Symposium 19 (S19): Elegant Science in Floriculture

Monday · August 12

Location: Metro Toronto Convention Centre, Room 206AB

1100–1200
S19–O–1
ETHICAL GERMPLASM ACQUISITION AND DEVELOPMENT OF NEW FLORICULTURAL CROPS

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New floricultural crops have been developed and continue to be developed from germplasm collected worldwide. In many instances the countries of origin of the material used in the development of new crops are unaware of this development and receive no compensation. The Convention on Biological Diversity has set guidelines for germplasm collection and development which require, among other things, prior informed consent and benefits sharing with countries of origin. The Ball Horticultural Company is an international, family-owned company involved in development, production and distribution of floricultural crops for nearly 100 years. In 1999 Ball entered into an agreement with the National Botanical Institute of South Africa, based at the world-famous Kirstenbosch Botanic Garden, for development of South African germplasm following Convention on Biological Diversity guidelines. To our knowledge this is the only agreement of its kind. This agreement requires close cooperation between Ball and the National Botanical Institute. Ball provides financial support for facilities development and collecting expenses, guidance regarding germplasm likely to be useful in floricultural crop development and technology transfer, including hosting interns and presenting seminars in South Africa. The National Botanical Institute identifies appropriate collection locations, collects germplasm using approved procedures, ensures all South African regulations are followed during collection, propagates the material, makes a preliminary evaluation and sends germplasm to Ball for evaluation. Intellectual property rights of developed material are owned either by Ball, the National Botanical Institute or jointly held. In all instances Ball returns royalties to the National Botanical Institute. These royalties are then distributed to appropriate stakeholders in South Africa. While the agreement has been generally well accepted, it has not been without controversy. Successes and challenges regarding this agreement will be discussed.

1200–1240
S19–O–2
NEW ORNAMENTAL CROP INTRODUCTION: A MODEL FOR COOPERATION BETWEEN INDUSTRY AND ACADEMIA

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The continued successful introduction of new crops is a difficult endeavor for academic institutions, due to limited time, limited facilities or insufficient industry-academic cooperation. Promotion and marketing of new crops requires significant funding and additional personnel to be successful. Historically, the academic community has had limited success in long term new crop introduction. The New Crop program at the university of Georgia initially introduced several new greenhouse-landscape taxa by inviting local industry members to share the material. New crops that were profitable were quickly propagated, resulting in credibility and visibility for the program. The methods of initial evaluation and distribution will be discussed. Recently, a number of national propagators and the New Crop program formed a marketing alliance known as Athens Select. The responsibility of the industry members is to promote and sell the plants in the program. University research facilities are also used for determining propagation, scheduling, and solving production-related problems with the taxa. Using the Athens Select program as a model, the protocol to establish such a partnership and its long term feasibility will be discussed.

1340–1440
S19–P–3
RESULTS AND NEW TRENDS IN BREEDING OF THE ROMANIAN *GLADIOLUS*

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The breeding work of *Gladiolus* started in Romania after 1953 at the Agricultural Research Station in Cluj-Napoca (Palocsay R., 1960). Development was slow because of the small number of researchers working with this species and also because the process of new cultivar approval was very slow for many years in the past. In Romania the assortment of *Gladiolus* has for many years been dominated by the cultivar Oscar. Since 1990 in Romania an extensive evaluation of new cultivars, mainly those of French and Dutch origin, has been carried out. The breeding work concerning *Gladiolus* at the Univ. of Agricultural Sciences and Veterinary Medicine Cluj-Napoca has been mainly focused on: collection, study and diversification of germplasm, improvement of the main characteristics (plant height, spike length, widening the color range, number and form of florets, resistance to diseases and pest). The major aims of our breeding process were achieved only by a deep understanding of the biological characteristics of germplasm used in our crosses and the most appropriate methods needing to be employed for each goal. Phenotypic and genetic variation has been achieved by controlled hybridization, the basic procedure in obtaining a valuable hybrid material used in breeding. In this paper we will show 20 new Romanian hybrids, obtained at the USAMV Cluj-Napoca. The intraspecific variability of the above-mentioned characters was mostly low and rarely medium, high or very high. The data of the experiments indicated that the new Romanian hybrids may be used as genitors for new crosses, and the best selections will be proposed for approval as a new cultivars. The coefficient of variability shows the modality of transmission of these characters to descendants. In the future we intend to use USA and Canadian cultivars in *Gladiolus* breeding and modern breeding methods based on genetic biotechnologies.

1340–1440
S19–P–4
TRIGGERPLANTS (*STYLIDIUM* SPP.; STYLIDIACEAE), A NEW FLORAL AND HORTICULTURAL CROP WITH PRELIMINARY ANALYSIS OF HARDINESS

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Triggerplants (*Stylidium* spp.; Stylidiaceae) present an outstanding opportunity for the development of a new floricultural and horticultural crop. Most being native to Australia, triggerplants have been known to Western Science for over two centuries, yet they have not been used extensively in horticulture, even in Australia. A wide variety of species have been identified—over 200—from the tropics to alpine regions, from tiny ephemerals to the 1.5 m perennial Tree Triggerplant, *S. laricifolium*. Many triggerplants present a number of horticulturally-valuable traits, including spikes of brightly colored flowers, the ability to grow on toxic and/or nutrient-poor soils, significant drought tolerance, and the ability to withstand extreme temperatures. In addition, two other points of interest for promoting sales include their unusual, active, hammer-like mechanism of pollination and their possible carnivory. Preliminary tests show that species from a variety of locations in Australia can be grown without damage, followed by attractive spring and summer flowers. Preliminary hardiness testing in Maryland, USA, and means of conventional and micropropagation will be considered along with cultivation requirements both in pots and in the ground. The members of the genus will also be considered in a general survey.

1340–1440
S19–P–5
TECHNIQUES FOR THE IN VITRO PROPAGATION OF *RHODOPHIALA* SPP.

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Rhodophiala spp. of the Amaryllidaceae is an endogenous geophyte from Chile and Argentina similar in appearance to the *Amaryllis*. They have attractive flower colors of red, orange, or yellow. Their novel yellow colors and easy growth habit make them a potential new ornamental that can be used as a cut flower or potted plant. Traditional propagation techniques that have been used for other bulbous plants were attempted under in vitro conditions to increase the number of bulbs. The mechanical treatments that were applied to the basal plate were scooping, scoring with only one basal incision, scoring with two incisions, sectioning into two pieces, sectioning into four pieces, and a control with no mechanical intervention. Initial plant material were collected in Chile and placed in vitro. The cultured bulbs that were used for these experiments weighed an average of 0.2 g each. Basal Murashige and Skoog medium plus vitamins was used for all experiments. The cultures were grown under constant light at an average temperature of 23 °C. The bulbs were transferred to fresh medium every four weeks. The evaluations at each subculture included total and bulb fresh weight, number of bulblets produced and production of shoots and roots. After 12 weeks of culture, the production of bulbs that were propagated by scoring with one incision and those sectioned into four pieces was ten times greater than the control bulbs. However, the bulbs that were produced by these two treatments were 30% smaller than the control bulbs. The scooping treatment did not produce any adventitious growth or bulbs and the plants eventually died. Control plants maintained normal growth during the culture period, but they did not produce any adventitious bulblets.

1340–1440

S19–P–6

INFLUENCE OF RHIZOME STORAGE TIME AND TEMPERATURE ON DEVELOPMENT OF ORNAMENTAL GINGERS

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Ornamental gingers are popular cut flowers that have been promoted as a flowering pot plant because of unique foliage, long-lasting colorful bracts, and few pest problems. Rhizomes are the primary method of plant production. Plants enter dormancy under short days. Controlling the onset and termination of dormancy is important in rhizome production for year-round forcing. Rhizomes of four ginger species (*Curcuma alismatifolia*, *Curcuma roscoeana* Wallich, *Globba winittii* C.H. Wright, and *Kaempferia galanga* L.) were stored for 2, 3 or 4 months at 15, 20, or 25 °C to determine the storage longevity of the rhizomes and consequent shoot emergence, growth, and flowering. Rhizomes were planted in a peat moss:bark:perlite mix and placed in a greenhouse with 25 ºC day/21 ºC night temperatures with 40% shade. Plants were fertigated at every watering at 200 ppm N. As storage time and temperature increased days to emergence and flowering decreased for *Globba*. Rhizome weight for this species increased as storage time increased and temperature decreased. Rhizome weight decreased and emerging shoot length increased at planting as temperature and storage time increased for *C. alismatifolia*. Days to emergence decreased as storage temperature increased for *C. roscoeana* and *Kaempferia*. Rhizome carbohydrate content of all ginger species varied by storage time and storage temperature.

1340–1440

S19–P–7

BREEDING OF DWARF TUBEROSE *POLIANTHES TUBEROSA* L.

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Tuberose (*Polianthes tuberosa* L.) has been one of the most important floral crops in Taiwan. The long spikes of these flowers are excellent for cut flowers. People like their sweet fragrance. Two major cultivars, namely, white-colored cvs. 'Single' and 'Double' were cultivated for commercial production. Crossing and back crossing among *P. tuberosa* 'Single', *P. tuberosa* 'Double', *P.* x *howardii* and *P.* x *blissii* were made and 15 hybrids showing pink, reddish-purple, purple, orange and yellow flower colors were selected. However, the long spikes of flowers in these colored hybrids were only suitable for cut flowers. To broaden the utilization of tuberose, breeding programs were continuously conducted. Four hybrids showing dwarf plant type were reselected and might be released for potting and/or bedding plants. This paper summarizes the pedigree and flowering performance of these selected dwarf tuberose hybrids.

1340–1440

S19–P–8

INBREEDING DEPRESSION IN SEED PROPAGATED *LILIUM* X *FORMOSANUM* INBREDS

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Lilium longiflorum, Easter lily, remains among the top ten potted flowering plants in the United States. *L. formosanum* is a closely related white trumpet lily. Currently one Easter Lily culitvar predominates in the U.S. market, 'Nellie White'. In an effort to increase the crop germplasm base, interspecific hybrids were generated. Commercial, interspecific seed-propagated hybrids, from crossing *L. formosanum* (female) x *L. longiflorum* (male), were used in this study. Hybrids segregated for self incompatibility and self compatibility. Self-compatible hybrids were self pollinated to generate 11 F_2 inbred populations (n = 1–30 plants/population). F_2 seedlings were grown to anthesis under glasshouse conditions of 70F/21C (day/night) and long day photoperiod (daylight + supplemental HID lighting + night interruption lighting). Data was collected on % pollen stainability, number of days to visible bud, number of days to anthesis (flowering date), plant height, inflorescence height, number of leaves, flower bud count, number of shoots/bulb, stem color, and any morphological abnormalities. Pollen stainability was significantly lower than the parents, frequently <50%. The number of days to visible bud ranged from 175 to 253 days, while flowering ranged from 196 to 283 days. All other traits showed significant inbreeding depression and varied depending on the inbred population. Additional abnormal symptoms indiciating inbreeding depression included malformed flowers with petals/tepals becoming leaves, lack of anthers, and no pollen dehiscence. While inbreeding depression is severe, several early flowering inbreds with reduced depression could be selected to continue inbreeding in future generations. The possible use of seed-propagated interspecific hybrids for Easter lily production schedules will be presented.

1340–1440

S19–P–9

PEROXIDASES ACTIVITY DURING ROOTING OF CUTTINGS IN *EBENUS CRETICA*: A PRELIMINARY STUDY

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Ebenus cretica L., a native species of Greece and a potent new flower crop, is reproduced in nature by seeds. Vegetative propagation is important commercially for introduction of elite clones. However, propagation by cuttings is difficult due to poor rooting depending on the genotype. Peroxidase activity was reported to be related with the rooting response of cuttings in a number of plant species. In this work, the peroxidases activity during rooting of cuttings in *Ebenus cretica* was studied. Terminal semi-hardwood cuttings were taken from two genotypes with different rooting response. Plants were grown in the greenhouse under controlled enviromental conditions. After the application of 0 or 0.5 g/L IBA, cuttings were planted in perlite and placed for rooting in fog. On day 0, 1, 4, 7, 11, 14, 18, 21 and 24 after placement for rooting, a basal portion from the cuttings (about 2 cm) was cut and used for determination of peroxidases activity. Acidic and basic peroxidases patterns were analyzed (native-PAGE) during rooting process. Also, rooting percentage, number and length of roots were evaluated at the end of the 4-week rooting period. Peroxidases activity showed two pH optima at 5.5 and 7.0. Peroxidases activity was increased during rooting process in cuttings without rooting ability in the presense of IBA. Acidic and basic peroxidases patterns revealed differences, during rooting process, between the two genotypes of different rooting ability.

1340–1440

S19–P–10

POTENTIAL OF 12 SPECIES AND CULTIVARS OF ANNUAL FLOWERS AS GREENHOUSE CUT FLOWERS

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The potential of some annual flowers for fresh cut flower production was evaluated during the spring and summer of 2001. Twelve species and cultivars were grown in containers in three greenhouse sites. The plants grown were 2 cultivars of each of *Antirrhinum majus*, *Callistephus chinensis* and *Matthiola incana* and one cultivar of each of *Calendula officinalis*, *Celosia argentea, Lavatera trimestris, Nicotiniana sylvestris, Scabiosa atropurpurea* and *Zinnia elegans*. Yield data (stem length, stems per plant, stems per unit area, % marketable stems) and data on flowering time (harvest dates, duration of harvest) were recorded. Yields and harvest periods varied a lot between species: *Matthiola* yielded 1 stem per plant (all harvested on one day) compared to *Zinnia* that yielded 17.3 stems per plant with a harvest period of 52 days. *Zinnia* and *Matthiola* were the fastest to flower: 88 to 116 days from seed to first harvest. *Callistephus chinensis* 'Matador' was the slowest to flower: 149-150 days from seed to first harvest. Results also varied between the 3 sites because of differences in harvesting technique. There seemed to be an inverse relationship between yield (stems per plant) and stem length with *Antirrhinum* and *Zinnia*.

1340–1440

S19–P–11

USE OF CHEMICAL GROWTH REGULANTS TO CONTROL PLANT HEIGHT IN THREE SPECIES OF *CUPHEA*

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When developing and evaluating a plant species as a new floriculture crop, information about height control is pertinent to commercial use and is necessary for acceptance of a new species into the floriculture industry. We compared the ability of three different concentrations of Cycocel (chlormequat); growth regulant to reduce the height of three species of *Cuphea, C. schumannii, C. pulchra*, and an unnamed hybrid (*C. angustifolia* x *C. schumannii*). Cycocel concentrations of 800, 1500, 3000 ppm, and a control treatment of water were applied to 14-day-old cuttings. At 28 days the apex of each plant was removed. Half of the plants in each treatment received a second application of growth regulator at the time of apex removal while the other half were treated two weeks after pinching. The third and final applications were 21 days after the previous treatment. The percent decrease in height, the number of nodes, and amount of lateral branching of treated plants were determined per growth regulator application group and compared with untreated plants. None of the concentrations of growth regulator significantly reduced the height of *C. schumannii* when compared to controls. However, *C. pulchra* and the hybrid exhibited greatest response to 3000 ppm concentration with a 42% and 12% reduction in height respectively, when compared to control. For each of the three species, height reduction was greater when the growth regulator was applied at the time pinching than when applied 14 day after apex removal. Results indicate that higher concentrations of growth regulator may be necessary to reduce height in *Cuphea schumannii*, and application of growth regulator at the time of pinching is more effective in height reduction for all three species than a delayed application.

1340–1440

S19–P–12

MORPHOLOGY, GROWTH AND FLOWERING BEHAVIOR OF *CURCUMA ZEODARIA*

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Curcuma species are tropical crops new as cut flowers, landscape plants and speciality potted plants. Among this group, the beautiful inflorescence and luxurious foliage of *C. zeodaria* (Christm.) Roscoe (a traditional source of Zeodary spice, tonic, and perfume) has potential in floriculture. General aspects of plant morphology, growth and flowering of this species, growing under Hawaiian conditions, are reported. Zeodary is a herbaceous and rhizomatous perennial plant conformed by a corm (an ovate rhizome), cylindrical axillary branches (that when fully matured are developed up to the third order), and fleshy roots. Some roots show at their end storage root structures (rounded to elongate tubers). The axillary active buds are on the lower side of the corm and branches. From March to April axillary buds of the corm elongate and branch and apical buds of the third order emerge above ground, differentiating into inflorescence. The basal flower spike will grow about 30 cm tall and appears just before the foliage. On the node closest to the flower spike, a vegetative shoot always develops. No additional floral buds sprout, but more vegetative shoots develop. On corms of recently formed aerial shoots, new branches start to develop. By autumn, the above-ground foliage dies back. From November to December storage roots are formed, having a high (>70%) sugar content. Sketches and photos illustrate the branching pattern and morphological plant structures. Anatomical structures of the corm, axillary buds, and terminal branches buds microtome-sectioned at 15-µm thickness are also illustrated by photomicrographs.

1340–1440

S19–P–13

EFFECTS OF IN VITRO BASAL PLATE CUTTAGE SYSTEMS ON BULBLET PRODUCTION OF LEUCOCORYNE COQUIMBENSIS

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Leucocoryne coquimbensis of the Alliaceae is an endogenous geophyte from Chile, and a new bulbous crop that can be used as a cut flower. Different mechanical treatments were used in vitro to determine the optimum method to increase bulb production rates. Leucocoryne coquimbensis bulbs were collected in Chile in October 2000 and were placed in vitro. The bulbs were cultured on basal Murashige and Skoog medium supplemented with vitamins. Growing conditions for the cultures were constant fluorescent lighting at an average temperature of 23 ºC. Bulbs were transferred onto fresh medium every four weeks. Basal plates were subjected to treatments of scooping, scoring with one incision, scoring with two incisions, sectioning into two pieces, sectioning into four pieces, and a control with no mechanical incision. Data that were collected included total and bulb fresh weight, number of bulblets produced and production of shoots and roots. After 12 weeks of culture, bulbs that were treated with either scoring technique and those that were sectioned into four pieces produced four or eight times more bulblets than the control plants, respectively. Bulbs that had their basal plates scored, with either one or two incisions, increased in bulb fresh weight the most. However, the fresh weight gain of the bulbs that were sectioned into four pieces was similar to the control plants. Only a few control bulbs produced some adventitious bulblets; most of the control bulbs remained inactive with no growth of shoots or roots during the culture period. This research demonstrated the importance of basal plate cuttage on *Leucocoryne coquimbensis* bulbs for increased in vitro bulb production.

1340–1440

S19–P–14

GROWTH AND PHYSIOLOGICAL RESPONSE OF HYDROPONICALLY GROWN *DORITAENOPSIS* 'TINNY TENDER' TO WATER STRESS

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It is critical to determine optimal culture conditions for high-quality production of *Doritaenopsis* orchids in hydroponic culture. Among culture conditions, the time and the frequency of nutrient solution supply are the key factors that affect plant growth and flower quality. This study has been conducted to determine optimal time and frequency of nutrient supply in hydroponic culture of *Doritaenopsis* '®Tinny Tender' and to observe the response of the plant to water stress conditions. Six-month-old *Doritaenopsis* '®Tinny Tender' plants in four types of growth medium (coconut chips, bark, sphagnum moss and peatmoss+perlite) were put under water stress conditions for 3 weeks. Physiological and biochemical characteristics of the plant were investigated. There were remarkable decreases in RWC, water potential, biomass growth, photosynthetic activity and maximum photochemical efficiency (Fv/Fm) during the dark period as the water content in the growth media decreased. Decreases were most significant in the plants grown in coconut chips and bark media. Water stress reduced total sugar and starch content in leaves, while increased soluble sugar such as reducing sugar and sucrose. Phosphoenolpyruvate caboxylase (PEPCase) and peroxidase (POD) activities peaked at 20 days after withholding water, which was highly significant on the plants grown in coconut chip and bark media.

1340–1440
S19–P–15
PHOTOSYNTHETIC FEATURES OF THREE GERBERA CULTIVARS IN LOW LIGHT

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In winter the light is the major limiting factor in greenhouse production in Finland and other northern countries. In order to produce gerberas with good quality and high yield all-year-round, the growers need to use artificial lighting. The goal of the research is to find a rapid and economic method for selecting gerberas cultivars more suitable for low light conditions. Our research describes the effects of low light on photosynthesis and biomass production in three micropropagated gerbera cultivars, Lamborghini, Lynx and Terra Regina, which react differently to light conditions. The photosynthetic features were measured on small plantlets, which after properly rooting had been grown for 16–28 days in growth chambers in following conditions: light intensity 80 $\mu mol \cdot m^{-2} \cdot s^{-1}$, daylength 12 h, air humidity 70%, CO_2 concentration 600 ppm. The watering was done manually with a commercial complete nutrition solution. The following properties were measured from the plantlets: 1) leaf net carbon dioxide uptake at different light levels (0, 25, 50, 100, 200, 500, 1000 $\mu mol \cdot m^{-2} \cdot s^{-1}$) 2) the leaf oxygen evolution at different light levels (0, 40, 80, 120, 160, 400, 740 $\mu mol \cdot m^{-2} \cdot s^{-1}$) 3) leaf chlorophyll fluorescence, describing conditions of photosystem II, 4) the fresh and dry weight and 5) the leaf area of the plantlets. In addition, the numbers of stomatas per unit leaf area, chloroplasts per cell and palisade cell layers were counted. The plantlets were afterwards grown in greenhouse for an additional four months. Flower yield during this period was counted and the leaf biomass was determined at the end of the period. According to the preliminary analysis of the results photosynthetic and morphological characterization gives possibilities for selection of gerbera cultivars more suitable for low light conditions.

1340–1440
S19–P–16
GENOTYPIC EFFECTS ON CUT FLOWER PRODUCTION OF *LIATRIS*

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The objective of this study was to evaluate and compare the growth and flower production of different species and cultivars of Liatris when grown in the field in USDA winter hardiness zone #5. The plants studied included *Liatris spicata* cultivars 'Kobold', 'Floristan Violet', 'Floristan White', and 'White Spires' and the species *L. aspera, L. pycnostachna, L. cylindriana, L. punctata, L. microcepheala, L. novaengliae,* and *L. punctata.* Established specimens were planted during the summer of 2000 at the Univ. of Connecticut Plant Science Research Farm in a randomized complete block design with 4 replications with 3 samples per replication. Data were collected during the summers of 2000, 2001, and 2002. Material evaluated included the total cut flower production per plant, length of inflorescence, date and duration of flowering, susceptibility to pests, disease resistance, and winter hardiness. The time of anthesis was determined when 3 florets per inflorescence were open. The length of flowering per plant was determined to be when the last flower on a plant reached senescence. The results from this study will permit recommendations to be made on cultivars and species selection in order to obtain maximum flowering throughout the summer. The number of flowers produced per plant determine the production rate for each species and cultivar and will allow the determination of economical value per production unit.

1340–1440
S19–P–17
BIODIVERSIFICATION OF ORNAMENTAL PLANTS DESIGNED AS INDOOR PLANTS IN ROMANIA

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During the last decade, in Romania the interest for ornamental plants considerably grew in general, and especially for indoor plants. A taste for beautiful, as well as psycho-social benefits created by plants in dwellings, service institutions or shops has expanded both in the urban and rural environment. In order to satisfying ever-growing requests, the Research Station Baneasa brings its contribution to increasing life quality by genetical conservation in the genetical collection of 318 "indoor decorative" plant species with 932 cultivars and varieties, decorative through architecture, leaves, flowers and fruits. Species composing the genetic collection originate from diverse geographical zones of the world: from equatorial and tropical zones with permanent moist climate (*Anthurium, Begonia, Bougainvillea, Dieffenbachia, Ferigi, Monstera, Orhidee, Pandanus, Philodendron*), from the tropical zone with periodically dry climate (*Aloe, Bromeliads, Clerodendrum, Dracaena, Ficus lyrata, Sansevieria trifasciata*), from tropical zone of savanah (*Agapanthus, Chlorophytum, Clivia, Pelargonium, Plumbago, Strelitzia, Streptocarpus*), from the subtropical zone of steppes (cactus and Euphorbiaceae), from the subtropical zone (*Anemone, Araucaria, Cyclamen, Cycas, Pittosporum*), from temperate continental zone which is also characteristics to Romania (Liliaceae, *Aspidistra, Primula, Azalea*). Objectives and results of research performed in the collection of decorative indoor plants refer to: biological requirements of each single species; establishing methods for rapid multiplication; obtaining new cultivars and varieties with superior decorative properties; choice of optium cropping substrate for each species;development of plant cropping technologies;conducting plant architecture; physiological disturbance of plants; identification of plant pathogens; development of integrated control strategies and diseases and pests of indoor decorative plants.

1340–1440
S19–P–18
CHARACTERISTICS OF GROWTH AND DEVELOPMENT OF *CALANTHE* DISCOLOR

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This study was conducted to investigate the characteristics of growth and flowering of *Calanthe* discolor which was cultured under the unheated plastic house in order to get the basic data for flowering control of *Calanthe*. When the mean temperature became above 5 °C in April, the flower bud sprouted and about 10 days after the inflorescence emerged. The flowering was observed in late April when mean temperature went up to 10 °C and florets wilted in mid May. Duration of flowering was about 15 days. As a result of observation of axillary buds which were detached at the 4th, 5th and 6th node from the base of stem after flower wilting, 4th buds produced six scaly leaves and after that did not grow further. However, 5th and 6th buds produced nine scaly leaves and were developed into flower buds in early July when the mean temperature went up to 20 °C. Flower bud formation progressed in order of growing point enlargement, primordium of bract, floret, petal, sepal and column, and lastly pollen. Flower bud differentiation began in early July when the mean temperature was over 20 °C. After that, florets of various developmental stage were observed. A pollen formation which reached to the stage of floret completion was observed in early August. It took about 30 days from the differentiation of floret to the completion regardless of species. The flower bud was almost completed in late September when all florets reached to the stage of pollen formation stage. The content of reducing sugar was high just after flowering in late May but after that decreased rapidly and did not change further. The content of non-reducing sugar was increased gradually during the examination. The starch content was increased continuously until July, early stage of flower bud differentiation. After that, it was decreased rapidly and showed the minimum level during August and September when the floret formation was at peak. In October when the floret formation was completed, starch content was rapidly increased again. It was thought that the starch which is storage sugar was used for flower bud formation, because of rapid decreasing of starch with the flower bud formation.

1340–1440
S19–P–19
INHERITANCE MODEL OF THREE MAJOR ANTHOCYANIDINS IN *EUSTOMA GRANDIFLORUM* CULTIVARS

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The inheritance of three major anthocyanidins, pelargonidin (Pg), cyanidin (Cy) and delphinidin (Dp) was studied by self- and reciprocal cross-pollina-

tions in lisanthus flowers. A clear phenetic segregation in the F2 population was observed with the presence of alleles for anthocyanidins synthase, which appeared basically with Mendelian ratios. However, prior to anthocyanidins synthase, B-ring hydroxylation in flavonoid biosynthesis was under regulation completely complementing each other between Pg- and Dp syntheses. The PgDp-phenotype does not exist and may accompany the Cy-phenotype. Based on these observations and Chi-square analysis, it is speculated that multiple allelism occurs in the B-ring hydroxylation system, with at least four alleles responsible for the flavonoid 3'- and/or 3', 5'–hydroxylase. The genotypes are presented as HT, HF, HD , and HO in lisianthus flowers, controlling 3'-; 5'-; 3', 5'-; and 3'- and 3', 5'-hydroxylation, respectively.

1340–1440

S19–P–20

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, at time when energy needs 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^3) 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

S19–P–21

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 2000/2001), 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.

