultural merit according to the primary selection criteria established. Those individuals selected for further development will be assessed for their response to the secondary criteria. Ongoing pollinations will introduce new hybrids into the programme each year, all will be assessed for both primary and secondary criteria. Hybrids that are superior in all respects will be trailed for commercial production, with the aim of commercial release.

**1540–1600**

**S18–O–14**

**INTERSPECIFIC HYBRIDIZATION BETWEEN *HIBISCUS SYRIACUS* L. AND *HIBISCUS PARAMUTABILIS* BAILEY**

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Different *Hibiscus syriacus* L. cultivars (diploid 'Melwhite' and 'Oiseau Bleu' and tetraploid 'Red Heart cv' and 'Purple cv') were used in a breeding program with *Hibiscus paramutabilis* Bailey. Compared to *H. syriacus*, a well known winter hardy ornamental shrub, *H. paramutabilis* grows more vigorously. When used as seed parent, *H. paramutabilis* failed to set fruit. However, when pollinated by *H. paramutabilis*, *H.s.* 'Oiseau Bleu' and *H.s.* 'Red Heart' reacted by setting fruit. Of *H.s.* 'Oiseau Bleu' 41 flowers were pollinated, resulting in 7 fruit. After pollination of 48 *H.s.* 'Red Heart cv' flowers, 5 fruit were harvested. Fruit containing swollen (=fertilized) ovules were not observed on *H.s.* 'Melwhite' or *H.s.* 'Purple cv'. The embryos were put in vitro 6–10 weeks after pollination on modified MS (half-strength macronutrients, full strength micronutrients + vitamins) + 3% sucrose. Twenty-six *H.s.* 'Red Heart' x *H. paramutabilis* embryos and 45 *H.s.* 'Oiseau

Bleu' x *H. paramutabilis* embryos were ented. They could already be isolated in the globular and heart-shaped stage; however, only some of the torpedo-shaped and cotyledonary embryos developed into plantlets. Since embryos could be isolated from the ovules easily, ovule culture seemed useless and was not attempted. Germination occurred within 2–3 weeks; however, true leaves were only formed after 4–5 months in vitro. Five *H.s.* 'Red Heart' x *H. paramutabilis* embryos and 7 *H.s.* 'Oiseau Bleu' x *H. paramutabilis* embryos could be converted. Ploidy analysis of these potential hybrids revealed that the *H.s.* 'Red Heart' offspring was triploid, as was expected. AFLP-analysis confirmed the hybrid character of all tested seedlings. The plants were acclimatized and put in soil; they grew vigorously and all showed strong morphological similarities with *H. paramutabilis*. The triploid hybrids grew at the same rate as the diploid ones. Flowers have not developed so far.

**1600–1620**

**S18–0–15**

**TRIFLURALIN-MEDIATED CHROMOSOME DOUBLING OF *ROSA CHINENSIS MINIMA* VOSS SEEDLINGS**

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Diploid rose species possess valuable traits including winter hardiness and disease resistance that can be introgressed into modern tetraploid cultivars. Interspecific, interploidy crosses are possible, but resulting triploid hybrids typically have limited fertility, hindering further breeding and selection. Chromosome doubling diploids before mating to tetraploids may alleviate this bottleneck. The efficacy of trifluralin was investigated for chromosome doubling *Rosa chinensis minima* V. ( $2n=2x=14$ ) seedlings. Treatments were trifluralin at 0.086% and 0.0086%, along with colchicine (0.5%) and distilled water as controls; each treatment included dimethyl sulfoxide and a surfactant. Seedlings (N=339) from two different open-pollinated females were randomly assigned to treatments over 8 potting dates. Following treatment application to the shoot apical meristem, data was collected on mortality, terminal leaflet length to width ratio, stomata size, and pollen diameter and stainability. Pollen diameter was used to screen for effective doubling; gametes arise from layer II of the meristem and are of greatest interest to breeders. Stomata size revealed all genotypes doubled in layer II were doubled in layer I. Nine additional genotypes were identified that were doubled in layer I, but not layer II. Trifluralin (0.086%) had the highest mortality (M) at 65%, yet was the most effective treatment with a 11.8% conversion (C) rate in layer II. Trifluralin (0.0086%, 4.71% C, 40% M), colchicine (0% C, 16% M), and water (0% C, 36% M) were not significantly different for conversion, but colchicine had a lower mortality rate. Seedlings from different females and across planting dates were not significantly different for doubling or mortality. Chromosome doubled genotypes had reduced pollen stainability and lower leaflet length to width ratios than non-doubled genotypes. Crosses between chromosome doubled genotypes and modern tetraploid roses have been initiated.

**1620–1640**

**S18–0–15–A**

**TO BE ANNOUNCED**

**1640–1700**

**S18–0–15–B**

**TO BE ANNOUNCED**

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**Tuesday · August 13**

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**1100–1140**

**S18–0–16**

**IMPACTS OF TECHNOLOGY ON THE DEVELOPMENT, PRODUCTION, AND MARKETING OF NURSERY CROPS**

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Technology has often served as a driving force underlying structural shifts in world-wide economies (e.g. Gutenberg's press, Watt's steam engine, and Kilby's integrated circuit). But technology has also impacted the green industry in significant fashion, enhancing the development, production, and marketing of nursery crops (e.g., tissue culture, irrigation and fertilization technologies, automation and climate control systems, and biotechnology/genetic engineering). In the last decade, however, information technology has had perhaps the most marked impact on the green industry supply chain. This paper addresses the innovations in information technology that have translated into real performance gains for wholesale and retail nursery businesses. The adoption of information technology (IT) has led to unprecedented changes in business practices and subsequent performance gains throughout many sectors of the economy. Manufacturing plants (nurseries) and service firms (garden centers) are becoming increasingly automated, while workers are given more flexible job assignments and stronger incentive pay, leading to improved performance. Supplier (and customer) relationships are becoming more closely integrated. Computer systems now coordinate various aspects of production and distribution, allowing firms to reduce inventories dramatically. Practices such as Efficient Consumer Response (ECR) and mass customization facilitate customer intimacy. Firm boundaries are also shifting, as firms outsource non-core (or inefficient) activities and move toward flexible, collaborative relationships such as joint ventures and strategic alliances with suppliers, customers, and even [previous] rivals. The result is an economy (and green industry) that is unusually dynamic, and entrepreneurial, with high rates of business formation and business failure reflective of the inherent risks associated with innovation. In these conditions, equity values of firms will continue to fluctuate, and the economy (and green industry) as a whole will likely continue to experience the rise and fall of business cycles (through creative destruction and hyper-competition).

**1140–1200**

**S18–0–17**

**FORCING CONIFERS FOR TABLE-TOP CHRISTMAS TREES**

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Based on preliminary work on developing table-top Christmas trees, we have found that consumers prefer newly flushed trees rather than those which have already set bud and hardened-off. Several interacting environmental factors, including chilling, photoperiod, and temperature, control bud-break in conifers. The objective of this trial is to: 1) determine the optimal combination of dormancy induction and chilling needed to force conifers to break-bud and flush on a target date; and 2) characterize species variation in response to forcing. We compared the bud flush response of several conifers: *Picea glauca* var. *densata*, *P. omorika*, *P. wilsonii*, *P. meyeri*, *P. pungens*, *Abies procera* 'Frijsenborg Blue', and *A. nordmanniana-ambrolauria*. The trees were treated with varying lengths of chilling in the middle of their normal growing cycle. The seedlings were chilled for 0, 4, 6, or 8 weeks at 3 °C. Prior to chilling, seedlings received a short day (9-hour photoperiod) treatment for 0, 2, 4, or 6 weeks at 20 °C. After the combination of short day and chilling, the seedlings were placed under a long-day (16-hour photoperiod) treatment at 20 °C. Seedlings were scored for date of bud-break, terminal growth, and terminal bud density. The species varied in response to the treatments. *Picea omorika*, *P. glauca* var. *densata*, and *P. wilsonii* are the most responsive to treatments. Results of the study suggest that certain conifers can be programmed to respond or flush on a target date based on short day and chilling treatments.

**1200–1220**

**S18–0–18**

**THE CHICAGOLAND GROWS PLANT INTRODUCTION PROGRAM—A MODEL FOR SUCCESS**

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Botanic gardens and arboreta, as repositories of living plant collections, are increasingly initiating plant introduction programs as vehicles for marketing unusual and valuable ornamental plants from their collections. One such program is the Chicagoland Grows Plant Introduction Program, a corporate

partnership between Chicago Botanic Garden, The Morton Arboretum, and the Ornamental Grower's Association of Northern Illinois (OGA), a network of nurseries located in northeastern Illinois. Established in 1986, Chicagoland Grows works collectively with industry professionals throughout North America (more than 85 nurseries in 22 states are licensed to propagate and grow the program's plants) to select, evaluate, produce and market new and recommended plant cultivars with proven performance under Northern growing conditions. From the collections of the partners and other sources ten trees and shrubs have been released, with eighteen more woody plants undergoing initial nursery production, and eighteen more plants (woody and herbaceous) being propagated for evaluation. New plants are initially evaluated by a group of gardens, universities, and municipalities, followed by production and field evaluations by co-operating nurseries. Once a plant's production figures reach a predetermined quota, it is released for promotion and open market sales. Plants are promoted through Plant Release Bulletins, a color flyer distributed to nurseries, landscape architects, and horticulture researchers; presentations at trade shows and professional plant society meetings; articles in trade magazines; booth exhibitions at trade shows; through the catalogs of the cooperating nurseries; and on the websites of the corporate partners. The program structure includes an executive committee; an R & D committee that recommends new plants; and a production scheduling committee that assesses propagation protocols, tracks inventories, assigns cultivar and trade names, and release dates.

**1220-1240**

**S18-0-19**

#### **SUSTAINABLE TRADE IN ORNAMENTAL HORTICULTURE**

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A large proportion of ornamental potplants produced in the developed countries are based on import of plant material from less developed countries, and most "potplant species" originate in less developed countries. There are however an increasing awareness and concern about the intellectual property rights on native plant species and about economic sustainability both at grower and in particular at consumer level. Sustainable or "fair trade" is an alternative approach to conventional international trade. It is a trading partnership which aims at sustainable development for disadvantaged producers. Fair trade are well established within a range of edible horticultural products (coffee, tea and cocoa), and fair trade has been adapted to a range of other products but so far not to ornamental horticultural products. It is obvious that fair trade if adapted to ornamental horticulture not only will create a whole new product line but also may create a new niche in the global potplant market. Ornamental horticulture is an industry with great job opportunities and with a great potential for generating much needed export income. It is however difficult for small and medium sized businesses in developing countries to enter the export market for horticultural products, especially because the demands to the transport chain are high for horticultural products. It is however evident that fair trade of ornamental plants will be a viable and sustainable business on longer term, this will however require training and education and increased research into the practical aspects of plant export and reestablishment.