1440–1500

S19–O–22

HERBACEOUS ORNAMENTAL PLANT GENEBANK—ITS ROLE IN THE FLORICULTURE INDUSTRY

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Ornamental plants encompass a vast number of plant genera and species from all climatic regions of the world. Many of them have thousands of years of domestication history and equally many new species are continuously being evaluated and introduced into our gardens. To date there is no specialized genebank in the world for conserving this vast amount of diversity. Most of the existing variations are in private collections of plant nurseries, seed companies and individuals, and in botanical gardens. Frequently, their emphasis is on specific groups of cultivars or clones and weak in representation of the entire range of variation of a species and its related species. This paper summarizes the existing plant materials stored at the USDA plant germplasm repositories of the US National Plant Germplasm System (NPGS) and describes the new USDA Ornamental Plant Germplasm Center at the Ohio State Univ.. An appraisal of the priority genera list (30 genera) formulated by the USDA Herbaceous Ornamental Crop Germplasm Committee was attempted. The genebanking procedure and the concept of long-term 'base collection' and medium-term 'active collection' will be illustrated. Networking and cooperation models undertaken between the Center and the botanic gardens and arboreta, horticultural and seed industry, species specific societies and association, and seed savers groups and individuals are presented. The collection, importation and utilization of germplasm will be discussed in relation to the Convention on Biological Diversity.

1500–1520

S19–O–23

BREEDING AND DEVELOPMENT OF NEW ORNAMENTAL PLANTS FROM NORTH AMERICAN NATIVE TAXA

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Perennial plant production and landscape utilization have increased steadily in recent years. The demand for new and varied herbaceous ornamental plants has likely never been greater. There has also been an increased interest in gardening with native plants due to concerns of nonnative plants potentially becoming invasive. In recognition of these trends, a program was initiated in 1995 to develop new ornamental crops from herbaceous taxa indigenous to North America. The program's goal is to develop through interspecific hybridization and selection, hardy perennial plants well adapted to the climate and landscape conditions of northern Illinois (USDA Hardiness Zone 5) and the Midwestern United States. Genera were selected based on four criteria: 1) including species indigenous to the Midwest; 2) including species or cultivated forms accepted by the gardening public; 3) potential for interspecific hybrid development based on the taxonomic and horticultural literature; and 4) minimal prior development of interspecific hybrids, or development was not with adaptability to the Midwest as the primary goal. Both wild collected germplasm and cultivated plants from nursery sources have been utilized. The target genera include *Asclepias* (milkweed), *Baptisia* (false indigo), *Echinacea* (purple coneflower), *Liatris* (blazing star), and *Penstemon* (beardtongue). Hybrid combinations that have been produced include *Asclepias* [*tuberosa* x *purpurascens*]; *Baptisia* [*australis* x l*eucophaea*], [*australis* x *sphaerocarpa*], [*sphaerocarpa* x *alba*], and [(*tinctoria* x *alba*) x *australis*]; two and three species crosses involving *Echinacea angustifolia*, *E. paradoxa, E. purpurea*, and *E. tennesseensis*;

two and three species crosses involving *Liatris aspera, L. ligulistylus, L. pycnostachya, L. scariosa,* and *L. spicata*; and numerous *Penstemon* hybrids. Several of these hybrid combinations have not been previously reported. The most promising selections will be highlighted.

1520–1540
S19–O–24
GLADIOLUS SCABRIDUS—THE ROAD TO CONSERVATION AND COMMERCIALISATION

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Southern Africa has the richest temperate flora of any area of comparable size in the world. These diverse and interesting species form an integral part of our natural heritage, hence the importance and value placed on each one. Despite this resource, little has been done to realize the commercial potential. Many of these species have also been classified as endangered and their conservation is an important process. In southern Africa there are at least 150 species of *Gladioli*. These popular and attractive flowers are commercially grown all over the world and many are hybrids which have been bred specifically, although a number of original species are grown commercially. *Gladiolus scabridus* is a vulnerable species with enormous commercial potential due to its unique floral characteristics. First named in 1978, it is endemic to the mountains of northern Kwazulu-Natal and southern Swaziland and is restricted to well-drained, rocky habitats. The large, bright pink flowers would make an attractive cut flower to satisfy ever increasing consumer demands for new products. However, little is known about its growth requirements. Therefore nutrient, water requirements and rapid propagation studies were done. Although originating from a stressful environment, they appear to show capacities for improved growth under controlled conditions. A successful tissue culture protocol has been established as have norms for postharvest handling. This information together with knowledge of its ecology, will allow for the promotion of its commercial production as well as aid the enhancement of its conservation status.

1540–1600
S19–O–25
INTERSPECIFIC AND INTERGENERIC HYBRIDIZATION IN BROMELIACEAE

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Hybridization is the most important source of genetic variation in breeding ornamentals. A large number of different varieties (forms and colours) are needed in order to satisfy the customers' demand. Leaves with armed (spined) margins are characteristic for the genus *Aechmea*. Interspecific crosses between spineless and spined *Aechmea* cultivars were attempted in order to obtain spineless offspring. Sufficient pollen germination (> 5%) of the parents (often F1-hybrids) was a crucial factor to achieve fertilization and seed formation. Crossing a spined and a spineless cultivar resulted in a progeny with 50% spineless plants. The hybrid products of two spineless parents had on average 75% spineless leaves. This indicated that the spineless character was dominant, although it had originated from mutation. Intergeneric hybrids between *Vriesea* and *Tillandsia* (*Vrieslandia*) and *Vriesea* and *Guzmania* (*Vriesmania*) were realised. Strong prefertilization barriers were observed (Vervaeke et al., 2001), but only minor postfertilization difficulties occurred. *Vrieslandia* had in part intermediate characters (leaf shape). Petal color, inflorescence shape and shoot formation resembled *Vriesea*, but bract colour was similar to *Tillandsia*. These new interspecific and intergeneric hybrids are unique for the bromeliad market. Ref. Vervaeke, I., Parton, E., Maene, L., Deroose, R. & De Proft, M.P. 2001. Prefertilization barriers between different Bromeliaceae. Euphytica 118: 91-97.

1600–1620
S19–O–26
DEVELOPMENT AND EVALUATION OF _CUPHEA SCHUMANNII_ AND _CUPHEA PULCHRA_ AS NEW LANDSCAPE ORNAMENTALS

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Two species of *Cuphea* are under examination as new floriculture crops for introduction into the production industry. This research involves development and evaluation of *Cuphea schumannii*, native to Mexico, and *Cuphea pulchra*, native to Brazil, as landscape ornamentals for temperate regions. The species *C. schumannii* and *C. pulchra* are characteristic of the genus as small shrubs bearing tubular, intense orange-red, ribbed flowers. Little information is known concerning flower physiology and no information is known regarding optimal production conditions for these two species. Greenhouse studies were established to assess the species growth and habit under controlled greenhouse conditions as well as to conduct experiments to produce information pertinent to commercial use and production such as propagation techniques, height control, optimum media pH, and irradiant levels. An outdoor bedding trial was conducted beginning May 31, 2002 in Columbus, OH, to evaluate the performance of *C. schumannii* and *C. pulchra* during the summer growing season in a landscape situation. Plants in the trial will be over wintered to determine if the two *Cuphea* species are perennial, as they are natively or annual ornamentals in a temperate climate. Bedding trial plants were evaluated bi-weekly for overall appearance, flowering, susceptibility to pests, and presence of pollinators. Digital photographs were taken to document trial progress. Both *C. schumannii* and *C. pulchra* perform well in the landscape with increasing growth throughout the season, continual flowering, minimal leaf damage by pests, and attracting bee and hummingbird pollinators. We conclude *Cuphea schumannii* and *Cuphea pulchra* both have great potential as profitable new floriculture crops.

1620–1640
S19–O–26–A
TO BE ANNOUNCED

1640–1700
S19–O–26–B
TO BE ANNOUNCED

Tuesday · August 13

1100–1140
S19–O–27
UNLOCKING THE HORMONAL AND MOLECULAR CONTROLS OF FLOWERING

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Highly sensitive measurements of gibberellin (GA) levels in the minute shoot apex in combination with studies of gibberellin synthesis and catabolism has begun to unlock one of the oldest mysteries in plants, namely the regulation of flowering. At earliest times of long day (LD)-induced floral evocation of the grass Lolium, levels of GA_5 and GA_6 double at the shoot apex. Days later there are larger (many-fold) increases in GA_1 and GA_4 content at the apex which, coupled with evidence from GA_4 applications, shows these later GAs act as secondary, late-acting LD stimuli involved with early inflorescence development. How GAs differ over time in their floral effectiveness reflects structure–specific inactivation by a GA hydroxylase enzyme. However, the structure of a GA can also be chemically-hindered so that it is no longer a candidate for the hydroxylase, a sparing role also evident on treatment with the synthetic plant growth retardant, Trinexapac ethyl. In horticultural species, inactivating enzymes could be particularly important for the promotion of growth and flowering by GA. Yet, paradoxically, GA may inhibit flowering and especially with tree species. However, unlike the responses associated with promotion of flowering by GAs, its inhibition clearly involves GA-mediated nutrient diversion. Our measurements of sucrose content of the shoot apex of fuchsia indicate that GA inhibits its early flowering response in LD by diverting assimilates away from the apex and into the growing stem. Furthermore, it is certain that flowering of fuchsia is regulated by sucrose supply because apex sucrose content and flowering increased in parallel with increase in light intensity in non-inductive short days. Clearly, a complete understanding of hormonally–regulated flowering must accommodate such multiple and sometimes conflicting actions of GAs.

1140–1200

S19–O–28

EFFECTS OF LOW LIGHT LEVELS DURING THE DARK PERIOD ON FLOWER DEVELOPMENT IN *EUPHORBIA PULCHERRIMA*

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Euphorbia pulcherrima is an important floriculture crop that naturally flowers in response to long night lengths. We observed that earlier flowering cultivars have a shorter critical night length and flower initiation occurs earlier under natural photoperiods. We compared cultivar responses to low levels of light during the long dark period and in one study with 'Freedom Red', 150 nE/m^2/sec of light from an incandescent bulb delayed, but did not prevent flower initiation. In a second experiment, four cultivars were grown under natural photoperiods or covered for a 16-hour dark period. Within those conditions they were given 0, 150, 1,500, or 7,500 nmole/m^2/sec of light. The 1,500 and 7,500 nmole/m^2/sec light levels prevented flowering of all cultivars under both natural photoperiods and the 16-hour dark periods. Under 16-hour dark periods, 150 nmol/m^2/sec delayed flowering of 'Orion', 'Red Splendor', 'Freedom Red' and 'Peterstar Red' by 11, 20, 25, and 39 days, respectively. Under natural photoperiods the delay was increased by 1 to 9 days. In a third study, plants were covered for 16 hours each night and then given 0, 3.5, 4, 4.5 or 5 hours of light at 150 nmol/m^2/sec. There was a significant interaction between cultivar and duration of the low light. At 0 hours of light, 'Orion', 'Freedom Red', 'Peterstar Red', and 'Success' flowered within 2 days of each other. However, at 5 hours of low light, the delay was 4, 8, 8, and 21 days, respectively. These studies indicated that low light delayed flower initiation, but did not affect rate of bud development following initiation. Also, the low light affected cultivars that naturally flower later more than early flowering cultivars, such as Orion.

1200–1220

S19–O–29

ANTHOCYANIN AND CAROTENOID PIGMENTS IN SPATHE TISSUE FROM SELECTED *ZANTEDESCHIA* HYBRIDS

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The flavonoid and carotenoid pigment profiles in the spathe tissue of several commercial cultivars of *Zantedeshia* (K Spreng.) were analysed as part of a project examining flower colour in this ornamental plant. *Zantedeschia* or calla lily is a perennial herb that is native to Africa but is grown world-wide both as a cut flower or potted plant crop. No information is currently available on the diversity of pigments present in spathe (flower) tissue although this would be useful both for further cultivar selection and as an indicator of ancestry. The cultivars chosen covered the colour range from maroon/dark red through pink, to orange, yellow, cream and white. Both anthocyanin and carotenoid pigments were detected, although as observed for other members of the Araceae, the pigment profiles were relatively uniform and individual pigments were of a simple type. The most common anthocyanin, present in the red and pink cultivars, was cyanidin 3-glucoside. The most common carotenoid pigment, present in the yellow cultivars, was lutein; while the orange cultivars had both pigments present but in different cell layers. Anthocyanins were observed only in the epidermis but the carotenoids were dispersed throughout the parenchyma tissue below the epidermis. Anthocyanin concentration in spathe tissue ranged from nil in the white and yellow cultivars up to 12 mg·g^{-1} DW detected in 'Majestic Red', a dark red cultivar. The greatest concentration of carotenoids (800 mg·g^{-1} DW) was detected in 'Florex Gold', one of the yellow cultivars. As well as anthocyanins, flavone C-glycosides accumulated in the spathe tissue. These compounds are colourless but can act as co-pigments and may have been responsible for the more subtle changes in spathe colour.

1220–1240

S19–O–30

TEMPERATURE AND PHOTOPERIODIC EFFECTS ON GROWTH AND FLOWERING OF *BRASSIA, DEGARMOARA, MILTASSIA,* AND *ZYGOPETALUM* ORCHIDS

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Flowering potted orchids have become the second-most valuable floriculture flowering pot crop in the United States, but detailed production information is unavailable for most orchid species. Scheduling orchid species to flower on specific dates requires knowledge of how environmental parameters regulate plant development from juvenility to maturity. We performed experiments to determine how temperature and photoperiod influence leaf development rate and flower induction of *Brassia* Rex Sakata, *Degarmoara* 'Winter Wonderland', *Miltassia* Charles M. Fitch 'Dark Monarch' and *Zygopetalum* Redvale 'Fire Kiss'. In one experiment, *Brassia* and *Zygopetalum* were placed into controlled-environment growth chambers with either 9- or 16-h photoperiods at constant temperatures of 14, 17, 20, 23, 26 and 29 °C. Leaf and inflorescence (spike) length, spike number, flower bud count, dates of the appearance of flower spikes and open flowers, and time to appearance of each node were recorded. In a separate experiment, all four orchid species were grown in a 23 °C greenhouse with a 16-h photoperiod, then were provided with a 9- or 16-h photoperiod for eight weeks, followed by exposure to constant temperatures of 11, 14, 17, 20 and 23 °C with 9- or 16-h photoperiods. Time to appearance of each inflorescent spike and time to flower were recorded, and at flowering, spike number and height and flower bud count were recorded. Average leaf unfolding increased as temperature increased from 14 to 29 C. A thermal-time model relating temperature with leaf development and flowering will be presented.

1340–1440

S19–P–31

FLOWERING RESPONSE OF *CLEMATIS* TO PHOTOPERIOD

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Clematis are often categorized into three groups based on when and where flowers develop on the plant. Group 1 plants flower on the previous year's growth (old wood), and natural flowering generally occurs from May to June. Group 2 plants also flower on old wood, but natural flowering generally occurs from June to August. Group 3 plants flower on the current year's growth (new wood), and natural flowering is from July to September. The flowering response under different photoperiods of four *Clematis* cultivars representative of each group was evaluated. Cultivars examined were *Clematis montana* 'Mayleen' (Group 1), *Clematis* 'Pink Cameo' (Group 2), Clematis 'John Paul II' (Group 2), and *Clematis* 'Madame Julia Correvon' (Group 3). Cold-treated plants were forced to flower under 10-h, 12-h, 13-h, 14-h, 16-h, 24-h, or night interruption (NI) photoperiods (9-hr natural day plus day extension provided by incandescent lamps). Plants were also forced to flower under a 16-hr photoperiod with day extension provided by high-pressure sodium lamps. *Clematis montana* 'Mayleen', a Group 1 cultivar, was day-neutral, flowering irrespective of photoperiod. Plants reached visible bud in 14 days and flowered in 30 days. *Clematis* 'Pink Cameo', a Group 2 cultivar, was also day-neutral and plants similarly reached visible bud in 14 days and flowered in 34 days. *Clematis* 'John Paul II', a Group 2 cultivar, was an obligate long-day plant, only flowering under photoperiods of 13-h or greater. Flowering plants reached visible bud in 85 days and open bloom in 104 days. *Clematis* 'Madame Julia Correvon', a Group 3 cultivar, was an obligate long-day plant, only flowering under photoperiods of 14-h and greater. Plants reached visible bud in 38 days and flowered in 56 days. For all cultivars, photoperiods 13 hours or longer were required for vining to occur. Photoperiods 12 hours or shorter induced dormancy of terminal meristems.

1340–1440

S19–P–32

TEMPERATURE EFFECTS FLOWER INITIATION AND DEVELOPMENT RATE OF *IMPATIENS, PETUNIA*, AND *VIOLA*

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Impatiens wallerana Hook f. ('Super Elfin Lipstick'), *Petunia* x *hybrida* Hort. ('Avalanche Pink' 'Dreams Rose', 'Wave Purple'), and *Viola* x *wittrockiana* Gams. ('Colossus Yellows Blotch', 'Crystal Bowl Supreme Yellow', 'Delta Pure White', 'Sorbet Blackberry Cream') were grown under different temperature regimes to

quantify the impact of temperature on flower initiation and development rate. Seeds were germinated under periodic mist (5 sec every 10 min) at 22 ± 2 °C. After cotyledons were horizontal to the media surface, seedlings were transplanted and were grown under an 8 hr photoperiod (non-inductive) at constant 18 ± 2 °C. After two weeks, 10 seedlings of each cultivar were placed in 4 growth chambers maintained at constant 12, 16, 20, or 24 °C with an 18 hour photoperiod (inductive; 350 $\mu mol \cdot m^{-2} \cdot s^{-1}$). Data were collected on days to first open flower (DTF) and leaf number below the first open flower when the first flower opened on each plant. DTF decreased from 112 ± 2 to 45 ± 1 day for *Petunia* 'Wave Purple'. DTF decreased from 68 ± 1 to 45 ± 1 day for *Viola* 'Sorbet Blackberry Cream' as temperature decreased from 24 to 12 °C. All Impatiens plants grown at 12 °C died. Interestingly, the number of leaves below the first open flower decreased for all plants as temperature increased, suggesting that the plants grown under higher temperatures flowered earlier developmentally. For instance, *V.* x *wittrockiana* 'Colossus Yellow Blotch' had 18 ± 1 leaves at 12 °C but only 13 ± 0 at 24 °C. The impact of temperature on DTF and leaf number below the first flower varied among cultivars of each species suggesting different levels of heat tolerance.

1340–1440

S19–P–33

REGULATION OF FLOWER PRODUCTION AND LATERAL SHOOT INDUCTION IN *ANTHURIUM ANDREANUM* USING BIOREGULATORS

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Bioregulators gibberellic acid (GA_3) and benzyl aminopurine (BAP) (250, 500, 750 and 1000 $mg \cdot L^{-1}$) were tried on 7–9 months old anthurium plants. The bioregulators did not affect the number, stalk length and size of the flowers significantly. However, the chemicals affected the angle between spathe and spadix and GA_3 500 $mg \cdot L^{-1}$ recorded the maximum angle between spathe and spadix. Biochemical analysis showed that the angle between spathe and spadix increased with an increase in content of Ca and Mg in the spadix. The potential of using growth regulators for manipulating the angle between spathe and spadix, a flower trait of commercial significance in anthurium is indicated. The lateral shoot production was significantly influenced by the bioregulator treatments. GA_3 750 $mg \cdot L^{-1}$ sprayed on topped anthurium plants produced the highest number of lateral shoots per plant. BAP 250 $mg \cdot L^{-1}$ sprays improved the production of lateral shoots in intact plants. Lateral shoots from GA_3 treatments were larger than those from plants sprayed with BAP.

1340–1440

S19–P–34

COLD-INDUCED CHANGES IN NON-STRUCTURAL CARBOHYDRATES IN TULIP BULBS

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A prolonged period of low temperature is required after the flower bud formation in tulip bulbs for subsequent growth, uniform flowering, fully formed normal flower parts, and floral stem elongation. As a part of the investigation into physiological and biochemical basis of cold requirement in tulip bulbs, we studied the changes in non-structural carbohydrates, induced by low temperature treatments. Tulip (*Tulipa gesneriana* L. cv. Apeldoorn) bulbs were stored at 17 or 4 °C for 12 weeks, and analyzed at 2-week intervals during storage. Bulbs were dissected into scales, basal plates and buds for carbohydrate analysis. The third scale of the bulb (counting from outside) was further divided into three longitudinal sections under the microscope to investigate the distribution of carbohydrates within that scale. Soluble carbohydrates were extracted with 80% ethanol and analyzed by high-performance anion-exchange chromatography with pulsed amperometric detection. Starch was determined by measuring the amount of glucose released after the digestion of ethanol extracted residue with amyloglucosidase. Starch was the most abundant non-structural carbohydrate in tulip bulbs (about 60%, 40%, and 25% of the dry weight in scales, basal plates and central buds, respectively). Soluble carbohydrates in tulip bulbs included fructans (comprising about 10% of the dry weight in scales and base plates, and about 5% in buds), and simple sugars such as sucrose, glucose and fructose. During the storage, the rate of starch break down was significantly higher in bulbs stored at 4 °C than bulbs stored at 17 °C. Starch break down in bulbs stored at 4 °C was accompanied with increasing concentrations of soluble fructans, sucrose, glucose and fructose. Within an individual scale, the starch break down and conversion into fructan, sucrose and monosaccharides was more intensive in the periphery of the scale compared to inner regions.

1340–1440

S19–P–35

QUANTIFYING FLOWER DEVELOPMENT RATE IN *PHALAENOPSIS TAISUCO* MOONRIVER X *PHALAENOPSIS EQUESTRIS* 'ALBA'

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Producing flowering plants for a specific market date requires knowledge of the relationship between temperature and flower development rate. Although *Phalaenopsis* orchids are now the fifth largest flowering potted plant according to 1998 USDA statistics and the second largest potted plant in the Netherlands in 2000, little specific quantitative information is available on the plant relating plant development rate to the environment. The objective of this investigation was to quantify the effects of temperature on time from spike emergence to flowering. Sixty *Phalaenopsis* H88-145 (*Phalaenopsis Taisuco* Moonriver x *Phalaenopsis equestris* 'Alba') plants with a 25cm leaf span were received from Taiwan, potted, then held at 25/20 °C day/night for 4 weeks after plant arrival to initiate flower spikes. Once flowering spikes were visible, plants were placed into one of six growth chambers with constant temperature set points of 14, 17, 20, 23, 26, or 29 °C under long days. Time to appearance of each node on the inflorescence spike, time to visible flower bud, and time to flower were recorded as were final flower size and flower number. Average time to visible bud increased from 5 weeks to 14 weeks as temperature decreased from 26 to 14 °C. Spikes on plants grown at 29 °C failed to initiate flowers or aborted buds shortly after they became visible. There was little variance in flower size and number on plants between temperatures except for 29 °C where plants only formed zero or one flower. A thermal-time model relating developmental stage and flowering will be presented.

1340–1440

S19–P–36

HIGH TEMPERATURE DIFFERENTIALLY REDUCES FLOWERING AND ALTERS MORPHOLOGY OF TWELVE PANSY CULTIVARS

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Twelve *Viola* x *wittrockiana* Gams. cvs. reported to vary in high temperature tolerance were grown in a greenhouse (20 ± 1.5 °C air temperature) until two true leaves unfolded. Ten plants of each cultivar were then moved to a 30 ± 1 °C air temperature greenhouse, while ten more remained in the 20 °C greenhouse. Plants remained in treatment until the first flower opened. Data were collected on leaf number below the first flower, lateral shoot number (>3 cm), peduncle length of the first flower, first flower diameter, flower bud number (buds >1 mm) and shoot and root dry mass when the first flower opened. Temperature and cultivar interacted to affect flower bud number, lateral shoot number, flower diameter and days to first flower opening. Leaf number below the first flower and peduncle length varied with cultivar and temperature. Increasing temperature from 20 to 30 ºC increased leaf number below the first flower of 'Crystal Bowl Primrose' from 6 ± 0 to 7 ± 0 leaves and of 'Skyline White' from 8 ± 0 to 9 ± 0 leaves. Increasing temperature from 20 to 30 °C increased peduncle length of 'Crystal Bowl Purple' from 62 ± 4 to 78 ± 3 mm, of 'Crystal Bowl Sky Blue' from 54 ± 10 to 77 ± 4 mm and of 'Delta Yellow' from 60 ± 4 to 79 ± 5 mm. The degree of flower bud reduction at 30 ºC compared to 20 °C varied from 23% for 'Crystal Bowl Purple' to 79% for 'Majestic Giants Red and Yellow'. The degree of flower diameter reduction at 30 °C compared to 20 °C ranged from 14% for 'Skyline Beaconsfield' to 44% for 'Super Majestic Giants Ocean'.

1340–1440

S19–P–37

LIGHT INTENSITY AFFECTS WHOLE-PLANT CO_2 EXCHANGE RATE AND WATER-USE-EFFICIENCY OF SUBIRRIGATED WAX BEGONIA

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Whole-plant CO_2 exchange rates for subirrigated wax begonia (*Begonia* x *semperflorens cultorum* Hort.) were determined under different light intensities. Plants were grown under four different daily photosynthetic photon fluxes (*PPF*) of 5.3, 9.5, 14.4, and 19.4 mol·day^{-1}, inside a semi-continuous, multiple-chamber, whole-plant gas exchange system for a period of 24 days. CO_2 exchange rates were determined at 20-minute intervals. Whole-crop net photosynthesis (Pn), dark respiration (Rd), gross photosynthesis (Pg), daily carbon gain (DCG, a measure of growth rate), and carbon-use-efficiency (CUE, the ratio of carbon incorporated into dry matter to the amount of photosynthates produced in Pg) were highest at 14.4 and 19.4 mol·day^{-1}. Photosynthesis-light response curves were determined at the end of the growth period. When PPF was increased from 0 to 700 µmol·m^{-2}·s^{-1}, Pn initially increased with PPF and reached light saturation at 700 µmol·m^{-2}·s^{-1} in all treatments. Light response curves were similar for plants grown at 14.4 and 19.4 mol·day^{-1}. The quantum yield was estimated as the initial slope of curves of Pn versus incident light at the top of the canopy, and increased with increasing light intensity. Water-use-efficiency was estimated from DCG and the amount of dry matter produced per liter of water lost in evapo-transpiration during a 24-hour period was 0.9, 2.0, 2.1, and 2.3 g·L^{-1} for plants grown at 5.3, 9.5, 14.4 and 19.4 mol·day^{-1}, respectively. Based on these results, growth of wax begonias would be expected to slow down significantly if they are grown at daily photon fluxes below 14.4 mol·day^{-1}, while plants grown at higher light intensities may not be superior in growth.

1340–1440

S19–P–38

DIFFERENCES IN PHOTOSYNTHETIC AND LEAF MORPHOLOGICAL PROPERTIES BETWEEN ROSETTING AND BOLTING PLANTS OF *EUSTOMA GRANDIFLORUM*

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Photosynthetic and leaf morphological properties in rosetting and bolting plants of *Eustoma grandiflorum* cv. Tsukushinoyuki were investigated. Seedlings were grown at high temperature of 30–34 °C after sowing. To release from rosetting, a half of them was exposed to cool temperature of 10 °C for 7 weeks, and transferred to high temperature again. When bolting occurred at high temperature, leaves of rosetting plants were thicker and had larger specific leaf weight, larger palisade cells and higher chlorophyll content, compared to that of bolting leaves. There was no difference in light saturated rate of CO_2 assimilation between both leaves. When the plants were fed with 13 CO_2 for 4 hours at 25–27 °C, amount of assimilated 13 °C was smaller in rosetting plants than in bolting plants on a dry weight basis. When it was expressed on a leaf area basis, amount of 13 °C assimilated in upper leaves was similar in both plants, however, in lower leaves it was smaller in rosetting plants compared with bolting plants. When compared to rosetting plants, bolting plants have an ability to increase growth rate, i.e., high rate of dry matter production or CO_2 assimilation on a plant basis. The increased photosynthetic capacity of bolting plant may be ensured by an improvement of light-intercepting efficiency due to the plant stand in elongated stem and their vertical leaves, not due to differences in photosynthetic capacity of individual leaves between rosetting and bolting plants.

1340–1440

S19–P–39

CHANGES IN THE AMOUNT OF CARBOHYDRATES OF ORIENTAL LILY BULBS AS INFLUENCED BY SUPPLEMENTARY LIGHTING DURING FORCING

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Following lily planting the reserve carbohydrates in mother scales are degraded and soluble sugars are transported to developing sprouts and daughter scales. The effects of additional lighting during lily forcing on carbohydrates and dry matter changes in mother and daughter scales were investigated. The experiment was conducted on oriental lily 'Star Gazer', grown in greenhouse at two light levels: natural light (control plants) and with additional lighting. At three growth stages (I–visible flower buds. II–buds 3-4 cm long and III–at flowering) plants were harvested and the level of starch, sucrose, glucose and fructose together with fresh and dry matter changes were determined. The obtained data show that additional lighting significantly influenced degradation of reserves in mother scales and accumulation of carbohydrates in daughter bulbs. The low light level during forcing increased the hydrolysis of reserves in mother scales observed as faster starch breakdown and higher concentration of of glucose and fructose compared with plants grown with additional lighting. The sucrose concentration did not vary very much among treatments, however, it was higher in plants grown at ambient light level. Proportionally to reserve carbohydrates depletion the decrease in fresh and dry weights of mother scales was observed. During plant growth the concentration of glucose and fructose in daughter bulbs decreased irrespectively the light level, however, the starch and sucrose concentration increased significantly at this time. At flowering, due to higher fresh and dry matter of daughter bulbs of plants grown with additional lighting, the accumulation of glucose, fructose sucrose and starch were 237%, 164%, 870% and 270% higher, respectively compared with control plants.

1340–1440

S19–P–40

TEMPERATURE EFFECTS ON WHOLE PLANT CO2 EXCHANGE OF MARIGOLD

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Temperature has an important effect on the growth and development of horticultural crops. In this study, we determined the effect of temperature on the CO_2 exchange rate of marigolds *(Tagetes patula* L.) throughout their development. Marigold 'Queen Sophia' seeds were planted in a sand/perlite mixture and germinated and grown inside CO_2 exchange chambers with a controlled environment. Plants were grown either at 20 or 30 °C and gas exchange of whole crops (36 plants) was measured once every ten minutes throughout a 60 day period (from germination to flowering). Light intensity at the top of the canopy was 410 µmol·m^{-2}·s^{-1}. Plants grown at 30 °C germinated faster and had higher photosynthetic and respiration rates than plants grown at 20 °C. Following canopy closure, there were distinct diurnal and nocturnal trends in CO_2 exchange of the plants. Photosynthesis was highest at the start of the light period an decreased throughout the entire light period, probably because of photorespiration and feedback inhibition. Dark respiration was high early in the dark period (possibly because of photorespiration and substrate availability), decreased during most of the dark period, but increased again at the end of the dark period. Carbon use efficiency (CUE, the ratio of carbon incorporated into plant dry matter to carbon fixed in photosynthesis) increased during germination and reached a maximum value of approximately 0.65 mol/mol (i.e., 65 % of photosynthates was converted into dry matter and 35 % was respired). Marigolds grown at 30 °C initially had a higher CUE than those grown at 20 °C, but a lower CUE during the latter half of the experiment. At 60 days after seeding, CUE had decreased to 0.52 and 0.46 mol/mol at 20 and 30 °C, respectively. Temperature effects on CUE appeared to be indirect, since changes in CUE were better correlated with the physiological age of the plants than with temperature.

1340–1440

S19–P–41

SUPPRESSION OF STEM AND INTERNODE ELONGATION BY A NEGATIVE DIF IN POT-GROWN MINIATURE ROSE CULTIVARS

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Experiments were conducted to determine the effect of difference between day and night temperatures (DIF) on the growth and flowering of miniature roses (*Rosa* x *hybrida*) 'Indian Meillandina', 'Colibri 79', 'Magic Carousel', 'Baby Masquerade', 'Yellow Meillandina', and 'Scarlet Meillandina'. In environment controlled growth chambers, rooted and pinched cuttings were grown at a 21.5 °C daily average temperature, but under three different DIF regimes. Day/night temperatures in zero, positive and negative DIF regimes were 21.5 °C/21.5 °C, 25.0 °C/18.0 °C, and 18.0 °C/25.0 °C, respectively. Photosynthetic photon flux of 180 $\mu mol \cdot m^{-2} \cdot s^{-1}$ was provided by cool-white fluorescent lamps during the 12 $h \cdot day^{-1}$ photoperiod. For all treatments, CO_2 was supplied at 1000 $mmol \cdot mol^{-1}$ during the day and relative humidity was maintained at 80 ±5%. Plant height was measured weekly, and the experiment was terminated when 60% of plants reached to anthesis. Plant height and internode length of all cultivars were strongly influenced by DIF. Final plant height in all cultivars was about 5–8 cm shorter in negative DIF than in positive or zero DIF treatment. Stem diameter was either not affected by DIF or was enhanced in negative DIF treatment depending on cultivars. In all cultivars, leaves became more upright and chlorophyll content increased with increasing DIF. However, days to anthesis and root growth were little affected by DIF. Number of lateral shoots, mean number of nodes, and leaf area showed cultivar difference. It is concluded that negative DIF resulted in suppressed plant height and length of internodes without an adverse effect on the growth of miniature rose cultivars grown as pot plants.

1340–1440

S19–P–42

PRODUCTIVITY AND PERIODICIETY OF FLOWERING IN *HELICONIA ORTHOTRICHA* CULTIVARS

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Medium flower size, bold coloration, good keeping qualities and a long season of bloom characterize selections of *Heliconia orthotricha*, a species relatively new to the palette of bold tropical cut flowers. An evaluation of four cultivars, Eden Pink, Garden of Eden, Macas Pink, and Candy Cane was conducted over a 2-year period to determine their seasonality of flowering and productiveness, and developmental progression from shoot emergence to flower harvest. The shortest time frames for shoot emergence to flower harvest and the month in which the shoot emerged were Eden Pink 155 days (April), Garden of Eden 125 days (May), Macas Pink 160 days (April), and Candy Cane 123 days (May). The longest time frames for shoot emergence to flower harvest and the month in which the shoot emerged were: Eden Pink 283 days (September), Garden of Eden 228 days (October), Macas Pink 291 days (September), and Candy Cane 206 days (October). Approximately 50% of the flowers of each cultivar were harvested during summer months, but all produced some flowers throughout the year. Per plant productivity during their first harvest year ranged from a low of 40 for Eden Pink to 54 for Candy Cane and Macas Pink and 57 for Garden of Eden. All four cultivars may be characterized as welcome additions to the export markets for tropical flower producers.

1340–1440

S19–P–43

EFFICACY OF PLANT GROWTH REGULATORS ON THE GROWTH OF *ARGYRANTHEMUM FRUTESCENS* 'COMET PINK'

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Due to the vigorous growth habit of *Argyranthemum frutescens*, commercial greenhouse growers face the challenge of maintaining a short yet robust plant that is proportional to pot size. The cultivar Comet Pink was treated with foliar sprays of various plant growth retardants (PGRs): daminozide (2,500 to 10,000 $mg \cdot L^{-1}$), flurprimidol (25 to 125 $mg \cdot L^{-1}$), uniconazole (5 to 80 $mg \cdot L^{-1}$), or paclobutrazol (20 to 160 $mg \cdot L^{-1}$) + daminozide (1250 $mg \cdot L^{-1}$) or manually pinched to determine the effect on height, diameter, and days to anthesis. Although there was no delay in flowering when compared to the control, height and diameter were not controlled with the highest concentration of daminozide or the highest tank mix concentration of paclobutrazol + daminozide. Control of plant height was observed when *Argyranthemum* plants were pinched to the fifth node from the stem base, or sprayed with flurprimidol at concentrations _ 50 $mg \cdot L^{-1}$ or uniconazole at concentrations _ 40 $mg \cdot L^{-1}$. Flowering was not delayed on plants treated with PGRs, but pinching delayed flowering by 6 days, when compared to the control. Plant diameter was not affected except for plants sprayed with flurprimidol at 125 $mg \cdot L^{-1}$. Excessive stunting and phytotoxicity was observed with flurprimidol at concentrations _ 100 $mg \cdot L^{-1}$.

1340–1440

S19–P–44

EFFECTS OF THE FREQUENCY AND THE DUTY CYCLE OF THE LED PULSE IRRADIATION ON THE GROWTH OF SAINTPAULIA AND LETTUCE

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Light Emitting Diode (LED) has the features of a simplicity of making pulse lights and a possibility of short distance irradiation and selecting wavelength. The spectrum of the wavelength of LEDs almost correspondents with that of the light which plants use during photosynthesis. It has been proposed that LED should be used as a light source to grow plants and many experiments have been conducted. Although light is indispensable to the growth of plants, the dark reaction of photosynthesis does not require light. There are significant benefits to growing plants using lower energy and lower costs. It is said that fluctuation and sunshine filtering through foliage improve the growth of plants, but there is not much quantitative data. In this study, the effects of the frequency and the duty cycle of LED on the growth of young Saintpaulia and lettuce were observed as a fundamental experiment. They were grown in separate chambers for four weeks. An illuminator, which consists of LEDs, was used as a light source. The plants were irradiated by the illuminator in two ways; the illuminator was used in different frequency and different duty cycle (=ratio of a turn-on time and a cycle of a pulse waveform). The lighting was turned on for 8 hours and off for 16 hours. Photosynthetic Photon Flux Density (*PPFD*) and the total energy of each test section were set equally. As a result of the experiments, the plant growth varied according to the frequency and the duty cycle.

1340–1440

S19–P–45

EFFECT OF PLANTING DEPTH ON GROWTH AND FLOWERING OF *ORNITHOGALUM SAUNDERSIAE* BAK. BULBS

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Ornithogalum saundersiae Bak. is one of the important cut flowers exported from Kenya. It is popular due to its attractive, nicely scented and long lasting flowers. Although this cut flower has been commercially grown in Kenya for over ten years and inspite of its popularity, growers still use trial-and-error methods to produce these cut flowers. This is because there are no research-based recommendations on the cultural practices of *O. saundersiae* available for reference. A study was carried out with the aim of investigating the effect of planting depth on growth and flowering of *O. saundersiae* and also determining the optimum planting depth for the bulbs. Bulbs of *O. saundersiae* were planted at 5, 10, 15 and 20 cm depth. At commercial flower harvest stage, bulbs planted at 5 cm had the tallest plants measuring 45.2 cm while bulbs planted at 20 cm had the shortest plants measuring 37.6 cm. The average number of shoots, visible leaves per bulb as well as the length of inflorescence decreased with increasing planting depth. The inflorescence average length at 5, 10, 15 and 20 cm was 85.0, 80.4, 77.4 and 63.8 cm, respectively. Days to commercial flower harvest increased as the planting depth increased. Bulbs planted at 5, 10, 15 and 20 cm reached flower harvest stage 119, 131, 125 and 138 days after planting, respectively. At full plant maturity the average number of daughter bulbs, their sizes and the total number of nodes per bulb generally decreased with increasing planting depth. Planting depth had no significant effect on number of florets and diameter of inflorescence. The best growth and flowering performance was observed in bulbs that were shallowly planted (at 5 cm). Deep planting, at 20 cm, adversely affected the growth and flowering of *O. saundersiae* bulbs.

1340–1440
S19–P–46
REQUIREMENTS FOR FLOWERING OF FORGET-ME-NOT

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The cyme inflorescence of forget-me-not (*Myosotis alpestris, Myosotis sylvatica*) is desired in corsages, small floral designs or as a flowering potted plant. Commercial availability is limited because adequate production guidelines and proper procedures for post-harvest handling are missing. Eight cultivars including selections with blue, white and pink flowers were evaluated for rate of development, growth habit and flower display. Six weeks after seeding the temperature was dropped to 6 °C. After 3, 6, 9 or 12 weeks, plants were moved to 16 °C, 16 hours day length and 8.6 $mol \cdot m^{-2} \cdot d^{-1}$. Flowers appeared faster after a longer cold period. Increasing the cold from 3 to 6 weeks reduced time to flower by approximately 2 weeks. Another 3 weeks of chilling reduced flowering time with 7 more days and 12 weeks of chilling, yet another 7 days. On average, 21 days were required at 16 °C for the appearance of the first flowers after 12 weeks of cold. Plants grown at 16 °C without any chilling did not flower during the 7-month duration of the experiment. Pinching the plant at the beginning or end of the 6 °C treatment generally resulted in faster flowering compared to intact plants. The plant branch number varied from 3 to 4 and increased to between 8 and 12 with a pinch treatment. The response to chilling, the rate of development and growth habit varied both within and among cultivars. The best suited cultivars for production of cut flowers or as potted plants of forget-me-not are identified based on growth habit, plant architecture and rate of development.

1340–1440
S19–P–47
EFFECTS OF TEMPERATURE, HUMIDITY, AND LIGHT INTENSITY ON THE GROWTH OF KALANCHOE (*KALANCHOE BLOSSFELDIANA* POELLN.) 'MARGRETHE' CUTTINGS

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Two growth chambers (E15, Conviron, Canada; KG-104, New Power Engineering, Korea) were used for the experiment. Six fully leaved cuttings were inserted to 50 hole cell tray filled with media (Perlite:Peatmoss = 1:1 by volume), and mat system was used for irrigation during the experiment. Temperature (ADT) was treated with 17/17, 20/20, 23/23, and 26/26 (day/night) °C, and DIF was treated with 24/22 (+2DIF), 23/23 (0 DIF), 22/24 (–2DIF), and 21/25 (–4DIF) °C among constant temperature treatment 23/23 °C. Rooting was faster at 23/23 and 26/26 (day/night) °C than 17/17 and 20/20 (day/night) °C whereas growth of cuttings was good at 23/23 (day/night) °C. When DIF went to minus, shoot length became shorter. The growth of cuttings was good at 23/23 (0DIF) and 22/24 (–2DIF) as DIF was treated to cuttings, but disorder happens on 21/25 (–4DIF). Four levels of relative humidity (55, 65, 75, 85%) were employed during experiment. Rooting was faster at 75–85% RH, than 55 and 65% RH, whereas 65% RH was good for the growth of cuttings. To investigate the optimum light intensity for kalanchoe cuttings, in experiment 1, PPFD (300, 400, 500, 600 PPFD) were employed from planting to the end of the experiment. In experiment 2, 300 PPFD was used during rooting, and after rooting, PPFD was treated with four levels(300, 400, 500, 600 PPFD) until the end of experiment. PPFD was optimum at 300, 400 PPFD for rooting but 400 PPFD was good for the growth of cuttings. Dry matter of cutting increased when PPFD increased, whereas leaves became yellow at 600 PPFD. The growth of cuttings was adequate at 400 PPFD even when cuttings were first treated with 300 PPFD during rooting. Thus, to cultivate *K. blossfeldiana* 'Margrethe', the optimum environment condition was 23/23 or 22/24 °C, 75% RH, and 400 PPFD.

1340–1440
S19–P–48
ESTIMATING POTENTIAL GROWTH OF SINGLE-NODE CUTTINGS IN ROSES FOR APPLICATION TO FACTORY SYSTEM

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To apply single-stemmed roses (SSR) to a factory system, rooting, shooting, and flowering characteristics of single-node cuttings (SNC) in cut roses 'Rote Rose' and 'Teresa' were studied. In the cutting conditions such as growth stage (GS), node position (NP), and leaf area (LA), LA showed as the main factor to influence rooting and shoot growth in SNC as LA accelerated rooting and shooting and improved shoot quality for cut flowers. NP affected the flowering rate and shoot quality like the height and fresh weight. Especially flowering shoots from SNC with a length of more than 45 cm, which is suitable to rose factory system, benefitted from a greater LA and a lower NP. Therefore, high quality cut flowers from SNC could be obtained by using a 5-leaflet single node located in the basal part. But there was no effect of GS. On the other hand, the width of shoot in SNC increased significantly above 15cm after the appearance of the floral bud in shoots, on which the LAI of SSR were maintained above 1 and the SLA was suddenly decreased. The expansion of planting density from 7.5 x 7.5cm to 7.5 x 15cm resulted in improving the flowering quality: 5% more in height, 10.4% more in petal number, and 32.6% more in dry mass of shoots. Therefore, the shoot potential growth in SNC could be improved through controlling LA and NP together with planting density.

1340–1440
S19–P–49
PERSISTENCE OF PLANT GROWTH REGULATOR EFFECTS ON PERENNIALS IN THE NURSERY

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There are still many unknowns in the production of containerized herbaceous perennials. We are screening herbaceous perennials for their response to several different plant growth regulators (PGRs). Under early summer conditions, the grower would like to know how long PGRs will hold back plant growth in the container. Uniform plants selected from nursery stock, were treated with one of the following foliar applications: 5000 ppm daminozide (applied twice), a tank mix of 5000 ppm daminozide and 1,500 ppm chlormequat, 500 ppm ethephon (applied twice), paclobutrazol at 0, 40, 80, 120, or 160 ppm or uniconazole at 0, 15, 30, 45, or 60 ppm. Plant height of *Heliopsis helianthoides* 'Summer Sun' was not significantly affected by paclobutrazol or uniconazole treatments, but plants treated with daminozide or the tank mix were less than half the height of the untreated controls. These height reductions persisted through 12 weeks after treatment (WAT). Ethephon caused 15% to 18% reductions in plant height that persisted through 12 WAT, but did not delay flowering. *Gaura lindheimeri* 'Corrie's Gold' was very responsive to all the tested PGRs but the effects of paclobutrazol were more persistent in the nursery container than those of uniconazole. Ethephon reduced plant height over 25% at 4 and 6 WAT, but the effect was no longer significant at 8 WAT. *Hypericum calycinum* was not responsive to daminozide, the tank mix, ethephon or paclobutrazol treatments, but uniconazole treatments resulted in linear reductions in plant height that persisted through 8 WAT. These results suggest that PGR rates may be selected to provide growth control for up to 12 weeks under nursery conditions.

1340–1440
S19–P–50
CONCENTRATION AND APPLICATION METHOD OF PACLOBUTRAZOL AND UNICONAZOLE AFFECT GROWTH AND FLOWERING OF KALANCHOE 'RAKO'

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Effect of concentration of paclobutrazol and uniconazole applied as drench or foliar spray on the growth and flowering of kalanchoe (*Kalanchoe blossfeldiana*) 'Rako' were examined. Both materials were applied twice, 7 and 17 days after pinching. At each drench treatment, 100 mL of 2.0, 4.0 or 8.0 $mg \cdot L^{-1}$ paclobutrazol and 100 mL 0.5, 1.0 or 2.0 $mg \cdot L^{-1}$ uniconazole were applied. At each foliar spray application, 240 mL per m2 of 20, 40 or 80 $mg \cdot L^{-1}$ paclobutrazol or 240 mL per m^2 of 10, 20 or 40 $mg \cdot L^{-1}$ uniconazole were applied. Plant growth and flowering, such as plant size, number of flowers,

flower stem length, number of flowers per stem, and days to flower, in these treatments were compared to the untreated control. Drench application of paclobutrazol at 2 mg·L^{-1} reduced plant size and flower stem length without affecting number of flowers per plant and days to flower. Drench application of uniconazole at 0.5 mg·L^{-1} reduced plant size, flower stem length, and number of flowers per plant. Paclobutrazol applied at 20 mg·L^{-1} as foliar sprays reduced plant size and flower stem length without affecting number of flowers per plant and days to flower. Uniconazole foliar sprayed at 10 mg·L^{-1} showed similar results except delayed flowering. Although all treatments had significant effect on suppressing plant size, drench applications required a lot more growth retardant due to increased amount of application.

1340–1440

S19–P–51

ARE THERE ANY OTHER SUBSTANCES LIKE CHITOSAN IN *EUSTOMA GRANDIFLORUM* (RAF.) SHINN.?

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Seeds of *Eustoma grandiflorum* (Raf.) Shinn. are very small and the growth of seedlings is slow. However, the growth of seedlings is fastened by a mixture of 1% chitosan. This study looked at alternate substances by which the seedlings are fastened like chitosan. Seeds of *E. grandiflorum* cv. Peter blueline 2 were sown in the sandy loam mixed with 1% of either chitosan, tryptone, casein, collagen or gelatin using 72-hole polystylene foam trays. At 8 and 11 weeks after sowing, leaf length and width, fresh and dry weight of the shoots and roots of 12 plants per treatment were determined. N, P, K, Ca and Mg in the plant of each treatment were measured using respective detector. NO_3-N in the soil was measured by NO_3 specific ion meter. When the seedlings reached three-pair true-leaf stage, 15 seedlings from each treatment were randomly lifted and transplanted into a plastic container filled with sandy loam : bark (1:1). At flowering time, first flowering day, leaf number, the weight of cut flower and flower number were determined. At 11 weeks after sowing, leaves of fifth node had expanded only in chitosan, tryptone and collagen soil treatments. Fresh and dry weights of shoot and root were remarkably increased by chitosan and tryptone soil treatments. N, P and K in shoot increased only in N side dressing. N and K in roots increased only in the above treatment. NO_3-N in the soil increased in tryptone and collagen treatments. First flowering day was fastened in chitosan, tryptone, casein and collagen treatments. The leaf number and weight of cut flower increased in chitosan and tryptone treatments. The flower number also increased in these treatments. Considering all the data, tryptone was equally effective as chitosan for growth and flowering of *E. grandiflorum*.

1340–1440

S19–P–52

INTERACTION OF METHYL JASMONATE AND 1-AMINOCYCLOPROPANE-1-CARBOXYLIC ACID (ACC) IN REGULATION OF SOME PHYSIOLOGICAL PROCESSES IN UNCOOLED AND COOLED TULIP BULBS

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It has been found that methyl jasmonate (JA-Me) applied in lanolin paste induced gummosis in bulbs, stems and basal part of leaves of tulips. In this work we report the interaction of JA-Me with ACC in regulation of the following physiological processes in uncooled and cooled bulbs of rooted and derooted Apeldoorn and Oxford cultivars of tulips: gum induction, ethylene production, ACC oxidase activity, anthocyanin accumulation, and CO_2 evolution. JA-Me greatly increased ethylene production from simultaneously applied ACC, through stimulation of ACC oxidase activity, in comparison to ACC applied alone. ACC evidently inhibited anthocyanin accumulation induced by JA-Me applied simultaneously. CO_2 evolution was similar after treatment with JA-Me, ACC and their mixture. Similarly, as was previously reported, simultaneous application of JA-Me with ACC induced gum formation more than these coumponds applied individually. Thus, interaction between JA-Me and ACC (ethylene) is synergistic in regulation of some physiological processes.

1340–1440

S19–P–53

VEGETATIVE ANNUALS VARY IN RESPONSE TO PLANT GROWTH REGULATORS

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Vegetative annuals are specialty floriculture crops propagated vegetatively rather than by seed as are most traditional annual bedding plants. The objective was to ascertain the effects of plant growth regulators (PGRs) on growth and flowering of sixteen vegetative annual cultivars to produce compact, well-proportioned plants that do not require excessive greenhouse bench space and are easy to ship. Plants were received as rooted cuttings in 82 to105-cell plug trays 16 Jan. 2001. All plugs were transplanted into 10-cm pots and grown under natural day length at greenhouse set points of 21 °C day and 19 °C night throughout the experiment. Plant growth regulators were applied on 1 Feb. Daminozide (5000 mg·L^{-1}) or a tank mix of chlormequat (1250 mg·L^{-1}) and daminozide (2500 mg·L^{-1}) were applied as foliar sprays to run-off. Paclobutrazol (50 mg·L^{-1}) was applied as a foliar spray at 204 mL·m^{-2}. Plant height, plant width and number of flowers were measured when plants were marketable. Growth responses varied among plant growth regulators and cultivars. Optimum height (erect plants) was determined to be a 20–25% reduction and optimum plant width (trailing plants) a 40-45% reduction compared to controls. Paclobutrazol reduced plant height by reducing foliage height and pedicle length on *Argyranthemum* 'Sugar Baby'. Paclobutrazol gave the optimum reduction in plant width for *Bacopa* 'Giant Snowflake' and 'Lavender Showers' and asteriscus 'Compact Gold Coin' whereas the other PGR treatments reduced growth more than the optimum amount for these cultivars. The tank mix gave optimum growth reduction for calibrachoa 'Million Bells Cherry Pink', supertunia 'Royal Velvet', and verbena 'Twilight Blue with Eye', but flowering was delayed for supertunia 'Royal Velvet'. Six of the remaining cultivars had negligible growth control at the rates used and three cultivars were not affected by any of the PGR treatments.

1340–1440

S19–P–54

TEMPERATURE CONTROL OF THE RATE OF DEVELOPMENT IN SHORT-DAY AND LONG-DAY PLANTS DURING VEGETATIVE STAGE OF ONTOGENESIS

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Combined effect of photoperiod and temperature on plant growth and vegetative development is poorly studied (Porter, Delecolle, 1988). The role of diurnal temperature gradients in the responses of plants of different photoperiodic groups is not clearly understood. Duration of developmental stages was used as an index of developmental rate in early ontogenesis (Rabotnov, 1950). Model plants were soybean (short-day plant–SDP) and wheat (long-day plant–LDP). Experiments were conducted in growth chambers. Multifactoral planned experiment was designed to test the effect of different combinations of day and night temperatures at photoperiods 8, 12, 16 and 24 h. During 24-hours illumination the thermoperiod was 12 h. It is established that temperature dependence of plant developmental stages duration can be described by quadratic equation. Optimum regions of day and night temperatures for the rate of development were constructed according to equations. It was shown that for SDP soybean optimum temperature regions under conditions of different photoperiod overlap and maximum developmental rate is reached at zero DIF (TD/TN 29/29 °C) irrespective of photoperiod. For LDP wheat optimum temperature regions shift from positive DIF to the constant mean diurnal temperature with the increase of photoperiod duration from 8 to 16 h.; maximum developmental rate was observed at TD/TN 35/15 °C (at photoperiod 8 h), 29/24 C (12 h), and 25/25 °C (16 h). Under 24-hours illumination the fastest development of wheat plants was observed at negative DIF and the maximum value at thermoperiod 20/23 °C. Thus, in the explored temperature range development of LDP was accelerated by the increase of the day length, while for SDP there was a wide range of temperatures where the day length did not affect the rate of development. These data testify to the different role of temperature in the development of plants of different photoperiodic groups during vegetative stage of ontogenesis.

1340–1440

S19–P–55

INFLUENCE OF LIGHT ON FRESH AND DRY WEIGHT PARTITIONING OF ORIENTAL LILIES DURING FORCING

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During winter forcing the quality of oriental lilies is often reduced as the result of insufficient light level. The effect of additional lighting on fresh and dry matter distribution of two oriental lily cultivars 'Star Gazer' and 'Laura Lee' was investigated and compared with plants grown at ambient light conditions. At 2-week intervals, plants were harvested and their fresh and dry weights of organs such as bulbs, stems, leaves and flowers were determined. The fresh and dry weights of lily bulbs (mother and daughter portion) decreased sharply during the initial six weeks of growth, meanly about 70% in both cultivars. The depletion of bulb weight in plants grown in ambient light level was observed until the flowering. The progressive increase in fresh and dry weights of bulbs of plant grown with additional light was observed from the tenth week till flowering, due to daughter bulbs enlargement. The rate of fresh and dry matter accumulation in leaves and stems was greater when light levels was higher. Since the eight week of growth the fresh and dry weights of these organs increased only in plants grown with additional lighting. Additional lighting throughout the forcing period strongly increased flower buds fresh and dry weights in both cultivars. At flowering the fresh weight of flower buds was 3 and 1.4 times higher in 'Laura Lee' and 'Star Gazer', respectively, compared with plants grown at ambient light conditions.