**1340-1440**

**S18-P-20**

#### **THE INFLUENCE OF DROUGHT STRESS ON LEAF CHLOROPHYLL FLUORESCENCE, GAS EXCHANGE, AND LIGHT ABSORPTION OF RED MAPLE CULTIVARS**

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Cultivars of red maple (*Acer rubrum* L.) are popular ornamental plants that are commonly placed in a variety of landscapes. To date, little information quantifies the drought tolerance among cultivars of red maple. The objective of this study was to compare the effects of water stress on the physiology of five different red maple cultivars. Two-year-old seedlings of 'Summer Red', 'Autumn Flame', 'October Glory', 'Autumn Blaze', and 'Red Sunset' red maple cultivars were subjected to two treatments: irrigated to daily container capacity or irrigation withheld. Leaf absorbance, gas exchange, and chlorophyll fluorescence measurements were conducted at specific soil moisture conditions. Under water stress conditions, the amount of light absorbance decreased in four of the

five cultivars. Additionally, absorbance between cultivars was different under both well watered and water stress conditions. Over the course of drought stress and a recovery phase, net photosynthesis and stomatal conductance were significantly different among cultivars. Maximum PSII efficiency of dark-adapted leaves was lowered by the water stress condition. The thermal dissipation of excitation energy increased in four of the five cultivars under drought. The efficiency of excitation capture by open PSII reaction centers was variable between cultivars. Photochemical quenching was higher in 'Autumn Blaze', 'October Glory', and 'Summer Red' under drought conditions, which corresponded with a low degree of closure of PSII centers. Additionally, the fraction of excess excitation energy was also lower. Lastly, water deficit presented an increase in PSII efficiency in all cultivars except 'Autumn Blaze'. This research has demonstrated physiological variation among commercially available red maple cultivars, the results of which, will allow selection for drought tolerance specific to landscape site conditions.

**1340-1440**

**S18-P-21**

#### **SALT RESISTANCE OF SEASIDE ALDERS FROM DISJUNCT WETLANDS: FOLIAR HEALTH COMPARED TO OTHER WOODY SPECIES AND EFFECTS OF ROOT-ZONE INUNDATION**

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*Alnus maritima* [Marsh.] Nutt. (seaside alder) occurs in wet or flooded soils on the Delmarva Peninsula and in small niches in Georgia and Oklahoma. Although some seaside alders exist in coastal estuaries, responses of the species to salt, and whether provenance differences in salt resistance exist, are not known. During our first experiment, we compared salt injury among alders from all provenances irrigated with dilutions of ocean water. Photosynthesis and growth after treatment with salt then were compared among seaside alders and four other woody species: *Baccharis halimifolia* L., *Ceanothus americanus* L., *Myrica cerifera* L., and *Cornus amomum* Mill. Interactions of salinity and root-zone inundation on photosynthesis of alders were documented in a third study. Lastly, salt injury was evaluated among alders planted at locations that differed in salinity along the Broadkill River, an estuary in Delaware. Seedlings from the three provenances responded similarly to salt. Increasing salinity up to 3.1 g/kg did not alter stem elongation but did cause leaf necrosis. This injury was restricted to old leaves and was quantified by comparing leaf fresh and dry weights. Irrigation solutions with salinities up to 12 g/kg had little effect on *B. halimifolia* and *M. cerifera*. *C. americanus* showed decreases in photosynthesis at 3, 6, and 12 g/kg. Neither *A. maritima* nor *C. amomum* showed decreased photosynthesis at 3 g/kg, but photosynthesis of both species was reduced at 6 and 12 g/kg. There was a more pronounced decrease in photosynthesis as salinity increased for seaside alders with roots partially or totally inundated in solutions with salt compared to plants irrigated but not inundated with these solutions. Symptoms of salt injury expressed along the estuary were consistent with those observed in a greenhouse. We conclude that the salt resistance of this riparian species does not vary with provenance and is intermediate to that of the other species we studied.

**1340-1440**

**S18-P-22**

#### **THE RELATIONSHIP OF HOMEOWNER PRACTICES AND CARBON ACQUISITION POTENTIAL OF LANDSCAPE PLANTS TO MESIC AND XERIC DESIGNED SOUTHWEST RESIDENTIAL LANDSCAPES**

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Mature landscape plants at eight suburban residential home sites in the greater Phoenix metropolitan area, AZ USA, of similar upper middle class socioeconomic standing and age were chosen for study of carbon acquisition potential (CAP) and irrigation practices in relation to mesic and xeric landscape design type. An annual estimate of landscape plant CAP was made using a trapezoidal integration model of seasonal diurnal and monthly maximum carbon assimilation measurements of dominate woody trees, shrubs, and ground covers at four mesic and four xeric designed residential landscapes during

1998 and 1999. Xeric landscapes consisted of a mixture of 10 species of drip-irrigated trees, shrubs, and ground covers, no turf, and decorative decomposing granite surface mulch. Mesic landscapes consisted of a mixture of seven species of drip irrigated trees, shrubs, and ground covers with sprinkler irrigated turf, and had 2.6 times more canopy cover than xeric landscapes. Home residents controlled irrigation frequencies and durations. Rainfall during the study was 210-mm. Water meters recorded irrigation water volume at each landscape. The monthly amounts of water applied to mesic landscape were higher than the amounts applied to xeric landscape in April-July; otherwise, the amounts of water applied to landscapes of either design type were similar. Mean annual estimates of CAP were  $111.2 \pm 12.6$  and  $100.9 \pm 11.4$  mol/m<sup>2</sup>/yr for mesic and xeric landscapes, respectively. There was no significant relationship between CAP and irrigation volume for either landscape design type (mesic,  $P = 0.26$ ; xeric,  $P = 0.32$ ). Assimilation efficiency (Ae) was calculated as the ratio of CAP to irrigation water volume. There was a significant ( $P < 0.01$ ) negative relationship between Ae and irrigation water volume (mesic,  $r = -0.97$ ; xeric,  $r = -0.98$ ). These data suggest that CAP and homeowner irrigation practices may not be related to planting design in southwest upper middle class suburban neighborhoods.

1340-1440

S18-P-23

### INTERACTION OF DEICING-SALT SPRAY AND FREEZING STRESS ON SIX ORNAMENTAL TREE SPECIES

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In the Northern United States, deicing salts are applied in large quantities annually to provide safe driving conditions. Deicing of the roads and highways injures or kills many trees and shrubs each year. The costs of replacement and replanting trees are very high. Only selected ornamental trees exposed to deicing-salts are able to survive, and other plant materials are either injured severely or are killed. Selected ornamental trees, e.g., *Gleditsia triacanthos* (Thornless honeylocust) have shown greatly good tolerance to aerial salt during winter. The mechanism underlying survival of selected ornamental trees exposed to deicing salts and its relation with freezing stress is not entirely known. Understanding the mechanism of survival to aerial salt will result in more selection of ornamental plant use for roadside and highways, and will have an impact on nursery production and the landscape industry. Three species in the Fabaceae family: *Cercis canadensis* (Eastern Redbud), *Gleditsia triacanthos* (Thornless Honeylocust), *Cladrastis kentuckea* (American yellow wood) and three species in the Rosaceae family: *Malus sargentii* (Sargent Crabapple), *Malus hybrida* 'Indian magic' (Hybrid flowering crabapple) and *Pyrus calleryana* (Chanticleer Pear) were planted on October 1999 in a complete randomized block design with two salt (Berm) and no-salt (Warefield) exposed sites at the Morton Arboretum in two block and five replication of each plant species. Plants were tested for cold hardiness by artificial freezing test stems. Stem and bud tissue were also harvested for tissue analysis. The amount of dieback was measured in spring 2000 and 2001. Deicing salt has total significant effect on reducing the cold hardiness in Rosaceae family compared to Fabaceae family plants. Sodium (Na) level significantly was higher in Berm site. The results on the cold hardiness, dormancy, dieback and tissue analysis will be presented.

1340-1440

S18-P-24

### PHOTOSYNTHESIS AND GROWTH OF CAROLINA BUCKTHORN (*RHAMNUS CAROLINIANA* WALTER) DURING DROUGHT AND FLOODING: COMPARISONS TO THE INVASIVE COMMON BUCKTHORN (*RHAMNUS CATHARTICA* L.)

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Common buckthorn is a stress-resistant but undesirable Eurasian shrub naturalized in North America. We are examining whether one of its more attractive North American relatives, Carolina buckthorn, merits increased use in managed landscapes prone to variable and extreme soil moisture conditions. We first characterized photosynthesis and growth of Carolina buckthorns subjected to five soil moisture treatments that ranged from complete inundation of the root zone to

severe drought and then compared potted seedlings of Carolina buckthorn to those of common buckthorn for their responses to partial flooding and drought under greenhouse conditions. Multiple drought cycles were imposed; each was terminated when soil moisture content had decreased to 10 percent or less. The first experiment showed maximal photosynthetic rate of Carolina buckthorn occurred at approximately 27% soil moisture, and that death of Carolina buckthorns can result from root-zone inundation. We then found that mean photosynthetic rate of Carolina buckthorn exceeded that of common buckthorn by approximately 30% over soil moisture contents from about 5 to 55%. Carolina buckthorn resisted marked deleterious effects of partial flooding. In contrast, common buckthorn showed leaf epinasty and reduced rates of photosynthesis rapidly upon initial exposure to partial flooding, but long-term exposure led to recovery of photosynthesis and normal shoot development. We conclude that both species are capable of maintaining carbon fixation and growth over a wide range of soil moisture contents but common buckthorn appears to undergo morphological, anatomical, or physiological adjustments in extremely wet soil to optimize its growth and photosynthetic rate.

1340-1440

S18-P-25

### SCREENING EXOTIC FIRS FOR PH TOLERANCE

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In much of the Midwestern United States the selection of conifers for landscape plantings has largely been limited to Colorado blue spruce (*Picea pungens*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), Austrian pine (*Pinus nigra*) and Douglas-fir (*Pseudotsuga menziesii*). The increased use of true firs (*Abies* spp.) in the Christmas tree trade has raised interest in true firs for landscape plantings. Unfortunately, growth and survival of true firs are often limited by soil characteristics, especially high pH. The objective of this project is to determine the relative tolerance of several *Abies* species to varying pH. We planted bare-root seedlings of five fir species which are exotic to the upper Midwest; Veitch fir (*A. veitchii*), Boris fir (*Abies borisii-regis*), Subalpine fir (*A. lasiocarpa*), Siberian fir (*A. sibirica*), and Sakhalin fir (*A. sachalinensis*) in 3.8-liter pots in a peat-perlite mix. The seedlings were treated periodically with Liquid lime (calcium carbonate) to achieve five target pH levels from 3.0 to 6.2. To evaluate the effect of varying pH on the seedlings we measured variable chlorophyll fluorescence, needle chlorophyll concentration, and macro- and micro-nutrient concentrations. Increasing media pH significantly reduced variable chlorophyll fluorescence (Fv/Fm), and chlorophyll a and chlorophyll b concentration of all five species. Changes in chlorophyll concentration were significantly ( $P < 0.05$ ) correlated with depressed uptake of Manganese as pH increased. Species x pH interactions were nonsignificant, indicating that the species responded similarly to variation in pH. Implications for selecting exotic firs for landscape use will be discussed.

1340-1440

S18-P-26

### CHILL-INDUCED REACTIONS IN POPLAR

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The aim of this work was to study the behaviour of a poplar clone under chilling stress conditions. Greenhouse grown plants of *Populus tremulax* *Populus tremuloides* cv. Muhs 1, were submitted to chilling (4 °C) and control (23 °C) conditions during their active growth phase. Sampling was realised during 14 days. Leaves were weighed, sampled in liquid nitrogen and conserved at -80 °C for further analyses. The first step of the work consisted in observation of the effects of chilling on biochemical or physiological stress indicators, i.e., growth rate, chlorophyll fluorescence as well as chlorophyll content. Chlorophyll fluorescence indicated that the plants were stressed. Changes in carbohydrate metabolism were also observed. Increasing sucrose, fructose and glucose levels as well as enhanced sucrose metabolism in the plants subjected to chilling stress were recorded. The comparison of the proteome of leaves under both conditions revealed modifications in protein patterns in stressed plants. Further characterization of those proteins indicated that their appearance seemed to be induced by chilling stress. Molecular weight, isoelectric point, kinetics of appearance, speci-

ficity to chilling stress were determined. Immunological analysis will be performed by using antibodies against dehydrins of poplar (provided by Prs. Close and Wisniewski) and SP-1 (or stress-protein 1, provided by Pr. Altman).

**1340-1440**

**S18-P-27**

**GROWTH AND WINTERHARDINESS OF *THUYA OCCIDENTALIS* L. AND FIVE *THUYA* CULTIVARS IN NORTH-EASTERN CANADA**

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Two-year-old cuttings of *Thuja occidentalis* L. and five *Thuja* cultivars were planted in 1991 in eight sites corresponding to different northeastern Canadian climatic zones (2 to 5). Winter hardiness and annual growth were evaluated over a 5-year period. Survival and growth could be grouped in four categories. 'Holmstrup', 'Mastersii' and 'Lutescens' survival was similar to the species. However, growth of 'Holmstrup' and 'Lutescens' was slower than the species in zone 2a. High damage and branch die-back were observed in zone 4 and 5 for cultivar 'Holmstrup' and in zones 2 and 4 for cultivar 'Lutescens'. Therefore these cultivars cannot be recommended for these zones. 'Mastersii' showed a better growth in zone 2a than the other cultivars and performed well in extreme climatic zone. 'Cloth of Gold' was the most susceptible cultivar while 'Globosa Aurea' cultivar showed intermediate response.

**1340-1440**

**S18-P-28**

**CONSUMER PREFERENCES FOR TABLE-TOP CHRISTMAS TREES**

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Fresh-cut, live Christmas trees are a popular holiday home decoration. Previous research suggested that as consumers age, their positive perceptions about bringing a fresh-cut live Christmas tree into their home declines. Older consumers consider live trees difficult to bring in and out of the home. They also consider them to create more mess. We hypothesized that an evergreen species produced to fit in a smaller space might be marketable to consumers who view larger trees too difficult. Our objective was to investigate consumer preferences for hardy evergreen tree species (USDA Zone 5) grown for use on a dining room or kitchen table. We conducted a survey in Dec. 2001 of 300 Midwestern residents' preferences for table-top Christmas trees. A conjoint analysis of six tree species, combined with three forms of decoration (undecorated, red color theme, gold color theme) at three price points (\$14.95, \$19.95, and \$24.95) was conducted using a web-based survey for which participants were given a \$5 coupon. The conjoint model accounted for 91.4% of the variance, with 61% of the consumer's preference based on species, 27% based on decoration theme, and 12% based on price. Black Hills spruce was the most preferred species. Consumers preferred the red-theme decoration and the lowest price point. Differences by age and gender were also evident.

**1440-1500**

**S18-O-29**

**EVALUATING AND PROMOTING THE COSMOPOLITAN AND MULTIPURPOSE *LAGERSTROEMIA***

Raul I. Cabrera\*

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The woody ornamental *Lagerstroemia* has been in cultivation for centuries in its native SE Asia, particularly China, where it was favored for its lengthy and colorful flowering. The genus, and in particular, *L. indica*, was introduced to the western world (Europe) in the mid to late 17th, and it reached America in the latter part of the 18th century. The genus has pretty much naturalized in the southern US, becoming its most distinctive and popular flowering woody ornamental. This popularity is undoubtedly due to its wide assortment of inflorescence colors and a rather long flowering period (up to 120 days), along with a characteristic, and often exceptional, exfoliating bark character. Recent breeding programs in USA and Europe, based mostly on two species (*L. indica* and *L. fauriei*), have signifi-

cantly enhanced its range of sizes (from miniature 30 cm shrubs to +10 m tall trees), cold hardiness (Zone 6-10), disease resistance (powdery mildew) and foliage fall colors. Likely unknown to ornamental horticulturists are the commercial timber and medicinal uses of some species, out of about 80, in the *Lagerstroemia* genus. We have released an educational website that highlights its history, biology, taxonomy, uses, culture and management in the nursery and the landscape. The main feature of this site is a comprehensive searchable database with descriptions and pictures of the approximately 300 ornamental *Lagerstroemia* cultivars available in USA and abroad. Details on the database and website will be presented, along with a preview of our efforts in the establishment of an extensive *Lagerstroemia* cultivar collection at our institution, and other research projects on the physiology, culture and management of these plants.

**1500-1540**

**S18-O-30**

**ADAPTATION EVALUATED: CASE STUDIES OF UNDERUSED TREES AND SHRUBS**

William R. Graves

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Many promising woody plants have not been evaluated for their capacity to thrive in managed landscapes, where environmental conditions restrict diversity to a limited number of adapted taxa. My colleagues and I assess the horticultural potential of obscure or rare taxa native to habitats that require resistance to stressors common in managed landscapes. I will summarize our research with several taxa and then focus on our evaluation of *Alnus maritima* (Marsh.) Nutt. (seaside alder). This rare species occurs in only three small, disjunct provenances (part of the Delmarva Peninsula, one swamp in northwestern Georgia, and two counties in southern Oklahoma) in USDA hardiness zone 7. Plants in all provenances grow exclusively in saturated soils, and some individuals on the Delmarva Peninsula occur in estuaries and in wetlands near salt water. While its ecological niche indicates seaside alder would perform well in flood-prone managed landscapes where winters are relatively mild, we questioned how drought, low temperatures, and salt would affect the species and whether provenance differences in resistance to these stressors exist. Results under greenhouse and field conditions demonstrated drought tolerance; although gas exchange was affected, all leaves were sustained without apparent damage as plants recovered from water deficits that caused severe wilting. Twigs sampled at five-week intervals between late September and late April from plants of all provenances in native habitats and in a plantation near the border of USDA zones 4b and 5a were far more hardy than necessary for a species restricted to USDA zone 7. Field trials confirmed whole plants overwinter in Iowa and Minnesota. Resistance to root-zone salt was intermediate to that of other woody species and was similar among provenances. These data provide an example of how adaptation to multiple environmental stressors can be evaluated as part of a coordinated program to conserve and commercialize a rare species.

**1540-1600**

**S18-O-31**

**SELECTING TREES FOR IMPROVING DROUGHT TOLERANCE: THEORETICAL AND PRACTICAL CONSIDERATIONS**

Bert M. Cregg\*

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Selecting trees for improved drought tolerance has long been of interest for those involved in landscape horticulture and urban forestry. However, there are several pitfalls that need to be addressed in designing studies for selecting drought tolerant trees. Standardizing and quantifying the amount of drought to which trees are subjected is a major problem both in field studies and in pot studies. In field studies, variation in rainfall can limit the ability to apply a known amount of drought stress. In container studies, different growth rates among the genotypes can result in different levels of drought stress even at comparable levels of irrigation. In this paper, I discuss some of the theoretical and practical limitations of various drought-screening methods, and provide suggestions for methods that may be used to effectively identify trees with superior drought tolerance. I present examples of two techniques that have been effective in identifying variation in drought tolerance in seedling trees; stress-

bed drought screening and the target water potential concept. Both of these techniques may be useful for screening a relatively large number of genotypes for drought tolerance. A second major constraint for screening trees for drought tolerance is determining the appropriate response variables to measure. Researchers have had varying degrees of success using single point-in-time measurements such as osmotic potential or gas exchange in identifying drought adapted genotypes. I present examples of the application of carbon isotope discrimination as an integrated measure of water use efficiency in studying genotypes of *Pinus sylvestris*, *P. ponderosa* and other conifers. I also discuss theoretical and practical limitations of using carbon isotope discrimination to identify drought-adapted genotypes.

1600-1620

S18-O-32

#### WATER RELATIONS AND GAS EXCHANGE OF RED MAPLE CULTIVARS (*ACER RUBRUM* L.) UNDER WATER DEFICIT STRESS

Mark Reaves\*, Thomas Whitlow, Jonathan Comstock

Room 25, Dept. of Horticulture, Plant Science Building, Cornell, Ithaca, NY, US, 14850

Species occurring over wide geographic ranges or differing habitats within a limited range may exhibit genotypic variation as a method of responding to environmental conditions. Red maple (*Acer rubrum* L.) is a broad range species indigenous to the eastern US, occurring over a multitude of soil moisture conditions. Recent research suggests genotypic variation exists between populations of *A. rubrum* collected at mesic and xeric locations with regards to drought response. Red maple is an important commercial crop commonly planted in areas of frequent drought. We believe that the range of drought tolerance currently found in commercial cultivars may not represent the full range of drought tolerance existing within the species. The long-term objective of this study is to use existing genotypic variation within the species to develop a cultivar of *A. rubrum* that will be better adapted to drought stress conditions. Current objectives focus on the physiological responses of red maple exposed to drought stress. Plant growth, gas exchange, and water relations of six commercially sold maple cultivars and two naturally occurring *A. rubrum* ecotypes were measured under drought conditions. Three *Acer rubrum* cultivars: 'October Glory', 'Autumn Flame', 'Northwood'; three *Acer x Freemanii* (*A. rubrum* x *A. saccharinum*) cultivars 'Morgan', 'Scarlet Sentinel', 'Armstrong'; and two naturally occurring ecotypes representing hydrological extremes were evaluated. All genotypes exhibited reduced stomatal conductance, photosynthetic rates, and water potential. The commercial cultivar with the largest reduction in photosynthesis relative to controls was 'Armstrong' (93% reduction), while the least was 'Northwood' (9.5% reduction). The native wet site ecotype exhibited the highest reduction in photosynthesis (97% reduction, vs. control) while the dry site ecotype had a 23% reduction. Freeman hybrids exhibited higher reductions in drought than red maples.

1620-1640

S18-O-32-A

TO BE ANNOUNCED

1640-1700

S18-O-32-B

TO BE ANNOUNCED

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### Thursday · August 15

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1100-1120

S18-O-33

#### ECOPHYSIOLOGY, PHENOLOGY, AND DEPTH OF COLD ACCLIMATION IN THE THREE SUBSPECIES OF *ALNUS MARITIMA*

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*Alnus maritima* (seaside alder) is a woody plant with strong potential for

use in managed landscapes. Because the natural distribution of the three subspecies of *A. maritima* is limited to areas with mild winter temperatures (USDA hardiness zones 7a and 7b), knowledge of cold acclimation and cold hardiness of these taxa is vital. Lab assessments of cold hardiness were performed by collecting stem samples seven times from Sept. 25, 2000, to April 23, 2001, subjecting the samples to cold-temperature ramping, and measuring the lowest survival temperature (LST) according to the tissue discoloration method. Samples were collected from indigenous plants of the three subspecies and from plants growing in a common garden near the border of USDA zones 4 and 5 in Ames, Iowa. Results indicate that plants of all three subspecies can survive mid-winter extremes as low as  $-80^{\circ}\text{C}$  (7 of 30 plants); that plants grown in Ames acclimated better, reached a greater depth of mid-winter hardiness, and were more uniform in cold hardiness than plants growing in warmer native sites; and that the three subspecies did not differ in cold hardiness. Results of field trials with plots of 150 plants each installed in three northern hardiness zones (USDA zones 5a, 4a, and 3a) supported these conclusions, showing survival of all 450 plants on the three sites. By rating the percentage of tissue survival for each plant, we resolved differences between subspecies. Subspecies *maritima*, from the northernmost provenance (the Delmarva Peninsula), showed the least tissue death across all three plots (4% tissue death), followed by subsp. *georgiensis* from northwestern Georgia (10% tissue death), and then subsp. *oklahomensis* from southern Oklahoma (13% tissue death). Our results suggest that cold-temperature stress should not limit the use of *Alnus maritima* in areas as harsh as USDA zone 3a. Selections based on cold hardiness may allow the use of *A. maritima* in areas with even colder winters.