1340–1440

S19–P–56

EFFECTS OF RINGING AND BA FOLIAGE TREATMENT ON CUT FLOWER QUALITY OF *PRUNUS LANNESIANA*

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Japanese flowering cherry trees are normally grown in a field and stems having flower buds are harvested and forced as a cut flower in early spring. Production is unreliable due to uneven flower bud formation on the stems. In order to improve cut flower quality, timing of ringing and BA treatment was investigated. Ringing from mid to late July in 'Toukaizakura', and from early to mid August in 'Keiouzakura' produced a larger number of flower buds per stem. BA (300ppm) foliage treatment between early July and mid August was also effective to increase flower buds. Ringing and BA treatment improved the cut flower quality, resulting in stable cut flower production of Japanese flowering cherry

1340–1440

S19–P–57

CHARACTERISTICS OF GROWTH AND DEVELOPMENT OF *CALANTHE* DISCOLOR

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This study was conducted to investigate the characteristics of growth and flowering of *Calanthe* discolor which was cultured under the unheated plastic house in order to get the basic data for flowering control of *Calanthe*. When the mean temperature becaome above 5 °C in April, the flower bud sprouted and about 10 days after the inflorescence emerged. The flowering was observed in late April when mean temperature went up to 10 °C and florets wilted in mid May. Duration of flowering was about 15 days. As a result of observation of axillary buds which were detached at the 4th, 5th and 6th node from the base of stem after flower wilting, 4th buds produced six scaly leaves and after that did not grow further. However, 5th and 6th buds produced nine scaly leaves and were developed into flower buds in early July when the mean temperature went up to 200 °C. Flower bud formation progressed in order of growing point enlargement, primordium of bract, floret, petal, sepal and column, and lastly pollen. Flower bud differentiation began in early July when the mean temperature was over 20 °C. After that, florets of various developmental stage were observed. A pollen formation which reached to the stage of floret completion was observed in early August. It took about 30 days from the differentiation of floret to the completion regardless of species. The flower bud was almost completed in late September when all florets reached to the stage of pollent formation stage. The content of reducing sugar was high just after flowering in late May but after that decreased rapidly and did not change further. The content of non-reducing sugar was increased gradually during the examination. The starch content was increased continuously until July, early stage of flower bud differentiation. After that, it was decreased rapidly and showed the minimum level during August and September when the floret formation was at peak. In October when the floret formation was completed, starch content was rapidly increased again. It was thought that the starch which is storage sugar was used for flower bud formation, because of rapid decreasing of starch with the flower bud formation.

1340–1440

S19–P–58

EFFECT OF DIFFERENT GREENHOUSES ON FLOWERING OF *ALSTROEMERIA*

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Ornamental horticulture is becoming a very important economic activity in some countries. It is a dynamic market that needs a production redistribution based on climatic conditions, soil cost, commercial distribution and production and postharvest technologies. *Alstroemeria* culture for cut flower production has greatly improved in the last years in Europe, especially since a number of new hybrids have appeared with good qualities that are suitable for glasshouse culture. The objective of our study is to determine if *Alstroemeria* could be a culture in Madrid region. Due to *Alstroemeria* culture is limited to temperature climate regions, we study in present work the effect of six greenhouses on flowering of ten *Alstroemeria* varieties during three years. The greenhouses (made of plastic or glass) were provided with heating and lighting support. First year two plastic greenhouses and one glass greenhouse produce a large flowering period. In the two late years, the results show that glass greenhouses produce a longer flowering period than plastic ones. In glass greenhouses the longer flowering period was obtained when heating and lighting was supplied.

1340–1440

S19–P–59

CONSTANT COMPARED TO FLUCTUATING CONTROLLED WATER TABLE IRRIGATION ON GERANIUMS

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A controlled water table irrigation system (CWT) automatically provides water to plants. One edge of a capillary mat on the bench surface draws water from a trough (water table) below the bench. The distance of the water table below the bench determines the growing medium water potential, water and oxygen content. In previous studies a constant CWT of 2 cm below the bench surface was the optimum placement for producing 15 cm pots of geranium. This study was conducted to compare a constant CWT with a fluctuating CWT; the systems operated day (D) and night (N) or only during the D. Geraniums were grown in 15 cm pots for 8 weeks. Treatments: 1. CWT 2 cm, D & N; 2. CWT 2 cm, D; 3. CWT max. 2 cm, min. 4 cm D & N; 4. CWT max. 2 cm, min. 4 cm, D. The fluctuating treatments were established by using two liquid level controllers connected to a switching mechanism that allowed the water table to fluctuate between 2 cm, max., and 4 cm, min., below the bench. One liquid level controller was used for the constant CWT treatments. The rate of movement of the water table from 2 to 4 cm was determined by the rate of transpiration and evaporation. As the water table slowly dropped from 2 to 4 cm, the growing medium water potential decreased the water content decreased and the oxygen increased. Turning the system off at N and allowing the water table to drop to a level in the trough determined by the evaporation rate reduced the leaf area. Plants irrigated with the fluctuating CWT had the same leaf area as those on the constant CWT.

1340–1440

S19–P–60

MANAGING HIGH FERTILITY AND SALINITY ISSUES IN GREENHOUSE ROSE PRODUCTION

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Greenhouse rose production is one of the most intensive ornamental cropping systems, with the high productivity rates of this crop demanding high water and nutrient inputs, particularly nitrogen (N). Fertilization recommendations for this crop call for annual N application rates, through liquid feeding, as high as 7000 to 9000 kg/ha. This excessive N use in roses has been brought up by the perception that if N is the nutrient that most dramatically influences crop productivity then it must be liberally applied to avoid falling into N deficiency conditions and sustain high yields. Our research indicates that such N application rates are in excess of crop demand, with leaching losses in excess of 50% of the applied N. We have found that reduction of liquid feeding N concentrations by as much as half of those currently used can sustain rose productivity and quality while significantly minimizing leaching losses. Furthermore, we have found a cyclic nutrient uptake behavior linked to the different growth and development stages (phenology) of the rose crop, opening the possibility of tight regulation and matching of nutrient delivery to crop demand. Roses have historically been categorized as salt-sensitive, an observation that contrasts with their high fertility management and current legislative pressures to recirculate drainage greenhouse effluents. Some of our recent research has revealed that rose plants can in fact tolerate relatively high NaCl salinity levels (up to 30 mM) without significantly affecting flower yield and quality. This response appears to be significantly affected by rootstock selection. Interestingly, an apparent positive effect of moderate Cl applications on rose yield was also found. These advances in the nutrition and cultural management of this crop, along with the development of efficient irrigation and water recycling/recirculating technologies promise a minimization of environmental impacts while sustaining rose productivity and quality.

1340–1440

S19–P–61

COMPARISON OF POURTHRU AND SATURATED MEDIA NUTRITIONAL VALUES

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Most commercial and university substrate testing laboratories' recommended floriculture nutritional values are based on the saturated media extract (SME) method. With the recent gain in popularity of PourThru nutritional monitoring, alternative recommended values are needed. Therefore, PourThru nutritional values were compared to the SME values to develop recommended nutritional values. Euphorbia pulcherrima 'Freedom Red' Willd. ex Klotzch. were grown in 16.5 cm plastic pots with Fafard 4-P root substrate and fertigated with 100, 200, 300, or 400 mg/L N from a 13N-0.88P-10.8K fertilizer. PourThru and modified SME extractions were performed at 0, 3, 6, 9, and 12 weeks (0 representing potting of rooted cuttings) and analyzed for pH (prior and post SME vacuum extraction), electrical conductivity, divalent cations (Ca and Mg), monovalent cations (K, NH4) and monovalent anions (NO3, H2PO4). Linear relationships existed among all nutritional parameters (R^2 ranged from 0.9346 to 0.9959). The established relationships will allow substrate testing laboratories to make nutritional recommendations based on PourThru extractions.

1340–1440

S19–P–62

COMPOST AMENDED MEDIA FOR BED CULTURE OF SPECIALTY CUT FLOWERS POSITIVELY INFLUENCES TIME OF HARVEST, GROWTH AND QUALITY OF SUNFLOWER (*HELIANTHUS ANNUUS*) 'SUNBRIGHT'

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Two-week old plug seedlings of 'Sunbright' sunflower (*Helianthus annuus*) were planted in 1.2 m wide beds on 15 cm centers amended with 0.0, 2.2, 4.4, and 8.8 cubic meters per square meter of compost in a randomized complete block design. The experiment was repeated at one week planting intervals on 6/20/2001 and 6/27/2001 respectively. Increasing rates of compost amended media positively influenced growth parameters such as flower diameter, stem length and total fixed carbon as compared to the untreated (0.0 compost rate) control. These findings are expected from results reported on other crops in the extensive literature on compost amended media. In addition to the enhanced quality aspect of sunflowers harvested from the compost amended beds, the average cropping time was reduced by 1.4, 2.2, 4.9 days respectively with increasing rates of compost compared to the control of 77.8 days to flower. This finding further encourages compost amendment use in intensive bed culture for specialty cut flower production.

1340–1440

S19–P–63

FOLIAR SYMPTOMOLOGY AND TISSUE CONCENTRATIONS OF NUTRIENT DEFICIENT OSTEOSPERMUM PLANTS

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Elemental deficiencies of N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn and B were induced in 'Kalanga' osteospermum (*Osteospermum ecklonis*) plants. Rooted cuttings were planted in 4.7 L plastic containers and fertilized with a complete modified Hoagland's solution or this solution minus the element that was to be investigated. Plants were harvested for tissue analysis as well as dry weight when initial foliar symptoms were expressed and later under advanced deficiency symptoms. Root architecture was also recorded for the plants treated with the solutions. The containers were replicated 3 times for each of the two harvests and were randomized in a complete-block design. Deficiency symptoms for all treatments were observed within eight weeks. The most dramatic expression of foliar symptoms occurred with N (chlorotic lower foliage leading to necrotic margins on the mature leaves), Fe (interveinal chlorosis of the young leaves), Ca (black necrotic spots on the tips of the young leaves), S (uniform chlorosis of young leaves and recently mature leaves), Zn (veinal chlorosis on young leaves), and B (deformed young leaves with fully expanded leaves becoming thick and leathery). The dry weight of plants treated with solutions not containing N, Ca, S, Cu, Zn, or B was significantly lower when compared to the control. Foliar tissue concentration data will assist plant tissue analysis laboratories in establishing foliar symptom standards for grower samples.

1340–1440

S19–P–64

EFFECTS OF MEDIA, POLYMER AND WETTING AGENT ON THE GROWTH AND FLOWERING OF KALANCHOE (*KALANCHOE BLOSSFELDIANA* POELLN.) 'MARGRETHE'

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Kalanchoe cuttings were inserted in 6 cm PVC pot, and were irrigated every other day with ebb and flow system. Before rooting, only tap water was irrigated, and after rooting, Sonneveld solution (pH 6.0, EC 1.2 dS/m) was irrigated. Three weeks after cutting, short days were given to kalanchoe from 1800 to 0900 every day until flowering. And 4 ppm paclobutrazol was sprayed to 3 and 9 weeks old cuttings of kalanchoe. In Experiment 1, Rockwool (RW), perlite (PL), peatmoss (PM) and three kinds of mixture media (PL:PM = 2:1, 1:1, 1:2 by volume) were used as potting media to promote kalanchoe growth and flowering. When RW, PL2PM1 and PL1PM1 was used, the plants showed better vegetative growth, compared with PL, PM, and PL1PM2. Whereas, flower growth showed better results in PL1PM1. Days to flowering was shortest in RW, but number of flowers, flower size, fresh and dry weight of flowers were better in PL1PM1. In Experiment 2, effects of wetting agent and polymer on the growth and flowering of kalanchoe were determined. Pot media (PL:PM=1:1 by volume) was mixed with 2% (by volume) psimatric, 0.1, 0.2, 0.4, and 0.8% (by volume) K-SAM (Kolon Co. Ltd.: K) and Terracotem (Terracotem Ltd.: T). Two percent P, K0.1, 0.2, T0.1, and 0.2 were better than control for vegetative growth, whereas 2 percent P, T0.1 was good for flower growth. In 2% P and T0.1, flowering became 1 week faster, number of flowers was 41, 67 percent increased, and flower fresh and dry weight were 70% heavier than contol. In conclusion, 2% P and 0.1% Terracotem (by volume) could be recommended to promote the growth and flowering of *K. blossfeldiana* 'Margrethe' planted at 6 cm size PVC pot.

1340–1440

S19–P–65

MODLELING NUTRIENT SOLUTION CONSUMPTION IN CUT ROSES (*ROSA HYBRIDA* L.) TO SOLAR RADIATION BY GROWTH STAGE

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This study was conducted to investigate the nutrient solution consumption (NSC) in cut roses 'Rote Rose' and 'Little Marble' according to several environmental factors: solar radiation (SR), air temperature (AT), root-zone temperature (RT), and relative humidity (RH), in order to developing the software for precise supply of NS in rose hydroponics. In greenhouse condition, NSC seemed to be influenced by SR and AT mainly, without effects of RT and RH. In the R^2 analysis of several environmental factors to NSC, the value of R^2 was 0.84 in SR singly, and improved a little 0.90 in SR + AT. Therefore SR could be determined as the primary environmental factor on NSC of cut roses. And also NSC to leaf area (LA) was investigated in the several level of SR. As results from the relations between NSC and SR and LA, the regression model for NSC of cut roses was developed based on growth stage in rose hydroponics using arching the method and was validated in the greenhouses (R^2 was 0.81).

1340–1440

S19–P–66

DEVELOPMENT OF OPTIMAL NUTRIENT SOLUTION FOR SINGLE-STEMMED ROSE IN A PLANT FACTORY

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The objective of this study was to develop optimal nutrient solution for single-stemmed rose in a plant factory system. Rose plant (*Rosa hybrida* L.) cultivar 'Red velvet' was grown from February 10, 2001 to March 24, 2001 in aeroponics and ebb & flood. The plants were irrigated with the nutrient solution of National Horticulture Research Station of Japan (NO_3-N 16.0, NH_4-N 1.3, PO_4-P 4.0, K 8.0, Ca 4.0, Mg 4.0 me·L^{-1}). Electrical conductivity (EC) levels of the nutrient solution were adjusted to 0.9 (1/3 S; strength), 1.2 (1/2 S), 2.3 (1 S) and 3.7 (3/2 S) dS·m^{-1} and with pH levels of 5.5 ± 1.5. All of the nutrient solutions at 1/2 S in both systems were more stable than others, and the EC and pH at 1/2 S remained balanced compared to other concentrations although there were no significant differences on the growth at the different concentrations. As a result, concentrations of nutrient solution at 1/2 S (NO_3-N 8.8, NH_4-N 0.67, PO4-P 2.0, K 4.8, Ca 4.0, Mg 2.0 me·L^{-1} in aeroponics and NO3-N 8.9, NH_4-N 0.73, PO_4-P 2.2, K 4.8, Ca 4.1, Mg 1.7 me·L^{-1} in ebb & flood) were optimal in the study . To examine the suitability of the nutrient solution developed by nutrient-water (n/w) absorption ratio in the above experiment, 'Red Velet' rose were grown in both systems from April , 23. 2001 to May 28, 2001 with different solutions and concentrations developed in the above experiment (UOS: The Univ. of Seoul) of 1/2 S, 1 S and 2 S. Overall, the growth of single-stemmed rose grown in the nutrient solutions at 1 S of UOS was better than other treatments in aeroponics and ebb & flood, especially, better than other treatments for stem length and number of five-leaflet leaves.

1340–1440

S19–P–67

DETERMINATION OF OPTIMUM SUBSTRATE AND HYDROPONIC SYSTEM FOR PRE- AND POST-TRANSPLANTING IN A ROSE FACTORY

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Rose factory is a new plant production system that enables year-round, planned, and high production by controlling the environment. This study was conducted to determine the optimum substrates and hydroponic systems for pre- and post- transplanting in a factory. Shoot initiation rate was higher in nutrient film technique (NFT) and ebb & flow system than in polyester mat system. Plant grown in vermiculite, rockwool cube, granulated rockwool and perlite + vermiculite (7:3, v:v) showed higher shoot initiation rate than those grown in other substrate. Photosynthesis and transpiration rate were also higher in plants grown in substrate in which plants showed higher shoot initiation rate. Mortality of rose was higher in plant grown in peatmoss, perlite and perlite+granulated rockwool (7:3, v:v). Growth and days to visible flower bud and anthesis after transplanting were not different significantly by hydroponic systems. Days to visible flower bud and anthesis were also not different significantly by substrates except peatmoss. After transplanting, plant growth rate was less affected by water content of substrate than before transplanting. But in peatmoss, rooting was reduced due to low air space.

1340–1440

S19–P–68

LONG-TERM SUCROSE SUPPLYING FOR POTTED COLEUS AND RADISH THROUGH PHOSPHATE REFRACTRINESS WITH ALUMINUM HYDROXIDE UNDER NON-STERILE CONDITION

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We developed a simplified sucrose supplying method for the potted plants in a non-sterile room by use of bacteriostasis through phosphate refractoriness using $Al(OH)_3$. The root zone were divided into top and bottom by water repellency rockwool. The plants planted the top zone, each roots penetrated the water repellency rockwool and invaded the bottom zone. The top root zone (the Root Zone with Phosphate: RZ-P) were supplied with some essential nutrients with phosphate (supplied by 1 g/pot of fused magnesium phosphate). The bottom root zone (the Root Zone with Sucrose: RZ-Su) were supplied with sucrose and all other nutrients except phosphate under bacteriostatic conditions by adding aluminum (containing 3% $Al(OH)_3$ w/v and adjusting to 1.5 dS/m with mixture of NH_4NO_3, KNO_3 and K_2SO_4 = 4:4:1 w/w, with sucrose). In this way, dividing the supply of essential elements prevented culture solution from not only rotting, but also the biase of plant roots distribution between these two root zones. The medium of RZ-P was hydrophilic rockwool. And that of RZ-Su was mixture of hydrophilic and water repellency rockwools. By using this aluminum bacteriostasis sucrose supplying method, sucrose could be supplied through root of coleuses and radishes under non-sterile condition for serveral months. Therefore a number of flower and amount of sucrose in the stems increased. And the falling off of leaves was retarded under the poor light of indoor conditions (3 to 48 μmol·m^{-2}·s^{-1} of PPFD). And under winter glass house conditions, coleuses grew better with the sucrose supply. And, this effect was decreased by the phosphate supply to RZ-Su for root zone rooting. However, neither the flowering period nor the number of leaves was altered in spite of the presence of sucrose under poor light indoor condition.

1340–1440

S19–P–69

THE EFFECT OF IRRIGATION FREQUENCY AND PHOSPHORUS LEVEL ON GROWTH, FLOWERING AND MINERAL ELEMENT CONTENT OF *OSTEOSPERMUM* CULTIVATED ON EBB-AND-FLOW BENCHES

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The purpose of this experiment was to study the effect of irrigation frequency and phosphorus level on growth and flowering of *Osteospermum ecklonis* 'Denebola' cultivated on ebb-and-flow benches. Leaf mineral element content and chemical characteristics of growing medium, as affected by above mentioned factors were also analyzed. Two irrigation frequency at –0.5 and –1.0 kPa (according to soil water potential) and four levels of P at 0.90, 1.61, 2.24, and 3.24 mmol/L were applied. The highest fresh and dry weight reached osteospermum watered at–0.5 kPa and fertilized with P at 2.24–3.24 mmol/L. Interactions between watering frequency and P level were found in respect to all growth parameters. Watering frequency did not affect flowering time, while the effect of P level on flowering time was rather small. The plants cultivated at 1.61–3.24 mmol/L P had more flower buds and flowers. Watering frequency and P level affected mineral nutrient content of osteospermum leaves. Higher watering frequency increased content of N and decreased content of P, K, Ca and Mg. At high P level leaf content of N, P and K was higher, content of Ca and Mg was lower. Taking into account that osteospermum plants grown at –1.0 kPa and 1.61–2.24 mmol P/L were of very good quality, the proposed ranges for macroelement contents in osteospermum leaves are: N 3.70–4.20, P 0.15–0.17, K 4.40–5.10, Ca 1.50–

2.80, Mg 0.20–0.27% d.w. Growing medium was divided into three equal layers: upper, middle and bottom. At the end of cultivation the highest pH was always measured in bottom layers and the lowest pH in upper layer. Opposite was found for EC. The lower pH and higher EC was measured at higher watering frequency. Increased P concentration paralleled increased pH, while EC decreased as P concentration increased. Final growing medium N and K decreased with increasing P concentration and increased with increasing watering frequency.

1340–1440

S19–P–70

THE EFFECT OF ORGANIC FERTILIZATION ON GROWTH AND FLOWERING OF *PELARGONIUM HORTORUM* L.H. BAILEY

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The use of organic fertilizers can reduce contamination of surface and groundwater from mineral fertilizers applied in horticulture. The objective of this experiment was to compare growth and flowering of geranium 'Tango Orange' fertilized with wholly organic fertilizer DCM Eco-Mix 4 (7-7-10) and mineral fertilizer (13-5-22 + microelements). The effect of both fertilizers on the development of leaf tissue was also analyzed. Organically fertilized geraniums had greater fresh weight, plant height, leaf and green inflorescence numbers than those fertilized with mineral fertilizer. No significant differences were found in respect to flowering time, lateral shoot and open inflorescence numbers and inflorescence diameter. Final substrate pH was lower in organically fertilized pots, opposite was found for EC. Final substrate N and K were significantly greater in pots fertilized organically, whereas content of K, Ca, and Mg was lower. Leaf pieces from central part of leaf blade were fixed with CrAF agent, dehydrated and dipped in paraffin, then cut across and stained with safranine and light green. The microscopic analyses of leaf tissue revealed the differences in vascular system. The vascular bundles of organically fertilized plants were larger than those fertilized with mineral fertilizer. Phloem and xylem of organically fertilized plants were composed of large cells. More cavities between palisade and spongy parenchyma cells of minerally fertilized plants were observed.

1340–1440

S19–P–71

MINIMUM CRITICAL LEVEL AND VISUAL SYMPTOMS FOR MACRO AND MICRONUTRIENT DEFICIENCIES IN NEW GUINEA IMPATIENS CULTIVARS 'GRENADA' AND 'TIMOR' (*IMPATIENS HAWKERI* BULL)

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To produce a premium crop on commercial scale, precise nutritional standards are indispensable, and these values are not available for this crop. Experiments were conducted by growing the plants hydroponically in a glass greenhouse. Treatments consisted of a complete modified Hoagland nutrient solution and 11 additional solutions, each devoid of one essential nutrient (N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn and B). Symptoms and plant size were chronologically recorded for shoots and roots. Youngest fully expanded leaves were analyzed for nutrient content. Shoot dry weight of N, P, Mg, Mn, Cu, and Zn deficient plants were greater in Grenada than Timor, and the dry weight of K, Ca, Fe, and B were greater in Timor than Grenada. A severe reduction of dry weight was noted in K and Cu deficient plants of both cultivars. Only in the Fe deficient plants, the dry weight was equal to or greater than control in both cultivars. Fe deficient plants were also the last to develop visual symptoms. On the other hand, delayed development of visual symptoms in K, Zn and B deficient plants, and a higher critical tissue concentration of B, Ca, and Cu was only noted in Grenada. With this study, it can be concluded that there is a difference in the foliar analysis standards, shoot dry weight, characteristics and days to develop visual symptoms between the two cultivars.

1340–1440

S19–P–72

CULTIVATION OF BRAZILIAN SPECIES OF *TILLANDSIA* IN DIFFERENT SUBSTRATES

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Only the well known species of bromeliads are grown in a commercial scale in Brazil. The tree fern fiber extracted from endangered Polypodiaceae is still the base to prepare the growing media mixtures. Experiments were carried out in greenhouse 70% shaded, at Jaboticabal, state of São Paulo, Brazil, aiming to cultivate Brazilian wild species of *Tillandsia* during a whole cycle, using or not tree fern fiber as substrate. The following species were cultivated: *Tillandsia carminea* W. Till; *Tillandsia dura* Baker; *Tillandsia gardneri* Lindl.; *Tillandsia geminiflora* Brongn.; *Tillandsia kautskyi* E. Pereira (endangered species); *Tillandsia grazielae* Sucre & Braga (rare) e *Tillandsia reclinata* E. Pereira & Martinelli (rare); *Tillandsia stricta* Sol. ex Sims; *Tillandsia tenuifolia* L. Plants at the transplanting size were used. The compared growing media for epiphytic species (*T. dura, T. gardneri, T. geminiflora, T. globosa, T. stricta* and *T. tenuifolia*) were: A = 45% tree fern fiber + 45% coconut (*Cocos nucifera* L.) fiber + 10% humus; B = 45% coconut fiber + 45% Pinus bark + 10% humus; C = substrate A-119 Amafibra (coconut fiber + micronutrients); D = substrate A-121 Amafibra (coconut fiber). Plants were grown in plastic pots. The saxicolous species (*T. carminea, T. grazielae* and *T. reclinata*) were cultivated on sheets of tree fern fiber or pressed coconut fiber. Epiphytic plants grew well through ten months in all substrates. *T. grazielae* and *T. reclinata* did not present rooting, and leaves started wilting after one to five months. So, they were removed from the sheets and planted in plastic pots filled with the studied substrates. In the new conditions, plants improved their growth. These preliminary results indicates that these bromeliad species can be grown at Jaboticabal, and the use of tree fern fiber is not necessary for their cultivation.

1340–1440

S19–P–73

NUTRITIONAL MONITORING GUIDELINES FOR GREENHOUSE PRODUCTION OF HERBACEOUS PERENNIALS

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With the advent of the pour-through solution extraction method, substrate testing is easier and more efficient, allowing for frequent monitoring of root-zone soluble salts and pH levels. Substrate testing guidelines have yet to be developed for most herbaceous perennials. Knowledge of target pH and EC ranges can help reduce fertilizer inputs in greenhouse-grown crops. Vegetatively propagated liners of eleven herbaceous genera (Astilbe chinensis 'Purpurkerze', *Campanula carpatica* 'Deep Blue Clips', *Coreopsis verticillata* 'Golden Gain', *Gaura lindheimeri* 'Siskiyou Pink', Heuchera 'Mt St. Helens', *Lamium maculatum* 'White Nancy', *Penstemon* 'Sour Grapes', *Perovskia atriplicifolia* 'Longin', *Physostegia virginica* 'Summer Snow', *Salvia nemerosa* 'Blue Hill', and *Veronica* 'Goodness Grows') were potted into trade gallons (2.8 liters) and grown in a greenhouse for 10 weeks. Fertilizer treatments were 15N-7P-15K at four rates of 50, 150, 250, and 350 $mg \cdot L^{-1}$ N. constant liquid feed. Root-zone pH and electrical conductivity (EC) were measured weekly using the pour-through extraction technique. Other data include weekly quality ratings (Q), days to flower, and dry mass (DM) of the shoots at the conclusion of the study. In analysis of all genera, most effects (Q, DW, pH, EC) varied with rate, genus, and rate x genus. Though higher levels of fertilizer N produced the largest plants in some cases, satisfactory quality was also attained with a lower rate. Quality and pH were negatively correlated for a few genera but most showed no relationship. The herbaceous perennials studied could be grouped by nutritional needs and target ranges for pH and EC developed based on dry mass and quality ratings.