1120-1140

S18-O-34

#### SALINITY TOLERANCE OF SOUTHWESTERN PLANT SPECIES

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Water is a precious and limited resource in the arid Southwest. One strategy to stretch the finite ground water resources is reusing or recycling used water or gray water for ornamental plant production or maintenance of plants in the landscape. The objective of this study is to determine salinity tolerance of plants common to landscapes in the Southwest. Three species of trees (*Acacia stenophylla*, *Cercidium floridum*, and *Chilopsis linearis*), shrubs (*Calliandra californica*, *Leucophyllum laevigatum*, and *Tecoma stans*), groundcovers (*Lantana* 'New Gold', *Verbena rigida*, and *Hymenoxis acaulis*) and accent plants (*Muhlenbergia rigens*, *Dasyliiron wheeleri*, and *Nolina microcarpa*) were used in the study. Plants were grown for 16 weeks in sand and were irrigated with a fertilizer solution containing 50 ppm N (control). The control solution was supplemented with calcium chloride and sodium chloride (1:3 ratio) to reach 2.5, 5.0 or 10.0 dS/m. The onset of injury symptoms under the four treatments varied by species. Irrigation with 10.0 dS/m solution resulted in the death or complete defoliation of all species except *A. stenophylla*, *C. floridum*, *L. laevigatum*. Leaf tips of *N. microcarpa* were dried and growth was stunted. Irrigation with 5.0 dS/m solution did not affect growth of the three species above and *C. californica*. This treatment was lethal to *H. acaulis* and *V. rigida*, and resulted in severe foliar drop or injury of all other species. Salinity of 2.5 dS/m resulted in light to medium foliar injury or stunted growth of all species except *A. stenophylla*, *C. floridum*, *L. laevigatum*, and *C. californica*. Plants irrigated with the control solution grew well and appeared healthy with the exception of *D. wheeleri*, which may not tolerate the high moisture conditions in this experiment.

1140-1200

S18-O-35

#### EVALUATION OF NEW ELMS FROM CHINA FOR COLD HARDINESS IN NORTHERN LATITUDES

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The high resistance of elms from China to Dutch elm disease and other elm problems makes them excellent trees for the urban landscape. There are many new Chinese elm species and hybrids being developed through the tree-breeding program at The Morton Arboretum. Several new elms are already on the market or will be available soon from nurseries. There is little known about the stress tolerance, e.g., cold, heat, drought, etc., of these new elms. The stem



cold hardiness of nine new elms from different provenance of China were evaluated in February 1998–99 from the elm breeding program at The Morton Arboretum by using artificial freezing test. The LT<sub>50</sub> (the temperature at which 50% of the tissues were killed) of the most to least hardy genera for February 1998 were *Ulmus macrocarpa* (>–36 °C), *U. wilsoniana* # 673 (–34 °C), *U. parvifolia* (–34 °C), *U. wilsoniana* # 669 (–34 °C), *U. wilsoniana* # 997 (–34 °C), *U. szechuanica* (–30 °C), *U. gaussenii* (–31 °C), *U. bergmannianavar. lasiophylla* (–28 °C), *U. castaneifolia* (–26 °C). In a companion study, selected elms from tree breeding programs from Schmidt Nursery, Oregon USA, were planted in a nursery at The Morton Arboretum in 1998–2000. The LT<sub>50</sub> of new elm cultivars were: *U. 'Morton' Accolade™* Elm (–35.5 °C), *U. 'Morton Red Tip'–Danada Charm™* Elm (–31 °C), *U. 'Morton Plainsman' Vangurd™* Elm (–40 °C), *U. 'Morton Glossy'–Triumph™* Elm (–40 °C), *U. 'Stalwart' Commendation™* Elm (–40°C), *U. 'Patriot' (–38.25 °C), U. parvifolia "AthenaR Elm (–23.5 °C), and U. parvifolia Alleer (–26.5 °C). Data on Dormanc, growth and performance will be presented.*

**1200–1220**

**S18–0–36**

**RESISTANCE OF ROSE CULTIVARS TO CROWN GALL DISEASE ARE RELATED TO THE QUANTITY OF ACETOSYRINGONE DERIVATIVES EXUDATES**

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Acetosyringone derivatives secreted by wounded plant cells induce activities of vir genes in *Agrobacterium tumefaciens*, ultimately causing tumorigenesis in the plant. This is what is widely known as crown gall disease. It is reported that there are differences among rose cultivar resistance to crown gall disease, but the mechanism of resistance remains unclear. To investigate the relationship between acetosyringone derivatives secretion and resistance, we developed a system for separation of 13 acetosyringone derivatives by HPLC, and investigated wounded cells' exudates of resistant and susceptible cultivars. Two resistant cultivars, PEKcougel and Lifirane, and 3 susceptible cultivars, Dukat, *Rosa multiflora* and *Rosa canina* were used. The 13 acetosyringone derivatives separated well under methanol 10% (0 min), 16% (40 min), 30% (60 min) gradients conditions, on the ODS column. Exudates from leaf disks of the 5 cultivars were extracted using chloroform, and the extractions were separated under the HPLC gradient conditions. Resistant cultivars secreted less acetosyringone derivatives than the susceptible cultivars, in terms of quantity and type. Thus it is concluded that at least part of the resistance mechanism of crown gall disease is related to acetosyringone derivatives exudation.

**1220–1240**

**S18–0–37**

**MORPHOLOGICAL CHARACTERIZATION AND EVALUATION OF THE PRODUCTIVITY OF NINE ROOTSTOCK OF ROSEBUSH (*ROSA* SP.)**

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In Brazil, garden and cut rosebushes are propagated by cuttings or grafting. Locally available rootstocks have been commonly used but little is known about their impact on plant vigor or overall scion performance. The objective of this work was to characterize and to evaluate the capacity of production of nine rootstocks (*Rosa multiflora* 'Paulista'; *Rosa multiflora* 'Japoneses'; *Rosa multiflora* 'Iowa'; *Rosa multiflora* 'Kopmans'; *Rosa indica* 'Mayor'; *Rosa indica x multiflora*; *Rosa* sp. 'Natal Brier'; *Rosa manetti*; *Rosa canina* 'Inermis') grafted with 'Versilia' and 'Tineke'. The experimental design was a factorial randomized design with 9 treatments, with 4 replicates and 10 plants per replicate. The productivity (number of commercial flowers/month/plant) was evaluated for 12 months (Oct. 2000 to Sept. 2001) in Andradas City, Minas Gerais State, Brazil, localized of 1251 meter above the level of the sea. Morphological observations were recorded on shape, size and number of leaves, number of thorn/15 cm of stem, plant vigor, incidence of *Diplocarpon rosae* and stem and leaf color. Based on the results, best rootstocks for 'Tineke' are *R. multiflora* 'Japoneses'; *R. multiflora* 'Iowa'; *R. multiflora* 'Kopmans'; *Rosa* sp. 'Natal Brier' and *R. manetti*; and for 'Versilia' recommended rootstocks are *R. multiflora* 'Paulista'; *R. multiflora* 'Japoneses'; *R. multiflora* 'Kopmans'; *Rosa* sp. 'Natal Brier' and *R. manetti*.

**1340–1440**

**S18–P–38**

**MANAGING NITROGEN ADDITIONS AND ASSESSING WATER QUALITY UNDER THE ROOT ZONE IN FIELD NURSERY PRODUCTION OF *TAXUS* AND *EUONYMUS***

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Michigan's landscape nursery industry is the fifth largest in the United States. Due to the moderate climate near Lake Michigan, nurseries are concentrated in the western part of the state. Soils in this area are coarse and sandy, which may lead to high leaching of nitrates and contamination of ground water. Incidence of nitrate leaching in nursery field plantations caused by fertilizer application in this region has not been investigated. The objectives of this study are to evaluate the impact of nitrogen fertilization approaches on crop growth and nitrate concentration of water under the root zone, and to determine the validity and logistics of applying relative addition rate principles to nursery crops. We established the study in collaboration with two major nurseries in western Michigan. At each nursery there are two fields, one growing *Taxus xmedia* and the other *Euonymus alatus* 'Compactus'. The fertilizer treatments were: 1) control (no fertilizer); 2) operational fertilization (based on the nurseries' current practices); and 3) relative addition rate (additions based on crop growth). Soil water below the root zone was collected after every significant rainfall event using porous cup lysimeters and the samples were analyzed for nitrates. Soil water nitrate concentrations varied seasonally and among treatments. Mean nitrate concentrations ranged from less than 7 ppm prior to fertilization to over 70 ppm on fertilized plots in mid-June. Foliar nitrogen levels varied between taxa and treatments. Fertilization did not affect plant growth. Implications of the results for nursery management will be discussed.

**1340–1440**

**S18–P–39**

**TREE PRODUCTION UTILIZING POT-IN-POT TECHNIQUES**

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The Colorado Nursery Industry is interested in growing larger trees in a shorter period of time, to become more competitive. In the spring of 2001, a study was initiated to assess the use of Pot-in-Pot (PIP) growing systems. Two different experiments are being conducted; a water/fertility study in PIP, and a systems study, a comparison of several modified PIP systems. Both experiments are being evaluated at two sites in Colorado. Trees used in these experiments, *Betula occidentalis* and *Alnus tenuifolia*, were transplanted from #5 containers into #20 commercial PIP containers and transported to the respective sites. All trees were planted and are being grown using the same media, irrigation practices and fertilization rates. Trees used in the water/fertility study were separated out and half received 2x (twice the recommended) rate of water and fertilizer. Conventional, in ground PIP system was used in this experiment. Trees used in the systems study were placed both in the ground and above ground in conventional and modified PIP pots. Growth measurements (caliper, height, width, and shoot length) were taken at the beginning of the experiment and at the end of the 2001 growing season. Media temperatures were periodically recorded and soil and water tests were conducted throughout the experiment.

**1340–1440**

**S18–P–40**

**CONTAINER NURSERY STOCK RESPONSE TO RECIRCULATED NUTRIENTS**

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Recirculating nutrient runoff saves considerable water and fertilizer but there is little information on container nursery stock response under this regime. Liners of *Deutzia gracilis* Sieb. & Zucc., *Cornus alba* L. 'Argenteo-marginata', *Spiraea xbumalda* Burvenich 'Anthony Waterer' and *Symphoricarpos albus* (L.) Blake were grown for one season in 6-L containers filled with pine bark and

municipal waste compost (1:1 v/v). One-year-old *Euonymus fortunei* (Turcz.) Hand.-Mazz. 'Emerald Gaiety' and *Juniperus sabina* L. grown the previous season under similar conditions were also included. Plants were fertigated via a computer-controlled multifertilizer injector, with or without nutrient recirculation, programmed to deliver 100, 13, 28 and 120 mg/L  $\text{NO}_3\text{-N}$ ,  $\text{NH}_4\text{-N}$ , P and K, respectively, plus Ca, Mg and micronutrients. For comparison, Nutryon 17-5-12 plus micronutrients controlled release fertilizer (nutrients non-recirculated) was incorporated into the growing substrate (6.5 kg/m<sup>3</sup>, liners) or top dressed (39 g/container, one-year-old). With few exceptions, top growth of plants was similar between the recirculated and non-recirculated nutrients, and greater than with controlled release fertilizer. Electrical conductivity (EC) and pH measured in the growing substrate (2:1 v/v water:substrate extracts) of all species over three dates tended to be similar with and without nutrient recirculation. With controlled release fertilizer EC and pH was comparably higher and lower, respectively.