1340–1440

S19–P–74

EFFECT OF POTASSIUM SILICATE ON THE PLANT GROWTH AND FLOWER QUALITY OF HYDROPONIC CUT FLOWER MINIROSE 'PINOCCHIO'

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The study was conducted to evaluate the effect of root and leaf applications

of potassium silicate on the plant growth and flower quality of hydroponically grown cut miniature rose 'Pinocchio'. In rockwool slabs irrigated with arrow drippers, plant growth and quality of harvested flowers were examined in four treatments, the control (untreated), root-fed, foliar sprayed, and root-fed + foliar sprayed at 200 mg·L^{-1} potassium silicate. Stem cuttings rooted in rockwool cubes were planted in rockwool slabs on Aug. 7, 2000 and grown for 413 days in a randomized block design of 4 replicates of 4 plants per replicate. All treatments had significant effect on plant growth and flower quality. Height, mean and total yields were significantly greater in root-fed than in other treatments. Stem diameter, number of branches per stem, dry matter, fresh and dry weights of harvested flower stems significantly increased in root-fed + foliar sprayed as compared to the control and the other treatments. Root fresh and dry weights measure at the end of experiment were significantly greater in root-fed than in other treatments. The stem elasticity was greater in root fed + foliar sprayed treatment. Observation by a scanning electron microscope revealed a layer of glass on the leaf surface in foliar sprayed plants. From the results, applications of potassium silicate proved to have beneficial effect on plant growth and flower quality in hydroponic production of cut rose 'Pinocchio'.

1340–1440
S19–P–75
EFFECT OF IRRIGATION METHODS ON ROOT-ZONE ENVIRONMENT AND GROWTH OF POTTED PLANTS OF KALANCHOE IN WICK-USED TROUGH CULTURE SYSTEM

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The root-zone environment is one of the most important factors influencing the plant growth, and it is greatly affected by irrigation conditions. In this study, the effects of irrigation and wick treatments on the root-zone environment and growth of potted plants were analyzed in both a water-flowing trough culture system (WFS) and water-containing trough culture system (WCS). Five kinds of irrigation frequencies within one day and 4 kinds of irrigation periods were used as irrigation conditions in WFS. The wick length was adjusted to 5 cm from water level to the bottom of pot in WCS. For wick treatment, vinyl-covered wicks were used not only to enhance the capillarity but reduce the water losses. At rooting stage, the plants showed better with increasing irrigation frequency and period. The water content of substrate after 2 weeks varied from 10% in 1 time of 5-min irrigation to over 60% in 5 times of 20-min irrigation. The criteria of irrigation conditions for healthy plants were over 4 times of 10-min irrigation with respect to rooting ratio, days until rooting, and water content of substrate. The water contents of substrate showed 30–60% in WFS and 80% in WCS. The roots grew greatest at 5 times of 20-min irrigation, showing no difference between WFS and WCS at more than 4 times of 10-min irrigation. At short-day stage, the roots grew greatest at 4–5 times of 10-min irrigation, and the shoots showed better in proportion to irrigation frequency and period. Furthermore, the plant height was greater at 5 times of 20-min irrigation in WFS than in WCS. The effects of vinyl-covered wick on the root growth of Kalanchoe were considerable at 4 times of 10-min irrigation. The water loss in WFS was 5–6 times smaller than that in WCS. Especially, WFS could maintain the nutrient solution without algae and pollution compared with WCS.

1340–1440
S19–P–76
THE EFFECT OF DIFFERENT NUTRIENT SOLUTIONS ON LEAF NUTRIENTS OF TWO *ANTHURIUM* CULTIVARS

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The effect of five complete nutrient solutions on some characters of two anthurium cultivars named *Anthurium andraeanum* cv. 'Mauricia' and *Anthurium* 'Southern Blush' was evaluated. At the end of the experiment some parameters were measured in order to determine the relationship between the concentration of the elements in nutrient solutions and the foliar nutrient levels and size of the plants and flowers. The following parameters were included: number of lateral shoots and flowers, spathe and spadix length, spathe width, flower size, leaf area and elements such as N, P, K, Mg, Ca, Mn, Zn, Fe and Na. This research was conducted in a Complete Randomized Design (CRD). For cultivar 'Mauricia', the nutrient solutions affected the number of shoots and foliar nutrient levels at $P < 0.01$. For the hybrid 'Southern Blush', the nutrient solutions affected the spathe and spadix length and flower size at $P < 0.05$ and foliar nutrient levels at $P < 0.01$. For both cultivars a solution with a ratio for N to K and N to P of 1/1.2 and 1/0.28, respectively, in combination with a moderate concentration of elements for the other nutrients produced the best plant with the most flowers. For this solution the hybrid 'Southern Blush' contained: 1.45% N, 0.48%P, 3.87% K, 0.51% Mg, 3.0% Ca, 437 ppm Mn, 232 ppm Zn and 461 ppm Fe in its leaves and the leaves of culitvar 'Mauricia' contained: 2.27% N, 0.66% P, 4.42% K, 0.32% Mg, 0.49% Ca, 470 ppm Mn, 97 ppm Zn and 110 ppm Fe.

1340–1440
S19–P–77
EFFECTS OF CHELATES VERSUS IONIC SALTS OF MICROELEMENTS ON HYDROPONIC SOLUTION PH

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Microelements are supplied at low concentrations, yet have a profound effect on plant growth. These experiments explore the role of the chemical form on plant uptake. *Chrysanthemum* cv. Bright Golden Anne which is sensitive to ammonium toxicity was the test plant. There were four hydroponic treatments with nitrogen supplied at 200 ppm as either 100% nitrate or 50:50 ammonium to nitrate. All other macro cations and anions were the same concentration. Micronutrients were supplied either in the chelate or ionic salt form. All solutions were allowed to stand for 24 hours and then adjusted to pH 5.9–6.0. Once the plants were set into the solution they were allowed to adjust for one hour before the pH was measured hourly for 24 hours. Solutions of 100% NO3 showed an increase in pH to between 6.2 and 7.1 within five hours. The 50:50 plus ionic salt treatment decreased to 5.2 to 5.8, but the 50:50 plus chelates was stable between 5.8 and 6.3 during the entire time course. The plotted data revealed a definite rhythm for each of the solutions. Visual leaf and root symptoms as well as nutrient solution concentrations will also be discussed.

1340–1440
S19–P–78
INFLUENCE OF MINERAL NUTRIENT LEVELS FOR SINGLE-STEM ROSE IN A PLANT FACTORY SYSTEM

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This study was conducted to determine optimum nutrient levels for single-stem roses in a factory system. Rose plant (*Rosa hybrida* L.) cultivar 'Red velvet' was grown in an aeroponic system from June 14 to July 30, 2001. The nutrient solution was supplied to each bench with different nutrient levels. Physiology responses such as photosynthetic rate, transpiration rate, fresh weight, stem length, and flower diameter were measured. The growth of single-stem rose was significantly responsive to nutrient content in the nutrient solution, increasing up to adequate nutrient level except for the response to K level. For single stem rose, the required nutrient showed relatively lower levels in comparison with the nutrient solution for fruit vegetables. Photosynthetic rate in leaves of flowering stalks was the highest in the range of N 100–150, P 20–40, K 100–150 mg·L^{-1}. Also, chlorophyll and anthocyanin were significantly influenced by the rate of N, P, and K.

1340–1440
S19–P–79
EFFECT OF PHOSPHORUS ON GROWTH AND FLOWERING OF *SCAEVOLA AEMULA* R.BR. 'NEW WONDER'

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Scaevola aemula R.Br. (fanflower) is a popular ornamental plant native to Australia. 'New Wonder' (new wonder fanflower) is a Proven Winner cultivar of the species, widely used for hanging baskets and as a bedding plant. Recently, reduced growth and quality were observed by growers because of high phos-

phorus concentrations. To determine the phosphorus effect, rooted cuttings were transplanted into 15-cm standard pots and grown under a regime of 20-P-16.6 (N-P-K) water soluble fertilizer, where P concentrations were 0, 20, 40, 60, 80, 100, 120 mg·L^{-1}. Growth and flowering data were taken every three weeks and the experiment was terminated after 12 weeks. Phosphorus had significant influence on growth and flowering of new wonder fanflower. The length of the longest branches was reduced significantly at P concentrations higher than 20 mg·L^{-1}. Much more decrease was observed at P higher than 60 mg·L^{-1}. The number of branches and shoot dry weight followed the same trend. Number of flowers per plant had no significant differences at P = 60 mg·L^{-1} or lower. However, the number of flower decreased significantly at P higher than 60 mg·L^{-1}. High phosphorus reduced leave size. Leaf areas in the 20 mg·L^{-1} treatment were more than three times larger than those in the 120 mg·L^{-1} treatment. To produce better quality plants, 20 mg·L^{-1} of phosphorus or lower should be applied at each irrigation. Phosphorus concentration higher than 60 mg·L^{-1} should be avoided. Further investigation should be conducted on the mechanism of how phosphorus affects growth and flowering of *Scaevola aemula* 'New Wonder'.

1340–1440

S19–P–80

EFFECT OF DIFFERENT NUTRIENT SOLUTIONS ON THE QUANTITATIVE AND QUALITATIVE YIELD OF CUT FLOWER IN ROSE PLANTS (*ROSA HYBRIDA* CV. VARLON SYN. ILONA)

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The influence of five nutrient solutions with different ratios of $NH_4/NO_3 + NH_4$ was studied on the quantitative and qualitative yield of cut flower production and mineral nutrition of greenhouse rose plants (*Rosa hybrida* cv. 'Varlon') grown on five different substrates (inert, organic and mixture media) included perlite (M1), sand (M2), perlite + sand (M3), perlite + sand + tree bark (M4) and perlite + sand + field soil (M5) in a greenhouse in the Horticultural Dept. of Tehran Univ. (during years of 2000–01). The following parameters were measured: yield, stem length and diameter, flower bud length and diameter, peduncle length, vase life, dry weight, effluent EC change, leaf and stem N, P, K, Ca, Mg, Fe, Mn and Zn content. By Duncan's Multiple Range Test except peduncle length, all parameter (at level of 5% and or 1%), were significantly affected by nutrient solutions, growing media and interaction between solutioin and growing media. By increasing the NH_4-N concentration in nutrient solutions an increase of yield was found, but with no significant differences between treatments (except S1 and S4) and an important effect was quality decrease of cut flower production. According to results, the nutrient solution in which the ratio of $NH_4/NO_3 + NH_4$ was equal to 0.02, was the best nutrient solution for nutrition of greenhouse rose plants, and the best growing media were M5, M1 and M4 for soil culture, hydroponics and soilless culture systems, respectively.

1340–1440

S19–P–81

CHARACTERIZATION OF PHOSPHATE AVAILABILITY IN PEAT-CLAY SUBSTRATES

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For growing ornamentals in pots, often substrate mixtures prepared from peat and clay are used. These substrates are supplied with compound fertilisers and have to be checked before use. For measurement of available nutrient content in the substrate, an extraction solution named CAT (0.01 M $CaCl_2$ + 0.002 M DTPA) is available which describes plant available nutrients. However, since P is continuously adsorbed in the soil during the first weeks after application, a procedure is required allowing an immediate check of the available P after substrate mixing. Thus the objective of the research was to investigate factors affecting P sorption and to establish threshold values for CAT soluble P. Eight peat-clay mixtures were supplied with five P levels, stored for 9 weeks at 20 C and subsequently cropped with *Euphorbia pulcherrima* and *Tagetes patula*. During cultivation, both crops received continuously P with a usual soluble multi-nutrient fertilizer. CAT soluble P content in substrate decreased during storage in the range of 20 to 80%, depending on the substrate, and reached an equilibrium after about 5 weeks. This was not affected by pH and clay content of the substrate. However, a positive correlation between P sorption and oxalate soluble Fe and Al content was observed. The P sorption in substrates was accelerated by higher temperatures and a treatment with 50 C for 24 hours resulted in the same P content as at equilibrium after storage for 9 weeks. Thus it is possible to check the P content immediately after mixing the substrate. The threshold value for unrestricted growth was 60 and 30 mg P_2O_5/L for *Euphorbia pulcherrima* and *Tagetes patula*, respectively.

1340–1440

S19–P–82

EFFECTS OF EXCESS PHOSPHORUS AND ZINC ION TREATMENT ON THE GROWTH AND BULB PRODUCTION OF *LILIUM LONGIFLORUM* 'GEORGIA' IN NUTRICULTURE

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This study was carried out to investigate the effects of excessive supply and deficiency of macro- and micro-elements on the growth and bulb production of *Lilium longiflorum* 'Georgia' in nutriculture. Most of the elements when supplied excessively and deficiently inhibit growth and bulb production of lily, especially when supplied excessively it had adverse effects on it. However, phosphorous and zinc, even though supplied excessively, had no adverse effects on it. Therefore, in the next year using the increased levels of P and Zn their effects were investigated in details. The results of the experiment indicated that phosphorous treatment up to 100 m·L^{-1} did not affect the growth and bulb production, but for the treatment of phosphorus over 200 m·L^{-1} it showed a negative effect. Zinc treatment up to 25 mg/kg did not affect the growth and bulb production, but zinc treatment over 50 mg/kg decreased growth sharply. Also, compared to control, there was no difference in the production of bulbs over 9 cm of circumference when the phosphorus up to 10 m·L^{-1} and the zinc up to 10 mg/kg were treated.

1340–1440

S19–P–83

DAILY LIGHT INTEGRAL INFLUENCES FLOWERING AND FINAL QUALITY OF *ACHILLEA* x*MILLEFOLIUM* 'RED VELVET', *GAURA LINDHEIMERI* 'SISKIYOU PINK' AND *LAVANDULA ANGUSTIFOLIA* 'HIDCOTE BLUE'.

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Achillea x*millefolium* L. 'Red Velvet' plants (with 6 to 10 nodes), *Gaura lindheimeri* Engelm. & Gray 'Siskiyou Pink' (with 3 to 4 nodes) and *Lavandula angustifolia* Mill. 'Hidcote Blue' plants (with 10 to 12 nodes) were grown from Jan to Jun 2001 with a 16-h photoperiod under four light environments in a 20 C glass greenhouse: ambient light (L1), 50% shade cloth (L2), supplemental light at 100 µmol·m^{-2}·s^{-1} from high pressure sodium lamps (HPS) (L3) and supplemental light at 150 µmol·m^{-2}·s^{-1} from HPS lamps (L4). *Achillea* plants were grown for 8 weeks beginning 29 Jan, 19 Feb, 05 Mar, and 19 Mar 2001; *Gaura* plants for 6 weeks beginning 19 Feb, 05 Mar and 19 Mar 2001; and *Lavandula* plants for 7 weeks beginning 05 Mar, 02 Apr, and 30 Apr 2001. By varying starting date and light delivery, average daily light integral (DLI) of 5 to 20 mol·m^{-2}·d^{-1} were achieved. Final quality, dry mass accumulation, and increased inflorescence, flower, and lateral shoot development of each species were strongly correlated with DLI averaged over the forcing duration. Dry mass accumulation increased 17 mg·mol^{-1}·plant^{-1} for *Achillea*, 2.9 mg·mol^{-1}·plant^{-1} for *Gaura*, and 5.7 mg·mol^{-1}·plant^{-1} for *Lavandula* with each additional mol of light received above 6.0 mol·m^{-2}·d^{-1}. Flowering percentage was not correlated with DLI for any of the species tested. Essentially all *Gaura* and *Achillea* plants flowered while flowering of *Lavandula* was more inconsistent. Time to visible bud for all species was correlated with DLI. However, correlations with DLI for inflorescence height and the number of nodes formed below the inflorescence varied with species tested.

1340–1440

S19–P–84

EVALUATION OF A POLYMER TO REDUCE NITRATE AND PHOSPHATE RUNOFF FROM BEDDING PLANT SUBSTRATES

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The objective of this study was to compare growth of begonia 'Cocktail Vodka' and impatiens 'Super Elfin Violet' plants as well as the amount of nitrate (NO_3) and phosphate (PO_4) leached from substrates containing a polyacrylamide (PAM) polymer. The PAM polymer was incorporated into Fafard #2, Fafard #3b, or Fafard #52 substrates at rates of 0, 1, 2, or 4x (1x = standard application rate). Plants were watered daily to establish a 0.20 leaching fraction. Once a week plants were fertilized with 250 ppm of N from 21 N-5 P_2O_5-20 K_2O Peter's fertilizer. Daily leachate samples were collected for each treatment combination and once a week leachate volume was recorded and leachate samples collected. Leachate samples were analyzed for NO_3, PO_4, and soluble salt concentrations. Incorporation of PAM at all rates to Fafard #2 did not reduce the amount NO_3 or PO_4 leached. However, incorporation of PAM to Fafard #3b at 1x and 4x did reduce the amount of NO_3 and PO_4 leached. Incorporation of PAM to Fafard #52 at 2x and 4x also reduced the amount of NO_3 and PO_4 leached. Begonia and impatiens plant quality (determined using principle component analysis) was greater in Fafard #2 and #3b than in Fafard #52.

1340–1440

S19–P–85

TYPE OF SHADING AND *LIMNANTHES* SEED MEAL INFLUENCE GROWTH AND *MARCHANTIA* INFESTATIONS OF CONTAINER-GROWN *PIERIS*

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Potted liners of *Pieris* 'Brouwer's Beauty' and 'Valley Valentine' were potted in June into 2.7 liter (15-cm) pots filled with 2.5 liters of Douglas-fir bark. All pots received 18 g of Osmocote 18N-2.6P-10K controlled release fertilizer applied to the substrate surface. Plants were grown under stationary shading (woven black shade cloth; 30% shading), retractable shading (woven poly-film, 50% shading when used), or without shading. Ten plants for each cultivar were placed in each of three replicates of each shading treatment, creating a split-block arrangement in a randomized complete block design. Five pots in each block were treated with 59 mL of *Limnanthes* seed meal spread evenly across the surface of the substrate. Irrigation was optimized for each shading area. *Marchantia* infestations were recorded as the percentage of substrate surface covered by thallus 50 days after potting. When not treated with *Limnanthes* seed meal, substrate surfaces were 100%, 48% and 22% covered with *Marchantia thallus* for stationary, retractable, and no shading, respectively. When treated with *Limnanthes* seed meal, substrate surfaces averaged 5% coverage for all shading environments. In October (120 days after potting), *Pieris* were taller and had more shoot dry weight when grown under retractable shading compared to stationary shading or no shading. *Limnanthes* seed meal did not influence the growth of *Pieris* in any shading environment.

1340–1440

S19–P–86

A MECHANISTIC STUDY ON THE EFFECTS OF SOIL HEATING ON FLOWERING TIME AND FLOWER QUALITY OF 'HUNTING SONG' GLADIOLUS

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Corms of gladiolus (*Gladiolus hortulanus* L.H. Bailey cv. Hunting Song) were planted on beds of two soil-heating treatments (150 W/m^2 thermal cable, maximum temperature 25 °C; 100 W/m2 thermal cable, maximum temperature 20 °C) and unheated beds during winter flower forcing in a glasshouse in Beijing. Dimensions, fresh weight and dry weight of root, bulb, leaf and flower spike were measured every 10–20 days until anthesis. Leaf chlorophyll content and photosynthesis rate were measured monthly. Flower quality (spike length and flower number per spike), minerals (N, P, K, Ca, and Mg) contents of root, bulb, leaf and flower spike were measured at anthesis and the distribution rates of dry matter and minerals among different organs of the plant calculated. Root and leaf growth were accelerated and carbon assimilation multiplied in the early growth stage by soil heating. Dry matter and minerals (N, P, K, Ca, and Mg) distributed to the flower spike were also increased. Spike development was accelerated and flowering time in heated treatments was respectively 16 and 14 days earlier than that of the control. However, the root senesced earlier and the leaf's photosynthesis rate declined more severely during the rapid spike development period in heated beds than in unheated beds. Consequently the spike length and flower number per spike at harvest was reduced by soil heating. It is recommended that soil heating is necessary for 'Hunting Song' gladiolus only if the soil temperature is lower than 16 °C.

1340–1440

S19–P–87

NITROGEN ABSORPTION AND THEIR CORRELATION WITH THE ENVIRONMENTAL CONDITIONS, LEAF AREA INDEX AND WATER CONSUMPTION IN *DIEFFENBACHIA AMOENA*

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Nitrogen uptake levels and their correlation with the environmental conditions, leaf area index, and water consumption, have been studied in *Dieffenbachia amoena* Tropic Snow. Data were collected during two 7-month growing cycles. *Dieffenbachia* was grown in a closed system on expanded clay. The trial consisted of 5 treatments with different supplies of nitrogen (nitrate, ammonium, and nitrate + ammonium). Nitrogen uptake rates were between 0.5–9.0 mmol·day^{-1}·m^{-2} and water consumption was between 0.08–0.81 L·day^{-1}·m^{-2} for plants supplied only with nitrate. When plants were supplied with ammonium, and nitrate + ammonium, nitrogen uptake rates were between 0.8-10.2 mmol·day^{-1}·m^{-2} and water consumption was between 0.05-0.67 l day^{-1}·m^{-2}. When nitrates were used as source of nitrogen, nitrogen absorption correlated with water uptake, temperature, and leaf area index. If nitrate + ammonium and ammonium were used as nitrogen sources, nitrogen uptake correlated with radiation.

1340–1440

S19–P–88

EFFECT OF END-OF-DAY FAR RED LIGHT TREATMENT ON CUCUMBER AND *ARABIDOPSIS* RESPONSES TO FLUCTUATING DAY/NIGHT TEMPERATURES

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Day temperature (DT) and night temperature (NT) alternation has a great impact on stem elongation and leaf morphology, but can be modified by an end-of-day (EOD) far-red (FR) treatment. Experiments with phytochrome B deficient lh mutant in cucumber (*Cucumis sativus* L.) as well as pytochrome A and B, and 2 cryptochrome deficient mutants (cry 1 and cry 2) in *Arabidopsis thaliana* indicate that phytochrome B is involved in thermoperiodic control of stem elongation. The wild type (WT) and the phytochrome B deficient, long hypocotyl (lh) cucumber mutant were grown under alternating DT and NT and either with or without an exposure of EOD-FR light. Alternating DT and NT were carried out with WT (*Arabidopsis* '*Landsberger erecta*') and two phytochrome and two cryptochrome deficient mutants as indicated above. For cucumber, without the EOD-FR light treatment, stem, internode and hypocotyls of the wild type were shorter under low DT/high NT (negative DIF) compared to under high DT/low NT regime (positive DIF). EOD-FR light treatment completely eliminated the effect of negative DIF on hypocotyl elongation. The lh cucumber mutant did not respond to EOD-FR treatment, and internode length was hardly affected by alternating DT/NT. In *Arabidopsis*, DT/NT alternation showed similar responses on stem elongation and leaf morphology for the phy A and cry 1 and cry 2 deficient mutants compared to the WT. However, the phy B deficient mutant showed significantly less response to alternating DT/NT than the WT. In conclusion, the results suggest that pytochrome B is required for a maximum effect of daily temperature alternations on stem elongation and leaf morphology in cucumber and *Arabidopsis*. Additional EOD-FR treatment, which almost eliminated the negative response in cucumber, indicates that a high Pfr / Ptotal photoequilibrium is needed for a strong inhibition by negative DIF.

1440–1500

S19–O–89

NATURAL FLOWER INITIATION IN *SPATHIPHYLLUM*: INFLUENCE OF DAY LENGTH AND LIGHT INTENSITY

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Spathiphyllum is a day neutral plant, which can be stimulated to flower with exogenous gibberellin (GA) applications. This results often in distorted inflorescences and peduncles, but it allows commercial production planning. Year round natural flowering on the other hand is very irregular. Temperatures exceeding 26 °C during the summer delay flowering, whereas the shortest culture period is during spring. In a year round greenhouse experiment, *Spathiphyllum* 'Alpha' was grown under natural light conditions. The 4 treatments were potted in separate seasons: 18 March, 10 June, 10 September and 26 November. Flower initiation was determined by macro-dissection, and started resp. after 215, 131, 97 and 88 days. Plants of the September and November cultures initiated flowers in an early vegetative stage (at respectively 12.4 and 7.4 leaves), compared to the plants potted in March and June (respectively 34.1 and 24.1 leaves). The total irradiation sum in the pre-initiation period was extremely low for the September and November cultures, namely only 15% and 8% of the value of the March culture. The possible effect of short day and/or light intensity on flower initiation was further investigated in a growth chamber experiment. High and low light intensities (110 and 55 $\mu mol \cdot m^{-2} \cdot s^{-1}$) were provided under both SD (8 hours) and LD (16 hours). All LD grown plants showed a more abundant vegetative development before flower initiation started (average 27.0 leaves and 5.2 shoots), whereas all SD plants started flower initiation with fewer leaves (15.9) and shoots (3.4). When applying an equal total irradiation sum over the culture period, provided over a LD (16 h at 55 $\mu mol \cdot m^{-2} \cdot s^{-1}$) or a SD (8 h at 110 $\mu mol \cdot m^{-2} \cdot s^{-1}$), the SD plants started flower initiation 40 days (110 $\mu mol \cdot m^{-2} \cdot s^{-1}$) or 20 days (55 $\mu mol \cdot m^{-2} \cdot s^{-1}$) earlier than the LD plants. Therefore a SD effect on flower initiation could not be excluded.

1500–1520

S19–O–90

CHARACTERIZATION AND CONTROL OF THE GRAVITROPIC BENDING RESPONSE OF CUT SNAPDRAGON FLOWERING SHOOTS

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The negative gravitropic response of cut flower stalks is a complex multistep process that requires the participation of various cellular components acting in succession or in parallel. The process was characterized in snapdragon (*Antirrhinum majus* L.) spikes in regard with: (1) gravity stimulus perception associated with amyloplast reorientation; (2) stimulus transduction mediated through differential changes in the level, action and sensitivity of auxin and ethylene and their possible interaction; (3) stimulus response associated with differential growth leading to stem curvature; (4) involvement of [Ca2+]cyt and actin cytoskeleton. Results will be presented showing the following sequence of events operating in gravitropism: amyloplast sedimentation started as early as 5 minutes following horizontal placement, and was completed within 30 minutes. This perception process seems to be mediated by $[Ca^{2+}]$cyt and the actin cytoskeleton. The early transduction events, manifested 30 min following gravistimulation, include: differential expression and/or distribution in favor of the lower stem half of early auxin responsive genes (Am-Aux/IAA1 and Am-SAUR1), of endogenous IAA levels and responsiveness to exogenous IAA. Later on, after 2h, differential expression of ethylene production across the stem was detected, as a late transduction event. Ethylene was found to serve only as a modulator of auxin action, and it had no role without auxin in the system. These transduction events leaded to differential stem growth, which was derived from initial shrinkage of the upper stem side and a subsequent elongation of the lower stem side. Consequently, the gravistimulated spikes exhibited a visual upward bending response after a lag period of 2–4 hours. Results obtained with various calcium- and cytoskeleton-modulators show that they may serve as means for controlling this undesired gravitropic bending in cut flowers.

1520–1540

S19–O–91

INCREASED ANTHOCYANIN ACCUMULATION IN FLOWERS AT ELEVATED TEMPERATURES DUE TO MAGNESIUM TREATMENT

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Temperature is one of the main external factors affecting anthocyanin accumulation in plant tissues: Low temperatures cause an increase and elevated temperatures cause a decrease in anthocyanin concentration. Several metals have been shown to increase the half-life time of anthocyanins by forming complexes with them. We studied the combined effect of elevated temperatures and increased metal concentrations on the accumulation of anthocyanins in aster 'Sungal' flowers. It has been found that magnesium treatment of aster plants or detached flower buds, partially prevents color fading at elevated temperatures. Anthocyanin concentration of aster 'Sungal' flowers grown at 29 °C/21 °C day/night, respectively, was about half that of flowers grown at 17 °C/9 °C. The activity of phenylalanine ammonia-lyase (PAL) and chalcone isomerase (CHI) decreased as the temperature increased. Treatment of both whole plants and detached flower buds grown at elevated temperatures in the presence of magnesium salts, increased flower anthocyanin concentration by up to 80%. Measurement of magnesium, following these treatments revealed an increased level of the metal in the petals, suggesting a direct effect. Magnesium treatment does not seem to cause increased synthesis of anthocyanin through a stress-related reaction, since the activities of both PAL and CHI did not increase due to this treatment. Recently, we have also shown that magnesium treatments increased the anthocyanin concentration in Anigozanthus flowers grown at elevated temperatures. The results of this study show that increasing magnesium levels in flower petals prevent the deleterious effect of elevated temperatures on anthocyanin accumulation, thus enhancing flower color.

1540–1600

S19–O–92

DIFFERENTIAL TEMPERATURE (DIF) EFFECTS ON THE GROWTH, MORPHOLOGY AND FLOWERING OF *ANTIRRHINUM MAJUS* L. (SNAPDRAGON) CULTIVARS

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Controlling stem height and the imbalance between vegetative and reproductive growth in cut-flower snapdragon production, has long been a problem. DIF, a non-chemical method for controlling plant height in greenhouse production of bedding plants is now used extensively in both Europe and the United States. We examined the responses of eight *Antirrhinum majus* cultivars in a series of growth chambers experiments. DIF treatments were imposed by increasing the air temperature to 24 ±0.3 C (+DIF) and by decreasing the air temperature to 12 ±0.3 C (–DIF) from a constant temperature of 18 C, from 4 am to 9 am each day. By measuring differences in plant characteristics, we found that –DIF decreases stem elongation in group 3/4 (spring/summer) cultivars, but the effect was not consistent in group 1/2 (fall/winter) cultivars. This is important, as stem elongation is more prevalent during the summer months in greenhouse production. Increasing the red/far-red (R/FR) ratio appears to enhance the response to DIF in most group 3/4 cultivars. However, it had differing effects in group1/2 cultivars. Negative DIF delays harvest time by 14–20 days in all cultivars tested. Negative DIF treatments appear to increase the vase-life and the total percentage of opened florets after cutting. However, DIF treatments appear to have no significant effect on total plant biomass or stem diameter of all cultivars tested. With further experimentation, we intend to develop an integrated temperature control model for different *Antirrhinum majus* cultivars and provide practical DIF guidelines for greenhouse snapdragon production.

1600–1620

S19–O–93

EASTER CACTUS (*HATIORA GAERTNERI*) FLOWERING IS INFLUENCED BY ENVIRONMENT BEFORE AND DURING INDUCTIVE TREATMENT

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Uniform flowering of Easter cactus (*Hatiora gaertneri* and its hybrids) requires that plants be exposed to cool temperatures followed by warmer temperatures and long days. Incomplete flower induction results in the development of both phylloclades and flowers on the apical stem segments, thus creating commercially unacceptable plants. Inconsistent flower formation sometimes occurs on plants grown for early-season sale. We hypothesized that photoperiod before low temperature, plant and phylloclade age, actual low temperature and low-temperature duration were important contributors to uniform flowering, especially on plants grown for early-season sale. Plants were propagated monthly from March through July, and immature apical pads were removed (leveled) 6 weeks before starting short-days, 1 week after commencement of short-day treatment, or 1 week after commencement of low-temperature treatment. In a separate experiment, short-day treatment durations prior to cold (0, 2, 4, or 6 weeks) and low-temperature duration (0, 2, 4, 6, or 8 weeks) were applied accordingly. Light pollution under naturally short days could negate a short photoperiod response. To determine the irradiance threshold necessary to prevent a short day response, plants were exposed either before or during the cold treatment to irradiances of 2.5 $\mu mol \cdot m^{-2} \cdot s^{-1}$ or less. Results show that short days before cold treatment are more promotive to uniform, early flowering than long days before cold, that older plants flower more uniformly, that and that most leveling treatments adversely affected flowering. In addition, night interruption or day extension treatments with an irradiance above 0.02 $\mu mol \cdot m^{-2} \cdot s^{-1}$ were detrimental to flowering both before and during cold.

1620–1640
S19–O–93–A
TO BE ANNOUNCED

1640–1700
S19–O–93–B
TO BE ANNOUNCED

Thursday · August 15

1100–1140
S19–O–94
IN SEARCH OF ETERNAL YOUTH: THE DELAY OF POSTHARVEST SENESCENCE IN FLOWERS

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Higher plants have evolved to produce beautiful flowers for the propagation of species through sexual reproduction. Throughout history, man has sought to produce plants for the beauty of flowers. Today, the floricultural sector of horticulture represents a significant international trade industry. Not surprisingly, the longevity of many flowers is quite short, as their biological function of reproduction is transient in nature. The senescence of floral organs is a highly regulated developmental event, often associated with the end of the useful life of an organ relative to that of the reproductive process. For example, flower petals function to attract pollinators and once pollination has occurred represent an expensive metabolic sink. Removal of petals through senescence and/or abscission could benefit the growth and development of reproductive structures. In the floriculture trade, delaying the onset of senescence is the focus of a great deal of research in an effort to extend the useful life of the product. This paper will summarize our current understanding of the biochemical and molecular processes underlying senescence and describe efforts to delay the process through chemical treatments and biotechnology.

1140–1200
S19–O–95
GENETIC ANALYSIS OF ADVANCED POPULATIONS IN *ANTIRRHINUM MAJUS* L. (SNAPDRAGON)

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Cutflowers of *Antirrhinum majus* L. have been evaluated to determine heritability of traits important to breeding and production programs. P1 (a white, long-keeping postharvest cutflower type) and P2 (a white, short-keeping postharvest cutflower type) were hybridized to produce an F1 (P1 x P2) which was self-pollinated to produce an F2 population. 485 F2 plants were then self-pollinated to produce F3 lines. 110 selected F3 lines were advanced through single-seed descent to the F5 generation and P1, P2, F1, F3, F4, and F5 lines were evaluated in the fall and winter of 2001–02 over three replicated plantings in a randomized complete block design using standard forcing procedures. Heritability data will be presented on 1) plant architecture including plant height, branching habit, floral head structure/size, stem caliper and strength, and stomatal index 2) cutflower postharvest longevity and senescence symptom and 3) days to flowering and harvest, uniformity of anthesis, and percent of florets opening after harvest.

1200–1220
S19–O–96
PATHWAY AND MECHANISM OF WATER AND SUGAR TRANSPORT IN CUT FLOWERS OF CARNATION AND LISIANTHUS

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The effects of defoliation and heat-girdling were investigated in cut flowers of carnation 'White Sim' and lisianthus 'Royal Purple' or 'Mickey Lavender'. Unopened cut flowers were placed in a jar containing 100 mg/L 8-HQ solution or 100 mg/L 8-HQ + 2% sucrose solution until full flower opening (6 days for carnations and 5 days for lisianthus) in a growth room kept at 23 C with a light period of 18 hours at 5000–8000 lx. The development of flowers expressed as the increment of cut flower fresh weight was enhanced by adding sucrose to the vase solution in both species. This effect was reduced when leaves were removed in lisianthus, whereas the effect was not influenced by the defoliation in carnation. These results suggested the importance and unimportance of leaves for the uptake of sugars in lisianthus and carnation, respectively. The effect of sucrose on flower development disappeared when the stems were heat-girdled just below the flowers in both species. Therefore, sugars seem to be transported into the flowers through the phloem. In lisianthus, the effect of sucrose on flower development was reduced remarkably when stems were heat-girdled at a position just above the leaves, whereas the effect was affected only slightly when stems were heat-girdled just below the leaves. In carnations, the effect of sucrose declined as the position of heat-girdling along the stems became lower, but whether the position of heat-girdling was above or below the leaves had little influence on the effect of sucrose on flower development. These results suggested that the leaves were the main place of sugar uptake into the phloem in lisianthus, while the sugars in the apoplast or xylem appears to be taken up by the phloem along the stems in carnations.

1220–1240
S19–O–97
DEFINING THE ROLE OF THE CHLOROPLAST IN NON-SENESCING LEAF YELLOWING

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Chloroplasts are the plant repository for the green color in plants. Chloroplasts as an organelle are generated, mature, age and then degenerate. In order to investigate the physiological mechanisms that allow yellowing leaves to regreen when fertilized it is necessary to more fully understand chloroplast biogenesis–particularly aging. As our first step, we want to understand chloroplast changes anatomically. There will be 3 phases. First, identify plants with distinctive chloroplasts (at light microscope level) second, characterize chloroplast biogenesis and senesce of selected leaves, and third create a staining procedure at LM level to distinguish functioning chloroplasts from non-functioning aged chloroplasts (gerontoplasts). Leaves of 32 horticultural species were screened for chloroplast size, leaf thickness and ease of fresh frozen sectioning. *Zantedeschia aethiopica, Dianthus caryophyllus,* and *Plectranthus australis* all had thick leaves (642–881 μm), large chloroplasts and were easily sectioned at a thickness of 12–18 μm. *Chrysanthemum morifolium* and *Alstroemeria aurantiaca* also had large chloroplasts and leaf thicknesses that were mid-range (321 μm) or thin (150 μm). Thus, leaf thickness and chloroplast size do not appear related. Of these plants, how-

ever, only *Dianthus, Chrysanthemum* and *Plectranthus* are easily, clonally propagated. As using *Dianthus* would make visual symptoms of yellowing hard to detect, *Plectranthus* was selected for the second phase of the study with *Chrysanthemum* as the alternative. In the research literature, silver nitrate had been used to stain living cells. So we attempted to create a protocol and fixation procedure to differentiate young and aging chloroplasts. Our results showed that *Plectranthus* does not respond positive to silver nitrate stain at concentrations of 1, 2, 5, or 10% at pH levels of 4 and 6.2. Protocols using chrysanthemum leaves as well as other stains will also be reported.

1340–1440

S19–P–98

TREATMENT WITH THIDIAZURON FOR PREVENTING LEAF YELLOWING IN CUT TULIPS, SOLIDASTER AND CHRYSANTHEMUM

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Postharvest quality of cut flowers is defined by many factors. In some species the quality can be compromised by leaf color changes before that flower petals senesce. It is well known that cytokinins are able to inhibit leaf yellowing in some cut flowers and potted plants. Thidiazuron is a substitute of phenylurea that induce cytokinin-like responses. The first applications of TDZ in cut alstroemeria and lilium have shown to delay extraordinary leaf senescence. In our experiments we applied thidiazuron for preventing leaf yellowing in cut tulips, solidaster and chrysanthemum that were selected among Italian cut flowers that show leaf yellowing as main postharvest disorder. The cut flowers were obtained from local growers. Pulse treatments of 24 hours with 10, 50 and 100 mM of thidiazuron were compared with 50 and 100 mM of 6-benzyladenine. In cut tulip flowers the leaf yellowing, stem elongation, petal abscission and chlorophyll content were measured during vase life. In cut chrysanthemum and solidaster the effect of treatments was evaluated by chlorophyll determination and leaf yellowing appearance. Results obtained have shown that TDZ was able to inhibit significantly leaf yellowing and more efficiently than BA in cut tulip and solidaster. On the other hand, TDZ and BA have not affected the cut chrysanthemum quality in no-yellowing species, but inhibited the rooting and promoted the lateral shoot elongation.

1340–1440

S19–P–99

PATTERNING STOMATAL INDEX IN *ANTIRRHINUM MAJUS* L. (SNAPDRAGON) OVER TIME AND DEVELOPMENT

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Stomatal index (SI) has been implicated by the authors as a correlated trait to cutflower postharvest longevity (PHL). The goal of establishing this correlation is to use SI, evaluated early in the life cycle and in early generations, to select genotypes with extended PHL when direct evaluation for PHL may be inaccurate. The current research seeks to ascertain an appropriate evaluation time for SI. To this end, P1 (low stomatal density) was hybridized to P2 (high stomatal density) to produce an F1 (P1 x P2) which was then backcrossed to each of the parents producing BC1 (F1 x P1) and BC2 (F1 x P2). Leaf imprints, created in super glue on glass microscope slides, were collected on the first true leaves and from leaves on every second node acropetally. Leaf imprints were collected every week beginning two weeks after sowing until anthesis at 11 weeks after sowing. Leaf samples were randomly and destructively taken from 5 plants out of a group of 30 plants of each genotype. Data will be presented on heritability of SI, changes of SI over time and with development of leaves at individual nodes, and recommendations will be presented on the use of SI as a selection tool in breeding programs for extended PHL.

1340–1440

S19–P–100

EFFECT OF PULSING WITH $AGNO_3$ OR STS ON THE SILVER ABSORPTION AND DISTRIBUTION, AND VASE LIFE OF CUT ROSE 'RED SANDRA'

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The vase life of cut roses maintained in distilled water or pulsed with 1 mM $AgNO_3$ or STS for 3 hr were 8.3, 10.8, 11.1 days, respectively. In this case, the petal withering of cut flowers treated with silver compounds was delayed by 6.3 and 4.8 days, respectively, as compared with that of control. Water potential at stem neck position of cut flower treated with silver compounds was maintained constantly without a decrease until the termination of experiment, whereas that of control decreased dramatically after 5 days. Surprisingly, more ethylene was produced in the cut flower treated with STS than that of control at 1–3 days after experiment. For the investigation of silver absorption through cut stem and its distribution to different parts, flower stems were immersed in distilled water only or the solutions containing 0.5 mM $AgNO_3$ or STS for 0 min, 5 min, 30 min, 1 hr, and 4 hr and after which cut flowers were divided into flower head, leaves, and the upper, middle and basal 15-cm stem segments, and then followed by the measurement of the amounts of silver absorbed into each part by using ICP. Silver absorption in cut flowers treated with $AgNO_3$ was only restricted within the basal stem, while silver in cut flower treated with STS was founded in all parts. However, total silver content absorbed by cut flower was about 2.4 times higher in $AgNO_3$ treatment than in STS treatment. Finally, the vase life of 5-cm stem recut flowers after treatments of $AgNO_3$ or STS was significantly extended as compared to that of control, whereas, in the case of 15-cm stem recut flowers, treatment of STS was best in vase life and treatments of $AgNO_3$ and control were almost the same. This data indicate that STS could be used as an effective pretreatment for rose and acts as not an ethylene action inhibitor but a germicide in cut rose, not like carnation, even though rose is traditionally known as a typical climacteric flower.

1340–1440

S19–P–101

SCHEDULED PLANTINGS OF SPECIALTY CUT FLOWERS

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Scheduled plantings of *Celosia argentea* var. *crisata* L., *Helianthus annuus* L., *Zinnia elegans* Jacq. and *Gladiolus* x*hortulanus* L.H. Bailey were conducted to determine the effect of time of planting on flower quality and yield. Plants were grown in an open field from April to September 2001. Dates of flower bud initiation, flower formation, harvest, and yield per planting were recorded on all crops. Days to flower bud initiation and first flower were less during the later scheduled planting dates, warmer temperatures and longer daylengths. Postharvest longevity differences between pollen-producing and nonpollen producing varieties of Helianthus were determined. Cut stems were placed in floral preservative and air temperature was maintained at 24 C with fluorescent lighting at 8 $\mu mol \cdot m^{-2} \cdot s^{-1}$. Nonpollen producing varieties were of acceptable quality an average of 4 days longer than pollen-producing varieties. Zinnia were grouped by two different stem cutting lengths, 30.5 cm and 45.7 cm, to determine yield differences. Plants with stems cut at 45.7 cm yielded an average of 30% fewer flowers than those cut at 30.5 cm. Highest quality and greatest yields were measured for the first plantings of *Helianthus* and *Gladiolus*, while the second planting of *Zinnia* and the forth of *Celosia* resulted in higher quality and greater yields. Scheduled plantings of cut flowers are necessary for season-long production of a particular crop, however, earlier plantings resulted in better quality and higher yields.

1340–1440

S19–P–102

EFFECT OF THE STORAGE OF CUTTINGS IN THE ROOTING OF DIFFERENT CHRYSANTEMUM CULTIVARS (*DENDRANTHEMA GRANDIFLORA* TZVELEV) IN TWO SEASONS

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Chrysanthemum (*Dendranthema grandiflora* Tzvelev) is commercially propagated by cuttings. Pre-rooting storage of cuttings, in the dark, is a common practice among producers and companies that work and trade with chrysanthemum cuttings. However, the maximum period of storage cuttings and differences of tolerance among cultivars have been investigated. In this context, the aim of this work was to determine the effect of time of cold storage of cuttings (0, 1, 2, 3, 4, 5 and 6 weeks) on rooting of four chrysanthemum cultivars (Su-

per White, Sheena, Dark Orange Reagan and Town Talk) in two seasons of the year (summer and winter of 2000) and also to analyse the origin of root formation in chrysanthemum cuttings. The experiment was arranged in a complete randomized design with 5 replications for each storage treatment. Each plot was constituted by three cuttings that were evaluated after 14 days after the cutting practice. In winter, cold storage affected cutting rooting, mainly after two weeks of storage for all cultivars. The rooting percentage was inferior in the winter and the cuttings were conserved for a shorter period. The source and growth of roots in chrysanthemum cuttings is endogenous. After three days, the callus was formed in the pericycle and the first emergence of the adventitious roots occurred at the fourth day of rooting.

1340–1440

S19–P–103

RESPONSE OF POINSETTIA CULTIVARS TO ALUMINUM EXPOSURE FOR POSTHARVEST DISORDERS

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Poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzch) bracts are susceptible to postharvest disorders like the pathogenic fungus, *Botrytis cinerea,* and the abiotic disorder, bract necrosis. Aluminum is a known antagonist of calcium uptake and Ca activities in plant membrane and cell walls. Aluminum exposure damages root tips, which are the sites of much Ca uptake and cytokinin synthesis. Therefore, Al exposure to poinsettia may aggravate the incidence of either or both of these disorders. Rooted cuttings of Supjibi and Maren were transplanted into a closed water culture system and later pinched leaving 4–5 nodes per shoot. The plants were grown in the standard Ca (4 mM) solution initially. At bract coloration, all plants were placed in the low, 0.5 mM Ca solution with three levels of Al (0, 60 or 120 µM added). For the Al treatments, initial pH was adjusted to 4.8 with sulfuric acid. After all plants of both cultivars were harvested their bracts were subdivided into transitional-bracts and true-bracts and the number of necrotic and healthy bracts recorded. Mineral nutrients in bracts were determined. Botrytis incidence was higher on transitional-bracts than on true-bracts for Supjibi at all Al levels while for Maren, Botrytis was higher on transitional-bracts than on true-bracts only at the highest Al exposure. Bract necrosis was not evident on Maren plants at any Al treatment level. The incidence of bract necrosis on Supjibi was the same on true-bracts and transitional-bracts in each Al solution. For Supjibi, exposure to different Al levels had no consistent effect on the incidence of bract necrosis.

1340–1440

S19–P–104

FOLIAR CALCIUM SPRAYS REDUCE THE SEVERITY OF UPPER LEAF NECROSIS ON *LILIUM* CV. STAR GAZER

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Upper leaf necrosis (ULN) on *Lilium* cv. Star Gazer is a calcium (Ca) deficiency disorder. To determine if foliar Ca sprays are effective in reducing ULN, experiments were conducted to investigate the effect of Ca salts, Ca concentrations, and application frequency. Necrosis severity of a single leaf was determined by necrosed area using an index from 0 (healthy) to 5. Single leaf severity then was added up to give whole plant severity. Daily foliar Ca sprays significantly reduced the severity of ULN. They also tended to reduce the incidence of necrosis, although it was not statistically significant. Fourteen daily sprays of 25 mM calcium chloride or calcium nitrate were both effective. However, seven sprays at 3.5-day intervals were not effective, even with high concentrations up to 150 mM. Daily sprays of calcium chloride or calcium nitrate were toxic and caused leaf tip yellowing when the concentrations exceeded 50 mM. Calcium chloride seemed to be more toxic than calcium nitrate at the same concentration. For effectiveness, it is necessary to have the Ca solution reach the enclosed young expanding leaves. Since daily Ca sprays would be very labor intensive, they may not be a useful recommendation to growers.

1340–1440

S19–P–105

DEHYDRATION OF ANNUAL CHRYSANTHEMUM (*C. CORONARIUM*)

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Unlike fresh flowers, dehydrated flowers can be stored for several years. The dehydrated flower industry has a large scope worldwide. But in India, only 20% of the raw material used in dry flower industry is cultivated and 80% is collected from the wild. Hence there is a need to standardize the proper dehydration technique of flowers. The flowers were dried in electrically operated hot air oven by embedding them in two dessicating media (sand and silica gel) and keeping them at controlled temperatures of 30, 40 and 50 °C for 24, 36 and 48 hours. Observations were recorded on weight (g), moisture (%) and carotenoid contents (mg/100 g) of fresh and dried flowers. Appearance score was also given visually on the basis of colour, cupping and stiffness of the petals. The weight of fresh and dried flowers was in the range of 1.25–1.44 g and 0.13–2.6 g with the moisture content of 87.43–88.78% and 9.19–15.68%, respectively. It was observed that weight and moisture content of dried flowers decreased significantly with the increase in oven temperature and duration. The % decrease was significantly more in silica gel as compared to sand. The carotenoid contents were 3.42–3.62 mg/100 g in fresh and 2.30–2.90 mg/100 g in dried flowers which increased significantly with the increase in temperature and duration of keeping them in oven in both the media. Silica gel was found best as % decrease in carotenoid contents was significantly less as compared to sand. Best quality of dried flowers were obtained by embedding them in silica gel and keeping at 500 °C for 48 hours in the oven as the % decrease in weight and moisture content was maximum and % decrease in carotenoid content was minimum. The visual score for these flowers was also found maximum as compared to other treatments.

1340–1440

S19–P–106

STUDIES ON POSTHARVEST LIGHT INTENSITY AND TEMPERATURE ON CARBOHYDRATE LEVELS AND VASE LIFE OF CUT FLOWERS

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Studies about affecting vase life of cut flowers by postharvest cultivation conditions are still very limited. In this study the changes in different photosynthetic attributes of cut flowers is presented under different light intensity levels and temperature. Chlorophyll is the main light-trapping molecule in green plants. Higher amount of this pigment during vegetative phase reflects the significant conversion of solar energy in to chemical energy, which eventually leads to source accumulation. Variations observed for these photosynthetic pigments were presented in graphs and tables. The higher level of the chlorophyll pigment itself does not mean higher economic yields. The critical determinant for growth appears to be temperature. Low temperature affects the growth from seedling to reproductive stage. Influence of high temperature on growth and yield of cut flowers in relation to there different planting dates was studied. The heat use efficiency was low in the early crop. The low yield obtained in the early crop was mainly due to a smaller and short-lived canopy leading to reduced interception of solar radiation more than the reduction in overall plant growth. High temperature lowered the yield, through reduced partitioning of photosynthates to the cut flowers. Accumulated day degree was calculated taking 4 °C as the base temperature. Plants from different contrasting habitats show considerable changes in physiological and biochemical parameters. It appears from the results that low temperature decreased the accumulation of starch and soluble sugars by inhibiting the activity of the carbohydrate metabolism. Total soluble sugars content also affected due to low temperature. The study also aims to compare the relative amount of proline accumulation. Total chlorophyll content in the leaf increased and the starch content decreased with reduction in light. The results from an extensive investigation were analyzed statistically.

1340–1440

S19–P–107

EFFECT OF PULSING, HOLDING AND LOW TEMPERATURE STORAGE ON KEEPING QUALITY OF ASIATIC LILY HYBRID

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Investigations were conducted on vase life studies in asiatic hybrid lily cultivars Alaska and Vivaldi. Uniform flowering stems consisting of three buds were harvested one day before the anthesis of first bud and kept in various vase solutions. Flowers pulsed with 10% sucrose + 1 mM silver thiosulphate (STS) for six hours significantly increased the vase life as well as improved various floral attributes like freshness, colour intensity and flower size. The vase life was further improved by keeping the pulsed flowers in a preservative solution (holding solution) containing 2% sucrose + 200 ppm HQC. Addition of 100 ppm GA_3 in the preservative solutions had better impact on reducing the yellowing as well as senescence of leaves and flowers. A pH of the vase solutions has greatly influenced the postharvest life of lily flowers being maximum at lower pH (3.5). Packaging of flower stems in poly sleeves was more effective than in craft papers. Flowers were stored more efficiently at 1 °C (as dry) at 90% relative humidity then at 4 °C. Temperature below 1 °C was more injurious to flower buds and leaves. Hence a combination of pulsing, low temperature storage and keeping the flowers in a preservative solution had the most impact on increasing the postharvest life of lily cut flowers.

1340–1440
S19–P–108
THE POSTHARVEST LIFE OF PULSED GLADIOLUS SPIKES: THE EFFECT OF PRESERVATIVE SOLUTIONS

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Plugging of vascular tissues by micro-organisms, depletion of available carbohydrates and damage by ethylene have been identified as the major cause of poor keepability of many cut flowers. Sucrose in combination with floral preservatives is known to improve the quality and extend the vase life of cut flowers. The present investigation was carried out to study the effect of four preservative chemicals on the postharvest life and quality of pulsed (20% sucrose for 24 hours) gladiolus spikes cv. White Prosperity. The cut gladiolus spikes were firstly pulsed with 20% sucrose for 24 hours and then subjected to the following floral preservative chemical treatments (i) Sucrose (5%) + 8-HQC (600 mg/L) (ii) Sucrose (5%) + aluminium sulphate (300 mg/L) (iii) Sucrose (5%) + cobalt chloride (300 mg/L) (iv) Sucrose (5%) + silver nitrate (200 mg/L) (v) Control (distilled water). The results showed that the vase solution containing 8-HQC produced the longest vase life (13 days), and the greatest number of florets (8.4) and floret diameter (7.8 cm). This might be due to inhibition of vascular blockage by 8-HQC. The vase solution containing $Al_2(SO_4)_3$ also significantly extended the vase life of cut gladiolus (12.5 days) compared to control (8.5 days). $CoCl_2$ effectively inhibited vascular blockage in the cut stems and hence prolonged the vase life (11.1 days), while the solution containing $AgNO_3$ also significantly enhanced the vase life (11.0 days) of cut gladiolus.

1340–1440
S19–P–109
EFFECTS OF NITROGEN AND POTASSIUM FERTILIZATION RATES ON YIELD AND VASE LIFE OF ORANGE JESSAMINE

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No information is available on the suitability and production of orange jessamine, *Murraya paniculata* (L.) Jack, for cut foliage use. Liners growing in 5-cm pots were planted in ground beds of Tavares-Millhopper fine sand on 30 Aug. 1995. Fertilizer treatments consisted of factorial combinations of nitrogen (from ureaformaldehyde) and potassium (from polymer-coated potassium sulfate) applied at rates of 196, 392 or 588 kg. From May 1997 (when the plants first produced marketable stems) through Sept. 2001, stems were harvested periodically to determine crop yield (number and fresh weight of stems). During that same period, stems were also cut for vase life evaluations. Stems were stored at 4 °C for two weeks and then evaluated for vase life under simulated home/office conditions (23 °C, 50% to 60% relative humidity, with 12 hours of light per day at 17 $\mu mol \cdot m^{-2} \cdot s^{-1}$ provided by cool-white fluorescent lamps). Yields increased over time and were not initially affected by fertilizer treatments. However, from 1998 onward, yields increased with increasing N application rates and by 2000 yields also increased with increasing K rates. There were never any interactions between N and K on crop yield. Average vase lives varied greatly by harvest (from 5.5 to 29 days), but were not affected by fertilizer treatments. Orange jessamine appears to have potential as a cut foliage crop; however, methods to ensure reliable vase life are needed.