#### 1340-1440

##### S18-P-41

#### MINERAL NUTRITION OF *TAXUS BACCATA* L. AS AFFECTED BY INOCULATION WITH ARBUSCULAR MYCORRHIZAL FUNGI

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The influence of the inoculation with arbuscular mycorrhizal (AM) fungi on the nutrition of yew was investigated in a growth chamber experiment. Terminal cuttings from one topiary yew and an unshaped yew were taken and inserted in a rooting bed of sterilised sand under intermittent mist in a glasshouse. Well-rooted cuttings were transferred to 1 L polyethylene bags filled with sterilised peat, under the following treatments (6 bags treatments): control, inoculation with *Acaulospora scrobiculata*, and inoculation with *Glomus deserticola*. Nine months after cuttings transplantation, shoots were removed and dried and P, K, Ca, Mg, Fe and Cu concentrations and uptake were determined. The inoculation with either *Glomus deserticola* or *Acaulospora scrobiculata* increased P, K, Ca, Mg and Zn concentration in the unshaped yew, corresponding with an increased uptake of all these nutrients by the plant. For the topiary yew, the inoculation with *Glomus deserticola* enhanced only P and Mg nutrition, but the uptake of the other nutrients was not affected.

#### 1340-1440

##### S18-P-42

#### ULTRASTRUCTURE OF NODULES FROM *ALNUS MARITIMA*

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*Alnus maritima* (Marsh.) Muhl. ex Nutt (seaside alder) is an attractive woody perennial, is the only North American alder that flowers in autumn, and is considered threatened in its three small, disjunct natural habitats. An understanding of the conditions that foster or limit growth of seaside alder is crucial to its use and, perhaps, to its existence. Establishment of effective symbioses between *Alnus* and *Frankia* bacteria is sensitive to the concentration of oxygen in the root zone. *A. maritima*, in contrast to other alders, is an obligate inhabitant of flooded soils. Our hypothesis is that low oxygen in flooded soils of seaside alder affects nodule structure and function and may be essential to symbiotic compatibility. The objective of this work was to describe the morphology and ultrastructure of nodules from indigenous plants as a first step in testing our hypothesis. Roots of *A. maritima* were excavated from saturated, sandy soils of Sussex County, Delaware. Nodules were excised from the roots and processed for both microscopy and for retrieval of viable *Frankia* inoculum. The nodules are coralloid structures from 1–4 cm in diameter and comprised of one to multiple nodule lobes. Each lobe is discreet in the smaller and younger nodules, but the cortical tissues of individual nodules merge as the nodules grow and age. Areas of *Frankia*-infected tissue surround the vascular cylinder, which grows out from and is continuous with the vascular bundle of the plant root. Large air spaces are interspersed throughout the nodule cortex. The ultrastructure of nodules from *A. maritima* has never been described, and retrieval of viable inoculum will facilitate further work on oxygen relations in the *Frankia*-*A. maritima* symbiosis.

#### 1340-1440

##### S18-P-43

#### FATE OF AMMONIUM AND NITRATE NITROGEN IN ACID PH AND NEAR NEUTRAL PH MEDIA

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Since the establishment of the Clean Water Act in 1972, there has been increasing concerns regarding nitrate ( $\text{NO}_3$ ) runoff from agricultural areas. Based on regulations governed by the EPA, nurseries must reduce or eliminate the runoff of  $\text{NO}_3$ . In order to accomplish this, the nitrogen needs of containerized woody ornamentals must be elucidated – determining the amount, timing and form of nitrogen [ammonium ( $\text{NH}_4$ ) and  $\text{NO}_3$ ] required during the entire production process of the plant. Fertilization programs must be refined so that at any given time during the development of a plant, only sufficient levels of nitrogen are available in the medium for plant uptake, thus minimizing nitrogen runoff. In the following study containers of either acid or neutral pH media were fertilized with either  $\text{NH}_4\text{-N}$  as  $(\text{NH}_4)_2\text{SO}_4$  or  $\text{NO}_3\text{-N}$  as  $\text{KNO}_3$ . During the course of 11 months, leachates were collected weekly and media were harvested monthly. Leachates were analyzed for EC, pH,  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$ . Media were analyzed for KCL-extractable  $\text{NO}_3\text{-N}$  and  $\text{NH}_4\text{-N}$ , total N, EC and pH. With these data the characterization of nitrogen cycling in media will be described. With the information gained in these studies, improvements may be made for the formulation of fertilizers and fertilization programs to maximize nitrogen uptake efficiency and minimize  $\text{NO}_3$  leaching from different planting media.

#### 1340-1440

##### S18-P-44

#### EFFECT OF SOLUBLE AND SLOW-RELEASE FERTILIZERS AND FROST PROTECTION ON THE GROWTH AND OVERWINTERING OF *CHAMAECYPARIS LAWSONIANA* AND *JUNIPERUS MEDIA* IN CONTAINER NURSERY

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*Chamaecyparis lawsoniana* 'Blue Surprise' and *Juniperus media* 'Pfitzeriana compacta' were transplanted from 0.5 dm<sup>3</sup> to 3 dm<sup>3</sup> in spring, summer or autumn and grown until the end of next season (3 replications in time). In spring planting the growing medium was amended with water-soluble complete fertilizer 2.5 g·dm<sup>-3</sup> and plants were top-dressed with the same fertilizer. Alternatively, Osmocote Plus 5/6M-4 g·dm<sup>-3</sup> was dibbled into the pots and plants did not receive any additional nutrition or they were irrigated with nutrient solution. In summer and autumn planting times the growing medium was enriched with a small dose of dry fertilizer (0.5 g·dm<sup>-3</sup>) and plants were top dressed next season, or alternatively Osmocote Plus 12/14M was added in rates of 3 or 5 g·dm<sup>-3</sup> without supplemental nutrition. Plants were left for winter without frost protection or they were covered with straw or by 60-cm high white plastic tunnel. Supplemental feeding of spring planted plants improved the growth, but increased their frost damage during the winter. Summer planted plants started to grow the same year and the growth was more intensive, when they were fertilized with Osmocote Plus 12/14M, especially in a higher rate of 5 g·dm<sup>-3</sup>. Plants planted in autumn did not increase their size, but the activation of growth could be observed – mainly when they were fertilized with Osmocote. Overwintering of *Juniperus* planted in summer and autumn without frost protection was good, when plants received the small dose of dry fertilizer but worse when the slow-release fertilizer was used, especially in higher rate. *Chamaecyparis* without frost protection did not survive the winter. The best frost protection was plastic tunnel, but even in this case the plant damage was observed, when they were fertilized with Osmocote. The lowest outside temperature was -23 °C.

#### 1340-1440

##### S18-P-45

#### IMPROVING HERBACEOUS PERENNIAL PRODUCTION ON THE CANADIAN PRAIRIES

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Saskatchewan-grown perennials are typically greenhouse-produced, either from seed or from cuttings. These perennials are produced for sale in the current or early next season and are typically small and not able to capture 'top' dollar. In order to supply larger plants, many growers rely on out-of-province supply of bare-root, rooted cuttings or large seedlings ready for potting up and growing on from February to April, a time when energy needs and costs are high. Over the last three years (1999–2001), we evaluated herbaceous perennial plant productivity using woody ornamental container production management under outdoor container-field conditions. A number of important recommendations were developed. 1) Perennials should be potted into their final container size when they are received. Overwintering container size (32-cell plug, 10-cm or 2.73-L) had a positive linear effect on final plant size, despite being potted into a common container size (2.73-L) following storage. Plugs planted in May in progressively larger containers from 55 JDeep to 5.6-L also resulted in progressively larger plants by the end of the season. 2) Bulk coarse peat is as good or better than commercial soilless medium for 2.73-L container production. The standard woody ornamental media used by our cooperators also performed well. 3) Organic mulch (wild rice hulls) used to control weeds in containers provided season-long control and outperformed the three pre-emergence herbicides evaluated. 4) Low to moderate fertilizer levels (0.6–1.2 kg N/m<sup>3</sup>) are sufficient to produce high quality herbaceous perennials. Higher levels lead did not translate to an equal increase in growth. 5) Non-encapsulated-controlled release fertilizer (neCRF) produced larger plants than encapsulated-CRF (eCRF) under prairie conditions. A temperature-dependent fertilizer release rate does not favour improved growth under prairie spring growing conditions, giving a neCRF an advantage over an eCRF.

1340–1440

S18–P–46

#### OVERWINTERING HERBACEOUS PERENNIALS ON THE CANADIAN PRAIRIES

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One problem that growers encounter with a multi-year production cycle on the prairies is the need to provide winter protection. Being in containers, otherwise hardy perennials do not have the benefit of a fully protected root zone and most roots will be killed or damaged at relatively high temperatures (>–10 °C). This study, conducted over two winters (1999–2000 and 2000–01), evaluated the effect of container size on the survival of herbaceous perennials overwintered at two commercial nurseries using their standard overwintering structures for woody ornamentals. Plugs were obtained in mid September, potted up into their treatment container size (32-cell plug, 10-cm square or 2.73-L container), grown on in an unheated hoop house and then transferred for overwintering in November. Plants were removed from storage in April, assessed for survival and potted up into a common container size (2.73-L). Growth was evaluated in June. We were able to draw a number of conclusions from our results: 1) Container size does not affect mortality. 2) Container size affects plant size: in general, plants grown in large containers are larger than those grown in small containers. The benefits of starting a plant in a finished container size eliminates the labour required to transplant from a smaller to a larger container, reduces the chance that plants will become rootbound and reduces the loss of growth potential due to transplant shock. 3) Plug-grown perennials acquired in the early fall may be planted in their final container size to maximize growth potential. Some species or individual specimens may be large enough for mid- to late-spring sales. Furthermore, planting in the fall relieves labour pressure during the typically busy spring period and growers are able to take advantage of lower plant costs available in the fall. Fall planting presupposes that growers have adequate storage facilities.

1340–1440

S18–P–47

#### MACRO AND MICRONUTRIENTS CONTENTS IN PEACH PALM (*BACTRIS GASIPAES* KUNTH) AS A FUNCTION OF LEAF ONTOGENY

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Macro and micronutrients contents were evaluated in peach palm (*Bactris gasipaes* Kunth) leaves in different ontogenetic stages from two year-old palms. The plants were grown outdoors in individual 80-L containers filled with a mixture of soil, sand and cow manure (1:1:1, in volume). The containers were evenly spaced (2 x 1 m) to avoid intershading. Prior to collection, leaf chlorophyll content (Minolta Spad-Meter) and gas exchange rates (ADC Infrared Gas Analyzer LCA-4) were evaluated in every leaf from three plants. Leaflets collected from the middle portion of leaves composed the samples for mineral analysis. Foliar analysis were performed by conventional methods and expressed in total content. N digestion was performed by Kjeldahl procedure and distillation. Other minerals analysis were determined by dry ashing, dissolution in HCl solution and evaluated by spectrophotometry (P, B), flame photometry (K), and ICP (Ion coupled plasma) (Ca, Mg, Cu, Fe, Mn and Zn). The results showed that nitrogen, phosphorus and potassium contents decreased progressively with leaf age. Calcium, magnesium and sulfur, secondary macronutrients, showed an increase with leaf age. The same was observed for manganese and sodium, although maximum content has been found in +3 leaf for the latter. There was a decrease in iron, zinc and boron with leaf age. Photosynthetic rates and chlorophyll contents also varied among leaves, with maximum values obtained for +2 and +3 leaves, with a sharp decline afterwards coupled with leaf senescence. (Research partially sponsored by FAPESP–project 00/02782-6).