1340–1440
S19–P–110
COMPARISON OF LEATHERLEAF FERN CULTIVARS FOR YIELD, FROND AND VASE LIFE CHARACTERISTICS

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Although it is the predominant cultivated florists' green, there is no published information on the characteristics of the cultivars of leatherleaf fern [*Rumohra adiantiformis* (Forst.) Ching]. Two patented cultivars, two cultivars derived using tissue culture techniques, and four additional cultivars were planted in a fernery in Tavares-Millhopper fine sand. Forty-eight rhizome pieces of each cultivar, 10 to 15 cm in length, were planted per plot. Plots were 3 square meters in size and were replicated six times per cultivar. During the first year, frond development from crosier to mature leaf was monitored. When fronds in the plantings reached marketable size, they were harvested, graded by size, counted and weighed. Periodically, mature fronds were harvested, stored at 4oC for 16 days, and then evaluated under simulated home/office conditions for vase life. After two years of harvesting, fresh weights of fronds were lower for the two tissue culture-derived (TC) cultivars (Dutch, Mayfield TC) and the patented cultivar Fancy compared to the other cultivars (Adair, Baker, Mayfield, Price, Roy Ruth). Price produced more extra large fronds than the other varieties wheres Dutch, Fancy and Mayfield TC produced fewer. Overall, Fancy produced the fewest fronds, followed by Roy Ruth. However, these two cultivars produced the heaviest fronds compared to the TC cultivars that produced the lightest fronds. Fancy fronds did not produce sori and there were few fertile TC fronds. Generally, larger fronds were more likely to be fertile, and this is probably explains the low percentage of TC fronds with sori. There was also a trend for vase life to decrease with increasing frond size for a majority of the cultivars. Seasonal vase life fluctuations were apparent for all cultivars.

1340–1440
S19–P–111
THE INFLUENCE OF TEMPERATURE ON THE VASE LIFE AND TRANSPIRATION OF CUT ROSES AND CARNATIONS

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The cut flowers of rose cultivars (Spinx, Bianca, First Red) and carnations (Ivonne, White Liberty, Indios) were kept in growing chamber on 20 and 30 °C, respectively. The average flower diameter was measured daily in 5 replicates of each cultivar, starting from flower bulb phase to wilting (flower senescence). The amount of transpired water was measured at the end of the experiment. There were signifficant differences in flower opening rate among tested cultivars, influenced by the air temperature. Howewer, the cultivars with shorter vase life transpired more water which indicates their water management during vase life. The temperature of 30 °C caused the shortening of flower longevity to 5 days, in respect to 10 days by roses and 8 days by carnations at 20 °C.

1340–1440
S19–P–112
EFFICACY OF TOPFLOR (FLURPRIMIDOL) ON BEDDING PLANTS

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Topflor is a plant growth retardant (PGR) now being registered for use in the United States. Trials with nine bedding plants (ageratum, begonia, celosia, coleus, impatiens, marigold, petunia, salvia, and vinca) were conducted to compare Topflor foliar sprays at concentrations of 10 to 320 $mg \cdot L^{-1}$ with paclobutrazol (Bonzi) at 30 $mg \cdot L^{-1}$ and uniconazole (Sumagic) at 5 $mg \cdot L^{-1}$. The plants were grown in 1801 bedding plant flats in a polyethylene covered greenhouse. Day/night temperature set points were 24/18 °C. Under North Carolina growing conditions, plant height and diameter was controlled with spray concentrations of 30 to 50 $mg \cdot L^{-1}$ on ageratum, impatiens, petunia, and salvia. Concentrations of 20 to 40 $mg \cdot L^{-1}$ were effective on celosia, coleus, and marigolds. On these bedding plants, excessive stunting and phytotoxicity was

observed with Topflor at concentrations >80 mg·L^{-1}. Both begonia and vinca were extremely sensitive to Topflor concentrations of 10 mg·L^{-1} and lower concentrations will need to be determined. The optimal Topflor concentrations will be compared with the paclobutrazol and uniconazole foliar spray concentrations used.

1340–1440
S19–P–113
SENESCENCE OF CUT CHRYSANTHEMUM REGULATED BY 6-BA, ABA PRETREATMENT

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Soluble protein content of leaves in cut chrysanthemum 'Shi Yuehuang', SOD activity, POD activity of leaves and florets were determined in cut chrysanthemum 'Si Jihuang'. The results showed that 6-BA, ABA pretreatment delayed or enhanced the senescence of cut chrysanthemum by inhibiting or stimulating the degradation of soluble proteins, respectively. 6-BA pretreatment increased and maintained the higher SOD activity in leaves at stage 4 and stage 5, but ABA pretreatment depressed SOD activity. The POD activity increased during whole vase duration, and ABA pretreatment stimulated it, POD activity under 6-BA pretreatment remained lower level than that of ABA pretreatment. SDS-PAGE (12.5% gel) profiles of proteins of leaves in cut chrysanthemum 'Shi Yuehuang' showed that ABA pretreatment could induced two new peptides (Rf 0.486, 0.638) relating to senescence at stage 4. SDS-PAGE (12.5% gel) profiles of proteins of leaves in cut chrysanthemum 'Si Jihuang' at wilting stage (stage 5) indicated contrary regulations by 6-BA, ABA pretreatment, ABA pretreatment greatly enhanced the expression of peptide at Rf 0.309 which was inhibited by 6-BA, other three new peptides (Rf 0.382,0.418,0.455) induced by ABA pretreatment were also inhibited by 6-BA pretreatment, ABA pretreatment caused the loss of three peptides (Rf 0.291, 0.327, 0.345), but 6-BA pretreatment retarded the degradation of those three peptides. It was concluded that these proteins might be responsible for the early senescence of leaves. Different regulation of expressions of SOD, POD isozyme by 6-BA, ABA was also observed, PAGE (7.5% gel) profiles showed that SOD isozyme bands in leaves and florets pretreated by 6-BA were deeply stained than those of ABA pretreatment, but PAGE profiles of POD isozyme in florets showed opposite characteristics of SOD stain.

1340–1440
S19–P–114
THE POTENTIAL USE OF LYSOPHOSPHATIDYLETHANOLAMINE (LPE), A NATURAL LIPID, ON THE VASE LIFE OF SHORT-LIVED LAVANDE AND SENSATION ROSES

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Cut rose cultivars such as Lavande and Sensation are in high demand because of their strong fragrance and unusual colors, but they have limited use in the floriculture industry due to their short vase life. Once placed in water, these flowers open very quickly and lose marketable life within three days. We investigated the use of an LPE dip on the vase life of these short-lived roses. Flowers grown at Pajaro Valley Greenhouses in Watsonville, California, were shipped to the Biotron on the Univ. of Wisconsin–Madison campus. The roses were sorted and only the most uniform and closed flowers were used. The roses were placed in vases containing a combination of LPE and chemicals to retard the growth of microorganisms. They were then moved to an environmentally controlled room, and observed for aesthetic value every twelve hours. Loss of aesthetic value was defined as the point at which a consumer would discard the flower due to complete opening or due to bentneck. LPE alone caused these roses to open more slowly. However, after about 60 hours from the time of treatment the roses die of bentneck due to microbial contamination. By retarding microbial growth, bentneck was eliminated, and under these conditions LPE continued to retard opening without the symptom of bentneck. Preliminary results indicate that we may be able to enhance vaselife of Lavande by 30% as compared to standard industry practices. LPE used in the retail cut flower industry could greatly increase the variety of flowers by prolonging the vase life of unusually colored roses.

1440–1500
S19–O–115
USE OF MOLECULAR MARKERS TO IMPROVE CUT FLOWER LONGEVITY IN CARNATION

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Postharvest longevity is one of the most important traits considered by the breeders of carnation. The availability of fast and simple methods for the early screening of F1 progenies could be very important to improve the efficiency of the breeding programs. In fact, we have to consider that it takes almost two years to evaluate flower longevity in the progenies, starting from the F1 seeds. In this work, RAPD analysis was used for the identification of molecular markers associated with flower vase life. These markers could then be used for the early screening of a population with a long vase life. Two cultivars (Roland and Milady) and their F1 and Backcross offspring were analyzed. The flowers of Roland showed a very long vase life with a very low ethylene production, whereas in Milady the early release of ethylene by the flowers promoted and accelerated flower senescence. Our previous studies on the segregation of the character in these progenies indicated that flower vase life is probably a complex quantitative trait in carnation, involving more than a single gene or mechanism, and that this character is controlled by genes showing predominantly additive effects. Sixty random primers were initially tested on a few genotypes. DNAs from 73 F1 and 36 Backcross offspring were then analysed with 10 selected primers. For each of RAPD band tested, the progenies were divided into two groups according to the similarity of the band pattern with Roland or Milady. The statistical significance of the differences in vase life between the two groups was evaluated. As a result, several bands resulted to discriminate significatively a more longeve population. Statistical analysis showed a positive correlation between the score of each progeny (number of RAPD bands similar to Roland) and flower longevity. These markers will be tested in other crosses in order to verify their general use for the assisted selection of flower vase life.

1500–1520
S19–O–116
LEAF PHOTOSYNTHESIS, FLOWER RESPIRATION, AND FLOWER LONGEVITY OF POT ROSES INFLUENCED BY CULTIVAR AND GROWING ENVIRONMENT

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Leaf photosynthesis and flower respiration were investigated on single-stemmed plants of *Rosa* L., cultivars Meiferjac, Ruijef and Ruirosora, grown in controlled environment growth chambers simulating summer-like and winter-like greenhouse growing conditions. When the flower on each plant reached developmental stage 2 (showing color, calyx reflexing, no petals reflexed), one group of plants was placed under a simulated interior environment at 21 °C under 15 μmol·m^{-2}·s^{-1} from cool-white fluorescent lamps for postharvest evaluations. On another group of plants at the same flower developmental stage, photosynthesis and flower respiration measurements were made under laboratory conditions at 23 °C, using a LI-COR 6400 Portable Photosynthesis System. Light and CO_2 response curves were measured for each plant. Flower respiration was determined under dark conditions by enclosing the whole attached rose flower, at development stage 2, into the 6400-05 LI-COR Conifer Chamber. The same pattern of differences was observed for flower respiration and flower longevity when comparing growing environments for each cultivar. Meiferjac and Ruijef plants exhibited greater flower longevity and lower flower respiration under summer as compared to the winter growing environment. Ruirosora plants exhibited similar flower longevity and similar flower respiration in both environments. Higher maximum photosynthetic assimilation rates were found for plants grown under the winter environment versus summer with no differences among cultivars. The quantum efficiency and the dark respiration calculated from the light response curve were higher for plants grown under a winter than a summer environment. These data were correlated to longer stems and larger leaves and flowers, but not to flower longevity. The carboxylation efficiency calculated from the CO_2 response curve was affected neither by growing environment nor by cultivar.

1520–1540
S19–O–117
STIMULATION OF PHYTOHORMONES ON SENESCENCE OF CUT CHRYSANTHEMUM

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The paper is to clarify the relations between phytohormones and senescence of cut chrysanthemum, especially early wilting of the leaves. The results by GC showed that cut chrysanthemum produced little ethylene during senescence, but both ACC(1-aminocyclopropane-1-carboxylic acid) and ethephon with high concentration, especially ethephon, could induce ethylene evolution in leaves and florets, make a leaf etiolation, and shorten a vaselife. The results showed indirectly that cut chrysanthemum must be belonged to non-ethylene climatic type failing to produce ACC and ethylene caused by ACS and ACO deficiency, and that it also belongs to non-ethylene-sensitive type. The results by ELISA showed that the iPA [6-(2-isopentenyl) adenosine] contents decreased continuously, the ABA and IAA contents increased continuously in leaves and florets of cut chrysanthemum during vaselife. But it was noticed that GA_{1+3} were not deficient in the later vase period and appeared a raising trend, GA_{1+3} could only increase diameter of the corolla. The decreasing trend of iPA contents during senescence was delayed and the vaselife was prolonged by 6-BA pulse treatment. By ABA pulse treatment, a sharp increase of ethylene in leaves and florets was induced, especially in leaves, and leaf etiolation and early wilting were also accelerated. Ethylene evolution induced by IAA was lower than that by ABA. It was observed that by 6-BA pulse treatment after by ABA, the ethylene evolution in leaves induced by ABA was inhibited greatly. All results showed that the cytokinin, represented by iPA, is the important factor delaying the senescence of the cut chrysanthemum, especially delaying early wilting of the leaves, and that ABA must be the main factor accelerating the senescence, for ABA (and IAA) could induce the ethylene evolution of the leaves, and accelerate etiolation and early wilting of the leaves, especially which under dry storage at 2 °C.

1540–1600
S19–O–118
INTERACTIVE EFFECTS OF PLANT DENSITY AND DURATION OF LONG DAY PERIOD ON EXTERNAL QUALITY OF CUT CHRYSANTHEMUM

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To reduce seasonal fluctuations in product quality and to achieve higher yield, cut chrysanthemum growers adjust plant density and duration of long day (LD) period according to the growing season. External quality of cut chrysanthemum is usually evaluated based on plant height, number of flowers per plant (NoF) and flower size. Furthermore, total plant fresh mass (TFM, g/plant) is also an important aspect for its commercialization. It is our aim to quantify the effect of plant density and duration of LD period on these quality aspects. Chrysanthemum cv. "Reagan improved" was grown from May till July in a greenhouse at 3 plant densities (48, 64 and 80 plants/m^2) combined with 3 durations of LD period (0, 1 and 2 weeks). TFM was used as a measure for assimilate supply. Plant height showed a strong positive linear relationship with duration of LD period. Decreasing LD period from 2 till 0 weeks resulted in 25% shorter plants. Plant density only had a minor effect on plant height and a positive quadratic response between these variables was observed. NoF increased with increased assimilate supply, whereas individual flower size (area and dry weight) was not affected. For example, plants grown under 2 weeks of LD period and at 48 plants/m^2 were the heaviest (91.5 g/plant) and obtained the highest NoF including buds (27.9 flowers/plant). The opposite treatment combination, i.e., 0 weeks of LD period and 80 plants/m^2, resulted in 57% lighter plants with 67% less flowers. A model to predict NoF was developed based on TFM (NoF = 0.353 TFM – 5.66; r^2 = 0.923). It was concluded that a similar TFM could be obtained using several combinations of plant density and duration of LD, without affecting either NoF or individual flower size. Although plant height was strongly influenced by LD duration a commercial length was always reached (>65 cm).

1600–1620
S19–O–119
EFFECT OF 1-MCP ON BLOOMING *PHALAENOPSIS* ORCHIDS AGAINST ETHYLENE

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The organic gas 1-methylcyclopropene (1-MCP) was shown previously to protect excised orchid flowers from being injured by ethylene up to 10 µL/L. However, with charcoal, other organic materials, and water in the potting media, it was not known if MCP would protect the orchid flowers on intact plants. In several experiments, blooming *Phalaenopsis* plants were first fumigated with 1-MCP for 6 h, exposed to ethylene for 24 h, and then evaluated under continuous 10 $\mu mol \cdot m^{-2} \cdot s^{-1}$ *PPF* at 23–25 °C. In all experiments, unprotected flowers wilted within 2 d of their exposure to ethylene. 1-MCP at 0.1 to 1.0 µL/L offered equal protection (flowers lasting 27 to 34 d) against ethylene. In another experiment, flowers treated with 0.4 µL/L 1-MCP and then exposed to ethylene after 7 or 14 d wilted within 4.5 d after ethylene treatment. However, plants that were re-treated with 1-MCP after two weeks and then exposed to ethylene lasted as long as the control flowers (50 d). In a third experiment, 0.5 or 1.0 µL/L 1-MCP protected flowers against ethylene for 6 d but not 14 d. Therefore, the protection offered by treating flowers with 1-MCP up to 1.0 µL/L was transient. It appears that unopened buds at time of 1-MCP treatment remained sensitive to ethylene after treatment. In the fourth experiment using excised flowers with no exogenous ethylene exposure, all untreated control flowers wilted within 2–3 d whether emasculated or not. Emasculated flowers pulsed for 24 h with 0.5 mM AOA lasted for 6 d, while the non-emasculated flowers treated similarly lasted for 9 d. Emasculated and non-emasculated flowers fumigated with 1 µL/L 1-MCP for 6 h lasted 9 and 13 d, respectively. 1-MCP apparently was more effective than AOA in suppressing ethylene synthesis in flower tissues. In the last experiment, pollinated, emasculated, and intact flowers lasted 3, 10, and 21 d, respectively.

1620–1640
S19–O–119–A
TO BE ANNOUNCED

1640–1700
S19–O–119–B
TO BE ANNOUNCED

Friday · August 16

0800–0900
S19–P–120
LEAF COLOR STABILITY AS AN INDEX FOR EFFECTIVE MASS-PROPAGATION OF *CALADIUM*

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Caladium plants were propagated by tissue culture using young leaf tissue. Micropropagation makes it easy to propagate *Caladium* rapidly. However, in the plants of some cultivars regenerated in vitro, leaf color variants are often observed. Such changes can be disadvantageous and may present problems to the commercial grower, whose objective is to produce and sell uniform plants. In this study, the leaf color stability was examined for the performance of *Caladium* cultivars in tissue culture. Leaf color developmental patterns were investigated in ten cultivars of *Caladium*. In some cultivars of *Caladium*, plants exhibited leaf color changing from young to mature leaf. The leaf color was measured by using a digital camera and analyzed through an image processing software program. Dominant leaf color was measured according to each color area compared with the initial and terminal leaf. After deciding the dominant leaf color, the percentage of terminal leaf should be divided by the percentage of initial leaf color to indicate a leaf color stability index. In our experiments, some cultivars showed their numerical value larger than 1 as leaf color index and also showed the high variants

(21 to 43%) in tissue culture. But some uniform leaf color pattern was also observed in some cultivars, which showed their numerical value less than 1 and also low variants (0 to 6%) during tissue culture. Therefore, a positive correlation of leaf color stability was established in relation to *Caladium* plants and their variants. In conclusion, multicolored foliage leaf of *Caladium* plants could be categorized into two groups as stable and unstable plants on the basis of leaf color status during plant development. From these present findings, it is considered possible to apply the tissue culture technique on the rapid propagation of non-variant plantlets and the induction of useful superior leaf color variants, if proper kinds of cultivars are chosen for growers.

0800–0900

S19–P–121

EFFECT OF DIFFERENT CONCENTRATIONS OF ROOTING HORMONES ON THE PROPAGATION OF TWO CULTIVARS OF DAYLILY FROM PROLIFERATION

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During the summmer of 2001, a study was conducted to determine the effect of different concentrations of rooting hormones on the propagation of two cultivars of daylily from proliferations. The rooting hormone indolebutyric acid at 0, 1000, 3000, and 8000 ppm was used in this study. Two daylily cultivars, 'Fiddle Dee Dee' and 'Three Wishes,' were studied. After four weeks of observations the results showed that the cultivar ' Fiddle Dee Dee' was superior to the cultivar 'Three Wishes' in forming roots with very little response from the rooting hormone concentrations. For rooting length, the two cultivars responded similar to the rooting hormone concentrations. The cultivar 'Fiddle Dee Dee' showed a slight increase in fresh weight as the concentration increased, while the cultivar 'Three Wishes' showed a slight decrease.

0800–0900

S19–P–122

CALCIUM HYPOCHLORITE TREATMENT ENHANCED THE SEED GERMINATION OF *CYPRIPEDIUM REGINAE*

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Effectiveness of calcium hypochlorite treatment on in vitro germination of the showy lady's-slipper orchid (*Cypripedium reginae*) seed was investigated. The genus *Cypripedium* has been known to be very hard to germinate in vitro. In general, the hypochlorite solution has been used for the surface disinfection of tissue culture materials. When seeds were soaked in 0.5% calcium hypochlorite (available chlorine) solution for 6 hours, the germination remarkably increased from 23.1% (control) to 95.9% on 1/4 strength MS medium supplemented with 2% peptone. Other concentrations (1 and 5%) of calcium hypochlorite were also more effective in enhancing percent germination than control. The germination of calcium hypochlorite-treated seeds was best when the agar medium contained 1/4 strength MS salts, 20 g/L peptone and 2 g/L activated charcoal. When treated seeds were observed under a light microscopy, seeds soaked in calcium hypochlorite changed the color of the embryo from brown to creamy white. The germination inhibiting chemicals present inside the embryo might have been eliminated by calcium hypochlorite resulting in a higher percent germination.

0800–0900

S19–P–123

ELIMINATION OF ASTER YELLOWS PHYTOPLASMA FROM *DENDRANTHEMA GRANDIFLORUM* BY APPLICATION OF OXYTETRACYCLINE AS A FOLIAR SPRAY

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Aster yellows phytoplasma infected chrysanthemums showing stunt, rosette and excessive branching were recovered from infection one month after final treatment by spraying with 400 mg/L oxytetracycline at three day intervals for a periods of 1, 2, 3 and 4 months. Two months after final treatment, new shoots from chrysanthemums revealed the disease symptoms again. Chrysanthemums propagated as cuttings from plants which were treated oxytetracycline followed by a final treatment with oxytetracycline have not expressed any phytoplasma infection symptoms for more than 10 months. Also, chrysanthemums soaked in 100 mg/L oxytetracycline solution combined with a foliar spray with 400 mg/L oxytetracycline for 4 weeks showed same results. Examination with an electron microscope of ultrathin sections of leaf midribs of chrysanthemum cuttings that were grown from plants treated with oxytetracycline for 4 months did not reveal any phytoplasma bodies 10 months after treatment. Nucleic acids from those plants that did not express symptoms after 10 months did not amplify phytoplasma specific DNA by PCR. These results could have implications in propagation schemes of healthy stocks for a wide range of plant species.

0800–0900

S19–P–124

ASYMBIOTIC GERMINATION AND SHOOT TIP CULTURE OF TEMPERATE *CYMBIDIUM*

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Orchids occupy an important place in floricultural industry. Oriental orchids, which are widely distributed in the temperate zones, have various kinds of species and are the most attractive ones. Inspite of these, the extent and speed of propagation in oriental orchids are quite poor, compared with others. Attempts have been made to develop rapid asymbiotic seed germination or efficient shoot tip culture techniques for orchid propagation. A great deal of progress has been made on the asymbiotic germination of temperate *Cymbidiums* of which success is now being matched with that in tropical or subtropical *Cymbidiums*. Through culture techniques necessary for asymbiotic germination of temperate *Cymbidium* seeds, days to germination could be shortened, and efficiency of rhizome growth and differentiation of plantlets from rhizome improved. The loss of leaf variegation and flower color can be prevented by shoot tip culture. In shoot tip culture of temperate *Cymbidiums*, establishment of initial culture techniques is very important; first, to ensure the elimination of organisms infecting the tissue externally and internally, second, to prevent oxidization of the inoculums in the culturing process. The *Cymbidium*, a perennial plant, is easily contaminated by organisms, which are very hard to eliminate. Regeneration ability is low because the shoot tips quickly brown after excising. Most of the aforementioned problems have been resolved through our experiments, permitting more efficient shoot tip culture. Commercialization through the rapid proliferation of excellent pedigrees is increasingly possible. The improved processes from seed sowing to plantlet regeneration are summarized. The processes identified with shoot tip culture of temperate *Cymbidiums* are summarized.

0800–0900

S19–P–125

MICROPROPAGATION OF *ORNITHOGALUM SAUNDERSIAE* BAK.

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Ornithogalum saundersiae Bak., a specialty cut flower is of economic importance in Kenya. It is one of the top ten cut flowers exported to Europe. Presently the only commercial method of propagation of *O. saundersiae*, which is still being cultivated in its wild form, is through offsets. This method results in a very low rate of multiplication and offers no opportunity for variation that can be exploited in developing new varieties. Unavailability of adequate planting materials continues to be a big constraint in the development of the flower industry in Kenya. A study was therefore conducted to investigate the possibility of micropropagation of *O. saundersiae* and the effect of NAA and BA concentration and their combination on organ regeneration from *O. saundersiae* scale portions. Preliminary studies to investigate the possibility of regenerating organs from inflorescence and floral explants of *O. saundersiae* were also done. In micropropagation

of *O. saundersiae* Bak. using scale pieces, combinations of NAA and BA at concentration of 0, 0.05, 0.5, 5 μM and 0, 0.5, 5, 10 and 20μM respectively in the culture media were compared. Explants on media without NAA and BA had 0–33.3% survival rate while the highest survival of 93.3% was observed in medium with 5 μM of NAA and 0.5 μM (88.9%). NAA at high concentration (0.5 and 5 μM) also resulted in the regeneration of roots while inclusion of BA inhibited root regeneration. Callus was only formed on explants on media with 5 μM of NAA and the highest number of explants that formed callus were found in the media with equal concentrations of BA and NAA. Tissue culture of *O. saundersiae* from various floral explants was possible but they required both NAA and BA in the MS media to regenerate organs. Plantlets, shoots, roots and/or callus were obtained directly or through intervening callus from immature florets, scape sections, pedicels and sepals.

0800–0900

S19–P–126

EFFECT OF MEDIA, BUD, AND TEMPERATURE ON MICROPROPAGATION IN *DENDROBIUM PHALAENOPSIS* CULTIVARS

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Natl. Hort. Res. Inst., RDA, Suwon, Kyunggi-Do, Korea, 441-440

These studies were conducted to test the effect of bud position, temperature, and media on the induction and propagation of PLB (Protocorm Like Bodies) between cultivars by culturing shoot tips of the apical and lateral buds of *Dendrobium Phalaenopsis* cultivars ('Earlsa Kul', 'Semi Alba', and 'Omya Pink'). The percentage of PLB induction was about 20% higher compared to culturing of apical buds in a MS medium, when lateral buds were cultured in a Vacin and Went basal medium. Use of the lateral buds and a VW basal medium were more effective than use of the apical buds and a MS basal medium for PLB induction. The appropriate concentration of NAA and BA for PLB induction was different depending upon cultivars. 'Earlsa Kul' was effective in 0.1 NAA + 0.5mg/L BA, but, 'Omya Pink' and 'Semi Alba' were better in 0.5 mg/L NAA than in other combinations. The probability of PLB induction between cultivars was highest in *Dendrobium Phalaenopsis* 'Earlsa Kul' and 'Semi Alba', but it was lowest in cultivar 'Omya Pink'. The optimal temperature for culturing was 25 C. Three cultivars cultured in 25 C were effectively propagated as PLBs and plantlets. On the other hand, plantlets which were cultured in 22 and 31 C changed to a brown color, and had short shoot lengths.

0800–0900

S19–P–127

EFFECT OF MEDIUM COMPONENTS ON IN VITRO TUBERIZATION OF *GLORIOSA ROTHSCHILDIANA* O'BRIEN

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Sucrose and mineral salts concentration in the medium are known to stimulate storage organ formation in vitro of many geophytes. Activated charcoal is also often added to plant tissue media to increase bulbil and tuber growth. The effects of these components on development of *Gloriosa rothschildiana* O'Brien 'Red Dark' tubers were investigated. Single shoots, derived from in vitro multiplied material, were used as explants. Shoots were cultured on the Murashige and Skoog (MS) basic medium containing 1x MS or 1/2x MS (half strength of macroelements), NaH_2PO_4 at 170 mg·L^{-1}, thiamine at 0.4 mg·L^{-1}, pyridoxine at 0.5 mg·L^{-1}, nicotinic acid at 0.5 mg·L^{-1}, glicyne at 2 mg·L^{-1}, myoinositol at 100 mg·L^{-1}, agar at 6.5 g·L^{-1} and sucrose in different concentrations: 0, 3, 6, 9 and 12%. Full-strength MS (1x MS) medium supplemented with 6% of sucrose and 0.1 or 1% of activated charcoal was also tested. The pH was adjusted to 5.7. The cultures were maintained at 22 C and light intensity of 35 μM·m^{-2}·s^{-1} and 16-h photoperiod. After 12 weeks of the experiment number, length, fresh weight of microtubers formed at shoot base (primary tubers) as well as tubers developed from the primary tubers (secondary tubers) were measured. Moreover formation of roots was evaluated. A culture medium containing half-MS macronutrients proved more successful for induction and growth of gloriosa tubers. Sucrose concentration had a significant effect on tuberization. Larger tubers formed on media containing 6–9% of sucrose compared to 3 and 12% of sucrose. The highest average fresh weight of primary microtubers was found on the medium with 1/2 MS and 6% of sucrose but for growth of secondary tubers more appropriate was a medium containing 1/2 MS and 9% of sucrose. Medium containing 1/2 MS and 6% of sucrose was the best for root differentiation. Activated charcoal slightly promoted root elongation but did not affect tuberization capability of gloriosa shoots.