1440–1500

S18–O–48

#### SUSCEPTIBILITY OF *PINUS LEUCODERMIS* AND *PINUS KORAIENSIS* TO *DOTHISTROMA PINI* HULBARY

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The conifer palette in the Midwestern United States has become limited by the combined pressures of climatic conditions, pests, and pathogens. Although not common in the Midwest, both *Pinus leucodermis* and *Pinus koraiensis* appear to have potential for landscape use in the region. However, their susceptibility to pathogen pressures common in the Midwest is unknown. *D. pini* H. is one pathogen that affects many conifers by infecting needles and causing defoliation. *Dothistroma* is a worldwide concern in both natural settings and managed landscapes. This study was designed to evaluate the susceptibility of *Pinus leucodermis* and *Pinus koraiensis* to *Dothistroma pini* H. compared to susceptibility of *Pinus nigra* (known to be highly susceptible). Our research objectives were to determine if the experimental taxa were susceptible to *Dothistroma* based on percent of infection and severity of infection, and to evaluate their physiological response to the pathogen based on gas exchange measurements and root carbohydrate analysis. Three replications of five trees per species were inoculated with 20 mL of *Dothistroma* conidia at a concentration of 6 x 10<sup>6</sup> conidia/mL. Control trees were treated with deionized water. The trees were then placed in opaque bags and placed in growth chambers for 24 hours at 24/16 C. Trees were kept in a greenhouse and monitored twice weekly for 90 days to document symptoms of disease development. Gas exchange measurements were taken at days 45 and 90 using a Li-Cor 6400 with a conifer chamber. Experimental taxa were susceptible to *Dothistroma pini* Hulbary.

1500–1540

S18–O–49

#### A CLOSED SYSTEM WITH LAMPS FOR COMMERCIAL PRODUCTION OF TRANSPLANTS USING MINIMUM RESOURCES

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We developed a closed system for commercial production of value-added plug transplants, which consists of a structure covered with thermally insulated opaque walls, multi-layered shelves with fluorescent lamps, home-use air conditioners, and supply units of CO<sub>2</sub> and nutrient solution. Ventilation and heat transmission through walls were strictly restricted to minimize annual cooling and heating loads, amounts of water for irrigation and CO<sub>2</sub> for promoting photosynthesis, insects/pathogens entering into the system, and to keep the environment inside the system optimally. The closed system was also designed to minimize the release of water containing fertilizers to the outside. Electric energy consumption per transplant was 0.7 MJ (0.2 kWh) and its electricity

cost was lower than 3 Japanese Yen when tomato transplants with 2–3 true leaves were produced in 128-cell plug trays, which market price was considered to be 25–30 Japanese Yen. Percentages of electric energy consumption for lighting, cooling, heating and others over total electric energy consumption were about 80, 17, 0 and 3%, respectively, on the annual average. About 95% of evapotranspired water vapor from plug trays was collected as liquid water at the cooling coils of air conditioners for recycling use of the water for irrigation. About 95% of liquid CO<sub>2</sub> supplied to the system was fixed as dry matter by transplants. Transplant production period was shortened to 17 days, compared with 20–40 days in greenhouses. Similar results were obtained for eggplant, sweet potato and Chinese cabbage transplants. In general, with use of the closed system, the growth development, vigorousness and their uniformity of transplants could be controlled accurately. As for the commercial transplant production of some horticultural crops, the closed system is economically competitive over the greenhouse, can produce higher quality transplants using less water, agrochemicals, CO<sub>2</sub> and labor than the greenhouse, bringing about less environmental pollution.

**1540–1600**

**S18–0–50**

**THE DEVELOPMENT OF AN IN-VITRO WEANING SYSTEM FOR *GARRYA XISSAQUAHENSIS* “GLASNEVIN WINE”**

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“Glasnevin Wine” is a hybrid of commercial value to the hardy nursery stock industry, prized for its extensive catkins. The hybrid can be micropropagated quite easily but ex-vitro establishment has proven very difficult. In-vitro rooted plants failed to establish under a standard dry fog system. The leaf and stem tissues consistently collapsed due to stomata remaining open. An alternative system was therefore developed in which the rooting plants were covered with a range of transparent plastic membranes with varying porosities. Under certain membranes, scanning electron micrographs of the developing leaves showed stomata in a wide range of positions from fully opened to closed. Leaves forming under other membranes showed all stomata remaining open. There was a direct correlation between water loss and membrane cover which matched the membrane classification. Plants which had been weaned under membranes with a water vapour transmission rate (wvtr) greater than 300 established well ex-vitro. Plants weaned at between 200–300 (wvtr) established poorly while those weaned below 200 (wvtr) failed. Currently the membrane with a water vapour transmission rate of 440 is being used to establish the plants ex-vitro.

**1600–1620**

**S18–0–51**

**MICROPROPAGATION OF *RHODODENDRON UWAENSE*, AN ENDEMIC AND RED-DATA (ENDANGERED/RARE) SPECIES IN JAPAN WITH COMMERCIAL PRODUCTION POTENTIAL**

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*Rhododendron uwaense* is a quite new species to horticulturists. This species was named very recently and has a narrow distribution only in one small valley in Shikoku, Japan. This plant has excellent fragrance and attractive purple flowers. The population size is very small and endangered. Earlier trials largely proved that this is a difficult plant to propagate by tissue culture techniques. Tissue culture experiments were conducted to aid quick mass propagation. Regeneration efficiency was improved by 45% on the 1/2 MS medium supplemented with 0.1 mg/L of NAA and 0.2 mg/L of 2-iP with young leaf cultures. The results will assist further work for not only mass production of nursery stocks but also conservation of this species in the native forest.

**1620–1640**

**S18–0–51–A**

**TO BE ANNOUNCED**

**1640–1700**

**S18–0–51–B**

**TO BE ANNOUNCED**

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**Friday · August 16**

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**0800–0900**

**S18–P–52**

***ACER SACCHARUM* ‘CADD0’ TREES DIFFER IN ROOTING POTENTIAL**

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Green softwood stem cuttings were taken from nine adult sugar maples (*Acer saccharum* Marshall) in Stillwater, Okla., chosen for superior horticultural traits including lack of leaf tatter and scorch during drought conditions. The cuttings were treated with 2.5 grams per liter IBA, 5 grams per liter IBA, 2.5 grams per liter NAA, 5 grams per liter NAA, 2.5 grams per liter IBA + 2.5 grams per liter NAA, 5 grams per liter IBA + 5 grams per liter NAA, 0 grams per liter IBA + 0 grams per liter NAA (alcohol control). Cuttings were evaluated after about seven weeks for number and length of roots. Rooting response varied by tree and there were significant differences among auxin treatments. Trees with greater rooting percentages tended to have the highest number of roots per rooted cutting and the longest roots. Seventy-five percent of cuttings from Tree 1 rooted when treated with 2.5 g·L<sup>-1</sup> IBA + 2.5 g·L<sup>-1</sup> NAA. Eighty percent of cuttings from Tree 9 rooted when treated with 5 g·L<sup>-1</sup> IBA. Tree 7 cuttings rooted well regardless of hormone treatment, with 48% rooting overall and 54% rooting when auxin was greater than 0 g·L<sup>-1</sup>. Cuttings from Tree 8 did not root. Chemical names used: indolebutyric acid (IBA), naphthalene acetic acid (NAA).

**0800–0900**

**S18–P–53**

**PHYSIOLOGICAL AND MOLECULAR CHARACTERISATION OF ROOT INDUCTION EVENTS IN A MODEL WOODY PLANT**

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Vegetative propagation by cuttings is the backbone of commercial Hardy Nursery Stock (HNS) production, and in the UK there are more than 250 million cuttings prepared annually. Rooting of these cuttings can be a limiting step that impacts on prediction and scheduling of crop production even in species that root quite readily. This predictability, and the quality of root formation is especially important in seasonally restricted and difficult-to-root species. To maximise predictability of rooting it is necessary to understand the associated physiological and molecular processes and the factors that influence success. In this study, the easy-to-root woody plant *Forsythia xintermedia* cv. Lynwood was used to investigate the correlation between tissue auxin content and rooting response, the mode of auxin transport and the relative gene expression patterns during root induction by auxin treatment. Rooting of in vitro internodes of *Forsythia* is auxin-dependent. When IBA is applied to the apex of the internode, it is transported by chemiosmotic diffusion and stimulates rooting at the base. However, experiments with [<sup>14</sup>C] IBA show that IBA is not transported as rapidly as IAA. Approximately 97% of the [<sup>14</sup>C] label remained in the apical position after six hours. This indicates that apically applied IBA indirectly affects biochemical conditions at the base, for example through stimulation of IAA transport or production. In a parallel study, tissue from internodes cultured under rooting permissive and non-permissive conditions for 0 to 48 hours was analysed for gene expression by differential display reverse transcription PCR (DDRT-PCR). The resulting differentially expressed cDNAs could be grouped into auxin-induced expression, modulated auxin-induced expression and wounding related expression. Most of the corresponding mRNAs that were induced by auxin were of greatest abundance by six hours. The cDNA clones are being characterised.

**0800-0900****S18-P-54****EFFECT OF SOME FACTORS IN WINTER GRAFTING (SIDE- AND SADDLE GRAFTING) TECHNIQUES IN WALNUT (*JUGLANS REGIA* L.)**

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Grafting success was evaluated in a factorial completely randomized design with three replications and 20 seedlings for each treatment in each replication at the Faculty of Agriculture in Tehran Univ. during years of 2000-01. The effect of two grafting dates (Dec. 21 and Jan. 23, 2000) and the kind of callusing bed (with bottom heat and without bottom heat) was studied. One-year-old rootstocks combined with scions of 'Zia Abad' genotype were used. Interpretation of the results suggest that side grafting, rather than saddle grafting, had a highly significant effect on grafting success. Callusing beds had no significant effect. In this experiment, the highest degree of success (65%) was obtained on the first date with bottom heat. In a second trial, results were more variable.

**0800-0900****S18-P-55****EFFECT OF CARBON DIOXIDE, NUTRIENT COMPOSITION AND SUPPORTING MATERIAL ON GROWTH OF MINIATURE ROSE 'SILK RED' IN VITRO**

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Growth and development of miniature rose 'Silk Red' plantlets in vitro as affected by various environmental factors were evaluated. Treatments used were two levels each of trophic phases (photoautotrophic and photomixotrophic) and nutrient compositions (half strength MS basal and Gato hydroponic rose solution), and three supporting materials (agar, gelite, and Tosilee, a commercial plug medium). Photomixotrophically micropropagated plantlets excised of roots were used as explants. Explants were cultured for 4 weeks under cool-white fluorescent lamps at an intensity of  $180 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  for  $16 \text{ h}\cdot\text{day}^{-1}$ , at  $25 \pm 1 \text{ }^\circ\text{C}$  temperature, and 70-80% relative humidity. Height, numbers of leaves, branches and flowers, length of the longest leaf, chlorophyll concentration, numbers of main and fine roots, and length of the longest root were promoted with increasing  $\text{CO}_2$  concentration. Plantlet growth under a photoautotrophic culture condition was enhanced in gelite as compared to agar or Tosilee. Number of roots was enhanced by the Gato rose solution as compared to the half strength MS solution under a photoautotrophic culture condition.

**0800-0900****S18-P-56****INVESTIGATING THE POTENTIAL BY CUTTING PROPAGATION IN WILD POPULATIONS OF HEATHERS IN NW SPAIN (GALICIA)**

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Interest in native plants has been growing over the last several years parallel to the increasing demand for land reclamation (revegetation and erosion control). In Galicia the heathers represent a quarter of all native plant material. The objective of this study was to investigate the potential of rooted cutting propagation on different wild populations of several species of heathers (*Calluna vulgaris*, *Erica ciliaris*, *E. cinerea*, *E. tetralix*, *E. umbellata*, *E. vagans*). The effects of source plant collection site (coast or mountain), hormone treatment (0.1% k-IBA; 0.4%k-IBA; 0.4% IBA talc, control), date of cutting (autumn, spring and summer) and species on the rooting success were studied. The variables analyzed were rooting percentage (RP) and visual rooting score (VRS). No differences were observed between locations in the most of species, except with *E. umbellata* where coast plants rooted better than those of the mountain site. Significant differences were observed among species and dates of cutting harvest. Over all treatments, *Calluna vulgaris* had the highest RP and VRS. The best date for cutting propagation for all heathers studied was early summer. During this time period, the application of rooting hormones was beneficial, with the exception of *E. tetralix* where the best treatment was no hormone. Significant interactions were detected among species, date of cutting, source plant

collection site and hormone treatment. The utilization of native plant material can be an effective resource for larger scale nursery production if proper protocols are followed.

**0800-0900****S18-P-57****TESTING DIFFERENT MEDIA FOR ROOT CUTTINGS OF POMEGRANATE (*PUNICA GRANATUM*)**

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Research was conducted in order to evaluate effects of different media on cuttings of *Pomegranata*. Eight media, including: Normal soil (Control), Sand, Leaf mold, Perlite, Sand+Leaf mold, Sand+Perlite, Leaf mold+Perlite and Sand+Leaf mold+Perlite, were used in a randomized complete-block design with three replicates. Each replicate included a pot of 10 cuttings approximately 20 cm in length and 1 cm in diameter. After 3 months, all cuttings were carefully removed and the length and number of roots were recorded. The results of ANOVA indicated that there were significant differences among treatments regarding average number of roots. However, no significant differences were observed considering average length of roots. The highest root lengths were observed in a medium of Sand+Perlite+Leaf mold (1:1:1). On the other hand, the shortest root lengths were observed with Leaf mold media.

**0800-0900****S18-P-58****INFLUENCE OF SUBSTRATE AND POT ON ROOTING OF STEM HARDWOOD CUTTINGS OF PEACH CV. OKINAWA AT DIFFERENT DIAMETERS**

M.B.D. Tofaneli\*, J.D. Rodrigues, E.O. Ono, L.C. Ming, R. Matheus Damato

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This work was carried out at Dept. of Plant Production/Horticulture of the Faculdade de Ciências Agronômicas (FCA) of the Universidade Estadual Paulista "Júlio de Mesquita Filho" (UNESP) located in Botucatu (SP, Brazil). The aim of the study was to evaluate the influence of substrate and type of pots on rooting of stem hardwood cuttings of peach [*Prunus persica* (L.) Batsch] cultivar Okinawa in different diameters. The cuttings were collected in July 2001 from plants of the orchard belonging to Coordenadoria de Assistência Técnica Integral (CATI) located in Itaberá (SP, Brazil). The cuttings were treated with  $2500 \text{ mg}\cdot\text{L}^{-1}$  of IBA and planted in the greenhouse according to the following treatments: six substrates [sand (Ar), carbonized rice husk (CC), vermiculite (Ver), Ar+CC (1:1), Ar+Ver (1:1), CC+Ver (1:1)]; three types of pots: [plastic bags (BPI), polystyrene trays (BPe), plastic trays (Saq)] and two diameter size classes of cuttings: [2 to 6 mm (<D) and 6 to 10mm (>D)]. The cuttings were maintained in the greenhouse for 50 days. The best rooting was observed with Ver + Saq + <D (47,40%); best growth with BPe, Ver and >D (20.3; 29.2 and 17.2%, respectively); highest number of roots with Ver and BPe (5.4 and 3.6 roots per rooted cutting, respectively) and greatest root lengths with Ver + Ar+Ver (6,5cm).

**0800-0900****S18-P-59****EFFECTS OF THIDIAZURON AND NUTRIENT SALT FORMULATIONS ON MICROPROPAGATION OF COMMON ROSE MALLOW (*HIBISCUS MOSCHEUTOS* HYBR. L.)**

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Effects of thidiazuron (TDZ) concentrations and nutrient salt formulations were studied on two *H. moscheutos* hybrids; 'Lord Baltimore' (cutting propagated cultivar) and 'Southern Belle' (seed propagated cultivar) to produce an efficient in vitro axillary shoot proliferation protocol for micropropagation. Six TDZ concentrations (0, 10-9, 10-8, 10-7, 10-6, or 10-5 M) were compared to determine which would stimulate the proliferation of the most viable axillary shoots. Also, five nutrient salt formulations (DKW, LP, MS, 1/2 Macro MS, or WPM) ranging from high to low salt formulations were studied to determine a suitable nutrient medium formulation for axillary shoot proliferation. The best treatment tested for axillary shoot proliferation of the two *H. moscheutos* culti-

vars was the medium containing DKW (high salt formulation) with 10-7 M TDZ. Thidiazuron concentrations higher than 10-7 stimulated shoot proliferation but the shoots did not elongate well and had severe chlorosis of the leaf tissue with subsequent necrosis of the shoot meristems. Thidiazuron concentrations lower than 10-7 M stimulated little to no shoot proliferation and these explants responded similarly to the control explants. Data were compared on axillary shoot number and subcultured explant number (excisable nodes). The axillary shoot number means (in parentheses) were 1.0, 1.0, 1.2, 3.1, 1.9, and 1.2 for treatments 0, 10-9, 10-8, 10-7, 10-6, and 10-5 M TDZ, respectively. The subcultured explant (number of excisable nodes from microshoots) means were 3.4, 3.1, 3.7, 6.8, 3.2, and 1.4 for treatments 0, 10-9, 10-8, 10-7, 10-6, and 10-5 M TDZ, respectively. Explants growing on MS, 1/2Macro MS, and WPM did not proliferate axillary shoots, rather the primary shoot elongated with no branching. Explants on LP medium (medium salt formulation) proliferated shoots but the shoots were not as vigorous as those on DKW.

**0800-0900**

**S18-P-60**

**PRODUCTION OF WOODY ORNAMENTAL CUT BRANCHES**

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There exists an increasing market for the cut branches of woody ornamental plants for the floral trade. This study examines the production, over time, of a newly planted (June 1999) plot of several species of woody ornamental landscape plants, including *Cornus baileyi*, *C. sericea* 'Cardinal', *C. sericea* 'Bud's Yellow', *Salix matsudana* 'Tortuosa', *Salix* 'Scarlet Curly' and *Salix* 'Golden Curly'. All three *Cornus*, and all three *Salix*, genotypes produced marketable yields in the second growing season, with substantial increases in yield between the second and third years. Detailed yield data is presented.

**0800-0900**

**S18-P-61**

**EARLY DEFOLIATION OF *SALIX MATSUDANA* 'TORTUOSA' FOR USE AS WOODY ORNAMENTAL CUT BRANCHES**

J.A. Young\*, B.C. Moser

4914 West 800 South, Lafayette, Indiana, USA, 47909

*Salix matsudana* 'Tortuosa' has utility as a woody ornamental cut branch in floral arrangements due to its interesting growth habit. However, to achieve earlier sales, it is necessary to defoliate the branches prior to natural leaf abscission. This study explores the use of ethylene gas and ethephon solutions to hasten leaf abscission. *Salix* branches were exposed to ethylene concentrations of 0, 1, 10 and 100 ppm inside controlled environment chambers for up to 48 hrs, and final abscission percentages were recorded after 72 hrs. After 48 hrs of treatment, leaf abscission was >90% for all concentrations. Ethephon treatments were applied as either foliar sprays or as solutions taken up from the basal cuts of the branches; concentrations of 0, 1, 5 and 10 ppm were used for both forms of ethephon treatment. Foliar spray applications of 10 ppm resulted in 100% defoliation within 72 hrs. Systemic uptake of ethephon solutions was carried out for durations from 0 to 24 hrs, followed by transfer of the branches to distilled water. After 72 hrs, leaf abscission was highest in branches pulsed with the 10 ppm ethephon solution, but did not respond to increased pulse duration beyond 4 hrs. Additional information on the use of ethylene gas and ethephon is presented.

**0900-0920**

**S18-O-62**

**ENVIRONMENTAL CONTROL SYSTEMS FOR MIST PROPAGATION OF CUTTINGS**

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A dynamic misting control strategy for poinsettia propagation has been developed. Evapotranspiration from cuttings was estimated using an energy balance (the Penman-Monteith) equation. The model was developed from parameters obtained in carefully controlled growth chamber experiments and validated in greenhouse studies using computer controls. The system requires

online measurements of air temperature, relative humidity and PAR intensity. Mist events were activated when predicted evaporation reduced stored water in the canopy to below a threshold quantity. Compared to static mist control (5 sec every 10 min) there was a 38% reduction in misting using the dynamic control system. Method of control did not effect the number of roots per cutting, but there was an increase in root biomass and production of finer (less diameter) roots when dynamic misting was used. Even though less water was applied to cuttings using dynamic control, there was no reduction in foliar nutrient loss during misting. Additional information about the degree of root development in the cutting can be obtained by monitoring media temperature. The dependence of water uptake on both medium temperature and time post-stick was evaluated, and used to develop a refined prediction of misting intervals for the dynamic model.

**0920-0940**

**S18-O-63**

**ASEXUAL PROPAGATION OF NORTHERN PLAINS NATIVE BUR OAK *QUERCUS MACROCARPA* FOR COMMERCIAL RELEASE**

Cheryl Moore Petersen\*<sup>1</sup>, Tracy A.O. Dougher<sup>1</sup>, Joseph D. Scianna<sup>2</sup>

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Windbreaks and shelterbelts protect wildlife, homes, crops, and recreational areas where adverse climatic conditions occur in Montana. The vegetative belts also are valuable as riparian buffers and for erosion control. Traditional windbreaks consist of several rows of deciduous and coniferous shrubs and trees. Desirable plant characteristics include a high rate of height growth, high seedling survival, good form, moderate density and strong wood. Using vegetation adapted to the area adds to the success of the windbreak. One such plant is the bur oak *Quercus macrocarpa*. Bur oak may reach 30 feet or more in height under dryland conditions in eastern Montana. It is extremely hardy, drought resistant and long lived, but a slow grower. Accessions of this species have been evaluated by the Plant Materials Center in Bridger, Montana, USA for increased rate of height growth, seedling survival, vigor, form, and density. Because propagation information is limited as is our ability to asexually increase these plants for a growing market, we developed hormone, temperature and timing response curves to optimize conditions for traditional rooting of cuttings from the accessions. We are also exploring more novel approaches such as etiolation, banding, and stock plant light quality effects on rooting.

**0940-1000**

**S18-O-64**

**QUANTITATIVE PHENOLOGICAL MARKERS AS AN AID FOR VEGETATIVE PROPAGATION OF *ACER SACCHARUM* (MARSH.) BY STEM CUTTINGS**

Denise Tousignant\*<sup>1</sup>, Jean-Philippe Mottard<sup>2</sup>, Claude Richer<sup>3</sup>, Jacques-André Rioux<sup>2</sup>, Nicole Brassard<sup>4</sup>, Stephane Guay<sup>4</sup>

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The objective was to develop a technique to mass propagate sugar maple trees (*Acer saccharum* Marsh). A genetic probe was used to screen those with higher sugar content. The best stage for harvesting the cuttings was determined. The development of young trees planted in 1993 was observed during 1999 and 2000, at Beaumont (Quebec). The water content at the base of the stem was negatively correlated with the number of pairs of scales on the terminal bud. The evolution of rooting of the cuttings harvested for the two studies was best during a six week-period (optimal period) in June and July, however we were not able to obtain similar results in subsequent years. During the optimal period 85% rooting was observed, however, the cuttings produced less than 30% roots if they were harvested too early or too late. Probes like the water content and the number of pairs of scales can be used to construct a reference curve to predict the optimum sampling period. There was a significant difference between clones in the root development, which can be affected by several factors including "bouturatheque" irrigation and soil temperature.