0800–0900

S19–P–128

EFFECT OF GA_3 AND NUTRITIONAL SOLUTION TREATMENTS ON QUALITY AND QUANTITY CHARACTERISTICS OF FOUR GENOTYPES OF *CYCLAMEN PERSICUM*

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Experiments were conducted in order to study the vase-life of *Cyclamen persicum* cut flowers at Dept. of Horticulture, college of Agriculture, Tehran Univ., Karaj, in 1996–99. Four genotypes of *Cyclamen persicum* which were the results of years of self pollination programs were chosen as white, purple, pink and red. Seeds of each genotype were sown and plant production was done by ordinary way of pot cyclamen production. Plant characteristics of all genotypes were studied. Five levels of gibberellic acid (0, 10, or 50 ppm in one application and 10 or 50 ppm in two applications) and four levels of nutrients in nutritional solutions were all considered as treatments. Three pots of cyclamen were used as the unit of this experiment. Number of leaves and flowers, vase-life of flowers, length, weight and diameter, Ca and Na of the cut flowers were all considered and measured. Highest hypocotyl weight was produced by nutritional treatments (solution No. 4) and the highest macroelements (K, Ca and Na) of cyclamen cut flowers were produced by nutritional treatment, (solution No. 3). The same treatment were effective in producing longer vase-life of cyclamen cut flowers.

0800–0900

S19–P–129

SOMATIC EMBRYOGENESIS IN *ANTHURIUM ANDREANUM* LIND. 'DRAGON'S TONGUE'

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As transgenic plants have been recovered from somatic embryos treated with *Agrobacterium tumefaciens* and particle bombardment, development of an embryogenic system would be important in facilitating micropropagation and genetic engineering of anthuriums. A study was undertaken to standardize the in vitro protocols for somatic embryogenesis in *A. andreanum* 'Dragon's Tongue'. Among the in vivo explants, only seed explants showed response (8.33%) to embryogenesis induction treatments. Callusing was observed from all the in vitro explants, but only leaves (53.00%) and petiole (18.90%) produced embryogenic calli. Within two months of culture in dark with subculturing at two weeks interval onto fresh media, translucent embryogenic calli were observed along the cut surface of both leaf blade and petiole explants derived from in vitro cultures. In the case of seeds, embryogenic calli produced were from hypocotyls. Leaf and petiole explants produced abundant embryogenic calli when cultured on NW medium, but for seeds, an ideal medium for embryogenic callus induction was Nitsch medium. For the initiation of somatic embryoids from embryo mass produced from leaves, 2,4-*D* 2.0 mg + kinetin 0.75 mg recorded the maximum response (53.00%). Supplementing the media with glutamine 200 mg recorded the maximum response in terms of embryogenic culture initiation (ranging from 43 to 53%). Number of embryoids/culture was maximum in the treatment combination involving NW + 2,4-*D* 10 mg + kinetin 0.15 mg + ABA 0.1 mg +glutamine 400 mg + sucrose 30 g. Of the different media tested to germinate the somatic embryos, _ MS + glutamine 200 mg + sucrose 20 g recorded the maximum germination (46%). After germination and development of plantlets, the cultures were moved to continuous light regime and were successfully transfered to ex vitro conditions.

0800–0900

S19–P–130

IN VITRO MUTAGENESIS STUDIES IN GLADIOLUS FOR INDUCTION OF RESISTANCE TO *FUSARIUM OXYSPORUM* F.SP. GLADIOLI

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Gladiolus is one of the most important geophytes being grown in India on 1000 ha area. It is highly heterozygous and propagated through corms, hence most suitable for mutagenesis. Fusarium Yellows of gladiolus caused by *Fusarium oxysporum* f.sp. gladioli (FOG) is an international problem and amounts to 60–100% loss in various parts of the world. In vitro multiplied shoot clumps of gladiolus cvs. Eurovision, and Wine & Roses were irradiated with different doses of 60 Co gamma rays. Survival rate of irradiated shoots decreased with the increase in the dose of 60 Co gamma irradiation. A dose of 50 Gy had the lowest survival rate, but was sub-lethal. Plants surviving on this dose of gamma irradiation were in vitro multiplied on GMM-7 (MS medium + 2 mM KIN) in cv. Wine and Roses, and on GMM-8 (MS medium + 4 mM KIN) in case of cv. Eurovision. In vitro selection by challenging with fusaric acid (1–1.5 mM) and culture filtrate (20%) of *F. oxysporum* f.sp. gladioli resulted Fusarium yellows insensitive mutants at the end of 3rd selection cycle. Ex vitro evaluation further confirmed that fusaric acid and cultrate are suitable phytotoxins for getting optimal resistance against FOG.

0800–0900

S19–P–131

STUDIES ON MICROPAGATION OF TULIPS AND DAFFODILS

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Techniques were developed for faster clonal multiplication of promising cvs of tulips and daffodils through micropropagation. Mercuric chloride (0.1%) treatment for 5 minutes of tulip axillary buds and 10 minutes of twin-scales and chip segments of daffodils resulted maximum uncontaminated growing cultures. MS medium containing NAA (1 ppm), BA (5 ppm), sucrose (3%) and agar 0.8%) was found to be best for shoot multiplication of tulips cvs. Recreado and Christmas Marvel. However, in daffodils cvs. Carlton and Dutch Master, maximum number of shoots were obtained on MS medium plus NAA (1ppm), BA (5 ppm), sucrose (3%) and agar (0.8%). In vitro rooting was found to be difficult in case of tulip cultivars. MS medium containing sucrose (9%), agar (0.8%) and NAA (1 ppm) was found to be most effective for in vitro bulblet formation and rooting of tissue culture derived shoots in daffodil cultivars.

0800–0900

S19–P–132

CHANGES OF PROTEIN AND STARCH ON REGENERATION AND GROWTH OF BULBLETS FROM IN VITRO CULTURE OF BULB SCALE SEGMENTS OF *HYACINTHUS ORIENTALIS* CV. ANNA MARIE BY PRECOLD TREATMENT AND SUCROSE SUPPLEMENT

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The regeneration of hyacinth depends on pretreatment of the parent bulb. Higher growth of explants (bulb scale segment plus regeneration bulblet) and larger regenerated bulblets have been obtained after 4 months' storage at low temperature (4 °C). However, the response of sucrose (2% w/v) supplement in the modified Heller medium varied with the culture period. Changes of starch levels in bulb scale explants were also found; the amount decreased during 2-4th weeks or 12-16th weeks of culture as a result of low temperature treatment. A sucrose supplement increased starch content during early culture (2-4th weeks), but the level decreased at the 16th week of culture. Starch grains were observed through scanning electron microscopy during the regeneration process at various stages after cultivation of scale explants, and the number of starch grains varied with the lapse of culture period. The most compact starch grains were found during the first 2 weeks of culture. SDS-PAGE analysis of scale extracts of hyacinth exhibited various polypeptide bands in electrophoresis gels. The most outstanding feature was the presence of the polypeptide band of 45KD, but the polypeptide band was greatly decreased in the gel at the 12th week of culture. This polypeptide appeared most strongly in the lane of zero week culture by nonprecooled treatment at 20 °C, and after 2 weeks of culture its intensity began to decrease, indicating that this polypeptide may be a family of major storage protein in the hyacinth scales. Protein levels in scale explants were decreased in the bulbs precooled at 4 °C; in contrast, the nonprecooled treatment in combination with sucrose (2%, w/v) mostly increased the amount of proteins during subsequent culture.

0800–0900

S19–P–133

PRODUCTION OF VIRUS TESTED GLADIOLI THROUGH IN VITRO AND IN VIVO TECHNIQUES

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Gladiolus is a popular flowering crop throughout the world. In India its cultivation is of recent origin being only a few decades old. Himachal Pradesh, situated in the North-Western Himalayan region offers a tremendous scope for its cultivation due to varied climatic regions where farmers can produce cut flowers during off seasons for sale in North Indian plains.The decline in production of gladioli has been observed in recent years due to inferior quality of crop as a result of phytopathological problems. Among other diseases viruses have been causing considerable concern to the gladiolus growers. Surveys conducted in the major Flower growing regions of the state revealed that the variety Morala carried 100% infection of Bean Yellow Mosaic potyvirus and Cucumber Mosaic cucumovirus, showing symptoms of mosaic, mottling, venation and necrosis on leaves. The viruses were found to be mechanically transmissible to *Chenopodium amaranticolor*. Plants free from theses viruses were produced by meristem tip culture, heat therapy and using a biovirus inhibitor. Meristem tips varying in size from 0.5–0.7 mm gave 50% survival on half strength MS medium supplemented with 0.5 mg/L BAP but all the surviving meristems produced plants free from theses viruses. In addition a hot water treatment of bulbs at 550C could also eliminate these viruses from the plants. The viruses could be eliminated from the crop by spraying infected plants with 9.0 ppm of root extracts of *Asparagus adscendens*. On the other hand, when the explants from infected plants were grown on a medium charged with this bio virus inhibitor even a concentration of 7.0 ppm was found suitable for getting rid of BYMV and CMV. This is the first report of use of a virus inhibitor of plant origin to control viruses infecting gladioli. The technique offers an environmentally friendly approach to tackle the two most devastating viruses of gladiolus.

0800–0900

S19–P–134

AN INNOVATIVE TECHNIQUE FOR DISEASE RESISTANCE BREEDING: GAMETOPHYTIC APPROACH

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Breeding for disease resistance is an important program in most of the cultivated crop plants. Large number of genes governing resistance invariably leads to handling of large plant population consuming large area and long time besides limiting the probability of recovering the desired type. As an alternate the present innovative technique was worked out where in gametes with desired alleles are selected in their haploid and unmasked condition. Easy handling as well as the possibility of handling a large gametophytic population in small area and in short time involved in this innovative technique enhances the probability of recovering the desired genotype. *Dianthus chinensis* is selected as a model system to work out the strategy to develop lines resistant to *Fusarium oxysporum* f.sp. *dianthi*. Stigma of flowers at receptive stage were pretreated with culture filtrate of *F. oxysporum* f.sp. *dianthi*. Pollination was attempted on pretreated stigma and on untreated stigma as a control resulting in progeny from selected pollen (PS) and progeny from unselected pollen (PUS) respectively. Both PS and PUS were artificially screened by incubating them in culture filtrate. Results clearly indicated that PS were more tolerant to fusarium compared to PUS. Observations of visual wilting, were further confirmed by measuring water holding potential as well as leakage of solutes. Germination of pollen grains in presence of culture filtrate indicated the positive association of pollen grain size with resistance to pathogen as indicated by germination percentage as well as elongation of pollen tube. Analysing the pollen grains for their histochemical such as starch, protein and nucleic acid content indicated that large pollen grains with high starch and low nucleic acid content are responsible for resistance. These gametophytic approach enhances the probability of recovering the right genotype from 1/22 n to a mini-

mum of 1/2 n or to a maximum of 1-1/2 n.

0800–0900

S19–P–135

CHARACTERIZING THE DIVERSITY OF TEN DOMESTIC POPULATIONS OF WESTERN FLOWER THRIPS AND THEIR POTENTIAL IMPACT ON FLORICULTURE CROPS

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Western flower thrips (WFT) are a significant insect pest of floriculture crops worldwide. Integrated pest management programs rely on mechanical, cultural, and chemical components to manage this insect pest. One underutilized cultural control, due to limited research, is host plant resistance. Plant breeding programs for host plant resistance must produce cultivars with durability across environments. The durability of resistance is proportional to the selection pressures, such as insect populations, applied during cultivar development. Feeding aggressiveness of insect populations is known to vary with population source. To identify an aggressive WFT population, insects were obtained from 3 research laboratory colonies, 3 greenhouse populations, and 4 native habitats. These ten populations were characterized based on morphological features, feeding aggressiveness, and resistance to Conserve at label and half label rates. Insect populations were isolated and reared under laboratory conditions. Insects from each population were used to inoculate two cultivars of impatiens. Feeding damage on the impatiens, as determined by image analysis, varied between insect populations when evaluated in a completely randomized design with repeated measures over five months. Several populations were classified as aggressive feeders. Insect size varied among populations and may impact feeding aggressiveness. Two greenhouse populations exhibited some level of resistance to Conserve, a current insecticide labeled for WFT management. Populations from laboratory and native habitats exhibited no resistance to Conserve. Diversity among these populations indicates that host plant resistance breeding programs must select aggressive WFT populations to ensure adequate selection pressures are applied on plant germplasm before commercial release.

0800–0900

S19–P–136

INDUCTION OF ADVENTITIOUS SHOOTS IN VITRO IN *CAMPANULA CARPATICA* JACQ.

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Efficient protocols have been developed to induce adventitious shoots in different types of explants of *Campanula carpatica*. More than five shoots (per explant) developed on hypocotyls of 5-week-old seedlings after 2 weeks of culture. Hypocotyls produced doubled the number of shoots than the cotyledons. TDZ proved to be about six-times more efficient than BAP. NAA had to be added to the regeneration medium to obtain the optimal balance of auxin and cytokinin to induce shoot regeneration. There were significant differences in the effects between concentrations of growth regulators. BAP induced doubled the number of callus clumps than TDZ. Incubation of explants in the dark produced about 6 shoots per explant while the ones in the dark produced only about 2 shoots per explant. Explants from 5 weeks old seedlings were significantly more regenerative than those from 15 weeks old seedlings (5:1 ratio). Explants from cv.White Uniform were more organogenic than those from cv. Blue Clip. Root segments were also found to found to form shoots when treated with CPPU.

0900–0940

S19–O–137

GENERATION OF NEW ORNAMENTAL VARIETIES THROUGH GENETIC MODIFICATION OF PIGMENT BIOSYNTHESIS

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The introduction of new colours and forms through genetic engineering is likely to become an integral part of the breeding of new ornamental varieties. Although application of these techniques to floriculture has been slow to progress in comparison with the major crop species, there are now transgenic carnations for sale in several countries, and many more floriculture products are in the pipeline. We have a programme aimed at understanding the basis of colour variation observed in nature, so that strategies for modifying flower and plant colour can be developed. Of the pigments responsible for flower colour, the flavonoids are the most common, the most commercially important, and from a biotechnology point of view the most amenable. A number of groups, including ours, have used sense and antisense technology for specific flavonoid biosynthetic genes to generate new flower colours and floral patterning in a range of species. Furthermore, the knowledge of the genes regulating the flavonoid biosynthetic pathway is now well advanced, enabling either the whole pathway, or sections of it, to be activated in chosen tissues. Production of specific target colours, such as yellow, blue or bright red from flavonoids relies on specialized pigment structures and cellular conditions, and remains difficult from a biotechnology perspective. Recent progress in producing these colours in target species will be reviewed, including prospects with non-flavonoid pigments such as the carotenoids, betalains and bacterial pigments. The presentation will highlight some of our laboratory and field trial results for a range of species, including petunia, pelargonium, lisianthus, cyclamen, chrysanthemum and cymbidium orchids.

0940–1000

S19–O–138

IDENTIFICATION OF AGLYCONES AND COPIGMENTS AND FLOWER COLOR INHERITANCE IN STOKES ASTER [*STOKESIA LAEVIS* (J. HILL) GREENE]

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Stokes Aster is an attractive herbaceous perennial native to the southeastern United States. Cultivars are available with blue, purple, yellow, or white (technically albescent) flower color. HPLC analysis of flowers from 'Peaches' and 'Purple Parasols' revealed that petunidin was the predominant aglycone responsible for blue or purple flower color. Albescent flowers from 'Alba' contained petunidin as well, but at a much lower concentration. Conversely, flowers of 'Maroon' contained negligible amounts of petunidin, instead showing cyanidin as the predominant aglycone. Luteolin was the primary copigment in these four cultivars tested. Inheritance of flower color was investigated using F1 and F2 families created from various cultivar combinations. F1 families derived from hybridization between all combinations of blue, purple, yellow, and white flowered parents all showed progeny with blue or purple flower color. This suggests that blue or purple flower color is dominant to white or yellow. An F2 family derived from 'Alba' (albescent) x 'Blue Danube' (blue) showed a segregation ratio of about 3 blue: 1 albescent, suggesting that white (albescent) flower color is controlled by a single recessive gene. Two separate F2 families were generated from the hybridization of 'Mary Gregory' (yellow) with either 'Omega Skyrocket' (blue) or 'Alba' (albescent). Yellow flowered progeny were recovered in the F2 family derived from 'Alba' x 'Mary Gregory', but not from the F2 family derived from 'Mary Gregory' x 'Omega Skyrocket'. This shows that yellow flower color is heritable, but will segregate in only certain parental combinations.

1000–1020

S19–O–139

TRANSFORMATION OF AFRICAN VIOLET (*SAINPAULIA IONANTHA*) WITH GLUCANASE-CHITINASE GENES USING *AGROBACTERIUM TUMEFACIENS*

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African violet (*Saintpaulia ionantha* H. Wendland) is one of the most important ornamental plants used in indoor decoration, gardening and landscaping. These plants are attacked by *Fusarium oxysporum, Phytophthora* sp., and *Pythium ultimum* which cause Crown Rot and by *Botrytis* sp. which causes

Botrytis Blight. Present work was envisaged to incorporate the genes producing chitinase and glucanase which impart resistant to these diseases. Transgenic African violets were produced via *Agrobacterium tumefaciens* mediated transformation. To start with, regeneration protocols were standardised through multiple shoot bud production from leaf and petiole explants using BAP and NAA as growth regulators. BAP at 2.5 mg·L^{-1} and NAA at 1 mg·L^{-1} gave the highest number of shoot buds (40) in leaf explants. In petiole explants, BAP at 0.5 mg l-1 and NAA at 0.1 mg·L^{-1} gave the highest number of shoot buds (22). Rooting of these shoot buds was found to be maximum with NAA at 2 mg·L^{-1}. Leaf explants were inoculated with the strain LBA4404 of *Agrobacterium tumefaciens* harbouring the binary pBINAR carrying Glucanase- chitinase genes and nptII selectable marker. Regenerants obtained on the selection media containing kanamycin (70 mg·L^{-1}) and cefotaxime (800 mg·L^{-1}) were excised and rooted on the media containing NAA. Integration of the transgenes in the plant genome was confirmed by PCR analysis and Southern hybridzation. Mean glucanase activity in the transgenic plants was 44220 mu mL^{-1} while that in control plants was 27060 mu ml-1. The crude protein extracts of transformed plants showed zones of inhibition when tested on *Fusarium oxysporum* and *Pythium* while control plants did not show any such inhibition or antifungal activity.

1020–1040
S19–O–139–A
TO BE ANNOUNCED

1400–1420
S19–O–140
CHARACTERIZATION OF GENE EXPRESSION IN *CYPRIPEDIUM PARVIFLORUM* VAR. *PUBESCENS* ROOTS INCUBATED WITH A MYCORRHIZAL FUNGUS

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Temperate, terrestrial orchids have large potential as a novel horticultural crop offering both the exoticism of the orchid flower with superior hardiness. Terrestrial orchids remain a peripheral commodity due, in large part, to the difficulty in propagation and production. This difficulty arises because of the dependence of orchid seeds on a mycorrhizal fungus for germination and of adult plants on the fungus for sustainable growth. To understand the processes underlying the formation of mycorrhizae in orchids, we undertook a differential display technique to identify genes that show regulation in the early stages of the interaction. *Cypripedium parviflorum* var. *pubescens* was grown in the presence or absence of *Thanatephorus pennatus*. RNA was extracted from roots of both treatments and subjected to RT-DD AFLP PCR. Of 5000 bands 16 were selected as being differentially expressed and of these 2 were identified as non ribosomal RNAs. One fragment showed homology to Trehalose-6-phosphate phosphatase/synthase and the other fragment showed homology to a nucleotide binding protein. Semi-quantitative PCR confirmed differential expression. PCR was used to analyze expression of both genes in roots in response to the fungi over time. Promoter: GUS fusion analysis was undertaken for the orthologs of both genes in *Arabidopsis.*

1420–1440
S19–O–141
DNA FINGERPRINTING OF CHRYSANTHEMUM CULTIVARS USING RAPDS

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Genetic variation in chrysanthemum (*Chrysanthemum morifolium* Ramat) was examined using Random Amplified Polymorphic DNAs. Thirteen commercial chrysanthemum cultivars representing standard and spray groups were selected to assess the genetic relatedness. Genetic variation was studied using sixty random decamer primers. Of these, 31 primers amplified chrysanthemum genomic DNA.. For the cultivars tested, between 3 to 21 bands were obtained for each primer and of a total of 257 clear and reproducible bands, 239 bands were polymorphic. The amplified DNA fragments normally ranged from 0.55 to 2.0 kilo base pairs. The primers screened revealed RAPD fragment(s) unique to a particular cultivar. For 11 of the 13 genotypes, it was possible to find at least one such primer which differentiates particular cultivars. RAPDs data of different cultivars were used to calculate Squared Euclidean distance matrix and based on this, cluster analysis was done using unweighed pair group analysis by arithmetic mean (UPGMA). Genetic variation amongst cultivars was high enough to divide it into three major groups. These groupings were in consistent with their morphological differences and on geographical distribution. The first group consisted of Snow Ball, Ajina Purple and Sonar Bangla cultivars, while the second group accounted for Nagpur Red and Haldighati. Cardinal, Puja, Jaya, Suneel, Vasantika, Gauri, Flirt, and Baggi were clustered into third group. The results indicate that RAPDs are efficient for identification of chrysanthemum cultivars and for determination of the genetic relationships among cultivars.

1440–1500
S19–O–142
ROL GENES AND NEW GENOTYPES OF *LIMONIUM GMELINII* THROUGH *AGROBACTERIUM*-MEDIATED TRANSFORMATION

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Limonium gmelinii was transformed using the disarmed strain LBA4404 of *Agrobacterium tumefaciens* containing the binary plasmid pBIN19 harboring rolA, rolB and rolC genes (EcoRI 15 fragment) of Agrobacterium rhizogenes.To verify that the regenerated kanamycin-resistant plants were genetically transformed, we provided molecular evidence performing PCR and Southern analysis. Rol A, B and C genes resulted integrated in plant genome for all analyzed samples showing a band of 4300 bp corresponding to the fragment EcoRI 15 cloned in plasmid pBin19. The genetically modified genotypes, when compared to the control, showed different morphological traits, ranging from very compact plants to semi-compact plants. Results of practical interest were obtained for the most compact types, which could be used as pot plants and for the production of small bouquets ready to get. These results suggest that genetic transformation with rol genes can really improve ornamental traits in *Limonium gmelinii*. The new ornamental traits of transgenic clones, together with the long post-harvest life, the high multiplication rate by micropropagation and the excellent acclimatization performances, are further important elements for economic success. Considering that the best varieties of *Limonium* are vegetatively propagated in vitro, proof of genetic stability through cycles of micropropagation is required before the introduction of the transgenic *Limonium* for commercial production.

1500–1520
S19–O–143
ELIMINATION OF VIRUSES FROM VIRUS-INFECTED GLADIOLUS PLANTS THROUGH INFLORESCENCE-DERIVED CALLUS CULTURE

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Gladiolus, as a vegetatively propagated crop, cannot escape from virus infection during cultivation. Twenty species of viruses have been reported to infect gladiolus plants in the world, and five species, such as broad bean wilt virus (BBWV), bean yellow mosaic virus (BYMV), cucumber mosaic virus (CMV), clover yellow vein virus (CYVV), and tobacco rattle virus (TRV), were identified in Korea. This study was conducted to eliminate viruses from virus-infected gladiolus plants through callus culture. 'Spic & Span', 'True Love' and 'Topaz' of gladiolus were used as plant materials. Viruses were observed and detected by direct negative staining (DN) method, transmission electron microscopy (TEM), enzyme-linked immunosorbent assay (ELISA) and immunosorbent electron microscopy (ISEM). Callus was induced on MS solidified-medium containing 2,4-*D* from young inflorescence of virus-infected plants, and procedure of Kim et al. was adopted to maintain, proliferate, and redifferentiate callus. In result, BBWV, BYMV, CMV and CYVV were detected from virus-infected plants of 'Topaz'. In case of plants obtained from cormel tips, BBWV and CMV, spherical virus, were completely eradicated, but BYMV and CYVV, filamentous virus, were still found in a low frequency. However, no virus particle was detected in plants redifferentiated from callus. Same result

was obtained from the cases of 'Spic & Span' and 'True Love'. This result shows callus-derived plants were significantly effective in virus elimination of virus-infected gladiolus plants.

1520–1540

S19–O–144

PLOIDY IDENTIFICATION IN M1 AND M2 GENERATION OF *VIOLA* X*WITROCKIANA* GAMS. AFTER MUTAGENESIS

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The polyploid plants usually have gigantic characteristics, such as thicker, wider and greener leaves with greater stomata size and larger flowers and they are attractive ornamentals. The aim of this study was to develop a novel approach to produce autopolyploid plants of *Viola* x*wittrockiana* Gams.–Pirna group. Two variants of colchicine treatment were used to induce chromosome doubling as well as they were compared for their efficiency. The first method was achieved by soaking or dipping swollen seeds in colchicine aqueous solution while in the second one, the colchicine was applied on the apex of the young seedlings. Early detection of novel ploidy levels was performed by screening stomata size, leaf index value (leaf blade length/width) and other morphological characteristics of the M1–generation plants. Subsequent screening of novel ploidy levels was performed by DNA flow cytometry (FCM). In addition to convenience and speed, an important advantage of low cytometry over other methods of ploidy screening is the ability to identify mixoploid tissues. Hexadecaploid, aneuploid and mixoploid plants were successfully identified by FCM. Results and analysis of M2 generation are also included.

1540–1600

S19–O–145

CYTOLOGICAL, ANATOMICAL AND MORPHOLOGICAL CHARACTERISTICS OF THE PLANTLETS DERIVED FROM THE COLCHICINE AND GAMMA RAY-TREATED CALLI OF *LILIUM LONGIFLORUM* L.

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Differences in the characteristics of the plantlets were observed after treating the calli of *Lilium longiflorum* L. with colchicine and gamma ray, respectively. When the calli were treated with colchicine solutions (0.1, 1 and 2% w/v) by immersing for 24 h, high concentration at 2% caused death of calli with browning. In contrast, most of the calli could survive after the treatment and proliferate without appreciable damage. However, efficiency of plant regeneration on MS medium containing 3% sucrose drastically reduced in the treated calli compared with the non-treated ones. Plant regeneration efficiency could be increased 5 times when the medium was replaced by half-strength macronutrient MS medium supplemented with 1.5% (w/v) maltose, 0.25 mg·L^{-1} of both BA and NAA. Flow cytometric analysis revealed that 66.7% of the plantlets obtained by the treatment with 1% colchicine became tetraploid. In gamma ray treatment, the calli were irradiated at 0 to 500 Gy. Survival rate of the calli 9 months after the treatment was reduced with the increased dosage, and no calli survived at doses over than 20 Gy. Although regeneration ability of the survived calli was reduced, it could be recovered by replacing the medium as in the case of colchicine treatment. In the regenerated plantlets grown in vitro, various changes were observed in the several characters such as chromosome number and morphology, shape, size and thickness of leaves, number, size and shape of guard cells, and bulblet formation.