Friday August 16

**1000–1020**

**S18–0–65**

### **NON-STRUCTURAL CARBOHYDRATE CONTENT AS AN AID FOR INTERPRETING QUALITY TESTING OF NURSERY STOCK PLANTS**

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An important percentage of the produced woody plants are still commercialised as bare rooted plants. Although it is well known that only fully hardy plants are more resistant to stresses linked to lifting, handling and storage; the nursery stock sector is asked to deliver plants from the end of October until April. Therefore it can not be guaranteed that all lifted plants during this period are fully hardy. During the past 10 years a set of techniques to assess the quality of forest nursery stock was developed (McKay, 1992; Mc Kay and White, 1987). These tests are mainly based on physiological characteristics of the plant species and include root electrolyte leakage (REL) and moisture content of roots and shoot. The effects of lifting date and increasing drought stress on REL and moisture content of seedlings of *Carpinus betulus*, *Fagus sylvatica* and *Picea abies* were assessed to obtain threshold values for predicting plant quality. The relationships of REL and moisture content to survival were determined. Lifting date influenced REL and moisture content; a seasonal trend for these parameters was observed. Furthermore, interpreting values of REL and moisture content without knowledge of the 'hardened' or 'dehardened' state of the plant could lead to wrongly classifying plant quality. Seasonal observations of bud dormancy (single node cutting test for broadleaves, mitotic index for conifers) indicated that bud dormancy is insufficient for indicating the 'hardened' and thus more stress supporting state of the plant. Seasonal changes of non-structural carbohydrates indicated that for the studied species the presence of raffinose and/or stachyose in bud or stem tissue were good indicators for 'hardened plants' and could help to interpret REL values and moisture content levels with respect to plant quality assessment.

**1020–1040**

**S18–0–65–A**

**TO BE ANNOUNCED**

**1400–1420**

**S18–0–66**

### **REGULATION OF PLANT GROWTH IN CONTAINER-GROWN ORNAMENTALS THROUGH THE USE OF CONTROLLED IRRIGATION**

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The development of appropriate plant habit is essential for the successful retailing of many horticultural ornamental crops. For most hardy ornamental nursery stock (HONS) species grown in containers, the market now demands a uniform crop of compact, well-branched plants. Indeed, excessive shoot vigour is undesirable and crops are pruned regularly in an attempt to promote and maintain the correct plant shape and size. However, pruning is labour intensive and 'wasteful' in terms of lost biomass. An alternative mechanism to control crop growth may be to regulate the amount of water available to the root system. This is feasible when crops are grown in containers, and the majority of water is applied through artificial irrigation systems such as overhead sprinklers or drip lines. The aim of our research was to evaluate the extent to which we could regulate shoot growth and improve plant quality through controlled irrigation techniques such as Regulated Deficit Irrigation (RDI) or Partial Root Drying (PRD). The project also aimed to assess any additional benefits from adopting such systems, for example, the potential for reduced water use and fertiliser inputs. Results on three ornamental woody plant species (*Cotinus*, *Forsythia* and *Hydrangea*) demonstrated that plant quality could be significantly improved and the requirement for pruning reduced when RDI was applied at <60% of potential evapotranspiration (ETp). Stomatal closure was associated with both the RDI and PRD

techniques, but reduced leaf water potential was only recorded in the RDI system. Changes in xylem sap pH and ABA concentrations were correlated with stomatal control, and appear to be generated by those roots exposed to drying soil. By adopting such controlled irrigation systems on commercial holdings it is estimated that water consumption could be reduced by as much as 90%.

**1420–1440**

**S18–0–67**

### **COMPARATIVE EVALUATION OF SPENT MUSHROOM COMPOST, TURKEY LITTER COMPOST AND MUNICIPAL COMPOST IN 18 WASTE-DERIVED CONTAINER NURSERY SUBSTRATES**

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Dogwood (*Cornus alba* L. 'Sibirica'), forsythia (*Forsythia xintermedia* Zab. 'Lynwood Gold') and weigela (*Weigela florida* Bunge A. DC. 'Variegata Nana') were grown for one season in containers filled with one of 18 waste-derived substrates formulated using three compost sources: spent mushroom compost (SMC), turkey litter compost (TLC), and municipal waste compost (MWC). Each compost was included at rates of 25, 33, and 50% by vol mixed respectively with 50, 33, and 25% paper mill sludge, and 25, 33, and 25% bark or sand (supplemental ingredients). Before mixing, electrical conductivity [EC, (dS/m), a measure of the soluble salts concentration using 1:2 v/v substrate:water extracts] in the unamended composts were excessive (SMC, 4.0; TLC, 4.1; and MWC, 3.0), due primarily to elevated quantities (mg/L) of K (1166–2792), Cl (848–1656), Na (139–511), and/or SO<sub>4</sub> (29–894). Analysis of variance with treatments in factorial combinations (3 compost sources x 3 rates x 2 supplemental ingredients) indicated variable species response. Dogwood (no treatment interactions) grew best with the SMC-amended substrates, providing equal but less growth with TLC and MWC. This species also grew better with bark as supplement than with sand and showed no response to compost rates. Corresponding results for the other species were: weigela, MWC>SMC>TLC, and increasing growth with increasing rates of all composts when supplemented with sand but not bark; and forsythia, SMC=MWC>TLC, and increasing growth with increasing rates of SMC with sand, or of MWC with bark. Despite these variations, all plants were at least of marketable size at harvest. There was no sign of nutrient toxicity because the soluble salts in the substrates (initially ranging from 0.6–2.6 at planting) declined rapidly after the first irrigation (0.2–1.0) and remained low thereafter (<0.6).

**1440–1500**

**S18–0–68**

### **NUTRIENT UPTAKE, PARTITIONING AND LEACHING LOSSES FROM CONTAINER-NURSERY PRODUCTION SYSTEMS**

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A three-year study was initiated in 1999 to gather long-term data on nitrogen (N) and phosphorus (P) movement from container-nursery operations. The overall objectives of this study are to quantify N and P application, partitioning and leaching losses for *Ilex cornuta* x *regosa* var. 'China Girl' (holly, a 'high' nutrient-use species) and *Rhododendron* var. 'Karen' (azalea, a 'low' nutrient-use species), using two irrigation methods (drip vs. overhead sprinkler). The research site consists of two, 72 m x 8.66 m hoop-houses, underlain by two continuous 6-mil polyethylene layers, sandwiched between groundcover fabric, so that all irrigation water, rainfall and the subsequent leachate from plant containers are captured. Each house is divided into eight replicate blocks (n = 448 plants per block); a central furrow captures runoff into underground 170-liter polyethylene drums at the end of each block. Nutrients were applied at industry-recommended rates, with controlled release fertilizer (averaging 29 g N/plant) and supplemental soluble (averaging 2.3 g N/plant) nutrient applications over the first 14 months of the study. During this period, irrigation method did not affect N uptake (availability) within species, although total runoff was over three times higher (2.5 g N vs. 0.7 g N) for sprinkler vs. drip blocks. Plant N-uptake efficiencies during this period were very low, averaging 6 to 8% for both species. Total N recoveries (plant, substrate and leachate) were below 17% for both species and irrigation methods. In a subsequent 16-week azalea study under controlled greenhouse conditions, plant N-uptake efficiencies ranged between 11 and 16% for plants fertilized with a similar N rate (250 mg

N/week). Large fractions of the total N applied were not accounted for by either study, indicating that, while plant N uptake-efficiencies in container production are very low, there may be significant microbial competition for available N in these systems over the long term.

**1500–1520**

**S18–0–69**

**DELAYED RELEASE OF PRIMARY DORMANCY AND INDUCTION OF SECONDARY DORMANCY IN SEEDS OF WOODY SPECIES CAUSED HIGH TEMPERATURE TREATMENTS**

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The effect of high temperature on the relief of primary embryo dormancy and induction of secondary dormancy is very poorly understood. The topics were studied in seeds of the woody species *Berberis thunbergii*, *Malus sargentii*, *Pyrus communis* and *Amelanchier canadensis*. Fully imbibed seeds of *Berberis thunbergii* were placed at 5 °C. After 14 days the treatment was interrupted by a period at 25 °C lasting for 0 (control), 1, 3, 5, 10, 15, 20 and 25 days, respectively, and seeds were then returned to 5 °C. Final germination percentages (ranging from 78 to 87%) did not differ significantly among treatments. The 1, 3 and 5 days treatments did not significantly affect mean germination time (MGT). However, MGT was increased after 10, 15, 20 and 25 days at 25 °C compared to the control treatment, although the increase after 10 days was not significant. The results suggest that in *Berberis thunbergii* seed a period of more than 5 days at 25 °C is required to inhibit or delay the dormancy release at 5 °C. Preliminary experiments with *Pyrus communis*, *Malus sargentii* and *Amelanchier canadensis* seeds germinated at 5 °C showed that a 2-week period at 25 °C increased the MGT significantly from 16.9 to 21.0 weeks in *Pyrus communis*, from 13.4 to 20.2 weeks in *Malus sargentii*, and from 16.3 to 23.0 weeks in *Amelanchier canadensis*. The delay in germination indicates that the high temperature not only interrupted the dormancy release processes but reverted the seeds into a state of deeper dormancy than seeds of the control treatment, i.e. induction of secondary dormancy. The relationship between delay of primary dormancy and induction of secondary dormancy is discussed.

**1520–1540**

**S18–0–70**

**THE EFFECTS OF SEED TREATMENTS ON EMERGENCE OF DORMANT *FRAXINUS AMERICANA* AND *F. PENNSYLVANICA* SEEDS**

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Various treatments were performed on dormant (non-afterripened and nonstratified) seeds of white ash (*Fraxinus americana*) and green ash (*Fraxinus pennsylvanica*) to determine whether the dormant seeds would germinate and emerge as well as or better than warm afterripened and cold stratified seeds. All seeds were removed from their pericarps and sown in a greenhouse in peat-lite medium that was kept at approximately 26 °C (80 °F) and that was treated every four weeks with Ban-Rot fungicide. Green ash seeds that had one third of their length excised from the cotyledon end (cut seeds) had a mean emergence of 43.5%, which was significantly greater than the green ash seeds that received an afterripening and cold stratification treatment, which had a mean emergence of only 13.5%. Both cut seeds and stratified seeds emerged at significantly higher rates than green ash seeds that were soaked in deionized water in the presence of light for 24 hours (mean emergence 5.5%) and green ash seeds that soaked in deionized water in light for 12 hours and then in darkness for 24 hours (mean emergence 4.0%). These last two treatments were not significantly different from each other. Non-afterripened and nonstratified white ash seeds had mean emergences of only 0–8%, whereas stratified white ash seeds had a mean emergence rate of 57.5%.

**1540–1600**

**S18–0–71**

**WEED MANAGEMENT SYSTEMS FOR JUNE BERRY (*AMELANCHIER* SPP.) IN NORTH DAKOTA**

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North Dakota growers interested in diversifying production operations with a long-term, high-value crop have begun planting juneberry or saskatoon (*Amelanchier* spp.) orchards. Management of these orchards is very labor intense due to the lack of weed control options. Field trials have been initiated to evaluate efficacy and the costs associated with chemical and non-chemical weed control treatments. Non-chemical treatments consisted of strips of black fabric or black plastic, wood chips applied to a 10-cm depth, mechanical control (hoe), and an untreated. Chemical treatments consisted of two rates of azafenidin, flumioxazin, norflurazon, and oxyfluorfen, and one rate of oryzalin and trifluralin. Treatments were applied to newly transplanted plants. All plants were physically protected from herbicide spray contact. Black fabric, black plastic, mechanical control, azafenidin, flumioxazin, oxyfluorfen, and oryzalin provided adequate season-long broadleaf and grass control. However, all herbicides except oryzalin also caused unacceptable injury. Perennial weed emergence and small animal digging opened the wood chip barrier allowing annual weed emergence. Annual weed control with norflurazon and trifluralin was inadequate. Reduced rates will be investigated on those compounds providing excellent weed control but unacceptable crop injury to see if compounds can provide crop safety and weed control.