Symposium 4 (S04)—Environmental Stress and Horticultural Crops

Monday · August 12

Location: Metro Toronto Convention Centre, Room 202AB

1100–1140
S04–O–1
INDUCTION OF ACQUIRED TOLERANCES OF PLANTS EXPOSED TO TEMPERATURE EXTREMES: APPRECIATING THE COMPLEXITY OF THE ASSOCIATED MOLECULAR RESPONSES AND EMERGING BASIC AND APPLIED ADVANCES

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Temperature stress is a reality for virtually all forms of life, and nearly every plant experiences some form of temperature stress during its life cycle. To cope with temperature extremes beyond the range of an organism's optimum for growth, stress responses and survival strategies have evolved to varying degrees in an organism-specific fashion. However, one type of temperature stress response that is highly conserved across all forms of life is that caused by heat shock. Presumably, the high conservation of this response emanates from the near-universal physiochemical influences that high temperature imposes on proteins and other macromolecular structures. In contrast, the known stress responses to suboptimal temperature exposure are far less conserved across all life forms and across different plant species. This less conserved stress response also, presumably, arises because of the different physical forms of stress that can occur depending on the severity of the low temperature extreme. Irrespective of the type of temperature stress, response and tolerance mechanisms are the products of many genes. The quantitative nature of temperature stress tolerance traits has implications in the complexity of molecular and cellular processes involved, and also for the efforts to improve the stress tolerance of plants using recombinant approaches. This presentation will underscore the complexities of plant responses to high and low temperature stress, highlight selected similarities and differences, outline recent advances in technology that are helping to advance our overall understanding of acquired tolerance mechanisms, and discuss practical applications that offer the prospect of enhancing crop stress tolerance.

1140–1200
S04–O–2
MALE STERILE MUTANT IN TOMATO SHOWS BLUE LIGHT-SPECIFIC HYPERSENSITIVITY TO ABA AND RESISTANCE TO ABIOTIC STRESSES

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A single gene 7B-1 mutant in tomato (*Lycopersicon esculentum*) is male sterile under long days (LD), but produces many flowers with viable pollen in short days (SD). The ability to restore fertility in the 7B-1 mutant makes it a useful system for hybrid seed production in tomato. The 7B-1 mutant is also resistant to osmotic, salt and low temperature stresses as determined by seed germination assay. In addition, the mutant is hypersensitive to abscisic acid (ABA) and the responses to ABA and abiotic stresses are amplified by blue light. Experiments involving inhibitor of ABA biosynthesis, analysis of endogenous ABA, and different light conditions show that 7B-1 mutant is an ABA over-producer and that blue light increases tissue sensitivity to ABA. Further, we suggest that the resistance of the 7B-1 mutant to abiotic stresses as well as the increased sensitivity to ABA are due to a defect in blue light perception or signal transduction.

1200–1220
S04–O–3
A 25 KD DEHYDRIN ASSOCIATED WITH COLD ACCLIMATION IN *RHODODENDRON*

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Previous research showed that levels of a 25 kD dehydrin were closely associated with varying levels of leaf freezing tolerance (LFT) among F_2 segregants (derived from *R. catawbiense* x *R. fortunei*) and cultivars of *Rhododendron*. The present study further examines the presence or absence and the seasonal accumulation pattern (i.e., in nonacclimated vs cold acclimated tissues) of this dehydrin in a wide array (~25) of *Rhododendron* spp. with cold acclimated LFT ranging from -4 °C to -60 °C, and in other Ericaceous genera. Results indicated that except for the two species [*R. brookeanum,* LFT of ~ -4 °C and R. tomentosum (*Ledum palustris*), LFT of ~ -40 °C], 25 kD dehydrin was present in all of the *Rhododendron* spp. used in this study. Data indicated a consistent increased accumulation of this dehydrin in cold acclimated leaves compared to nonacclimated ones. Quantitative comparisons of percent increase in the accumulation of 25 kD dehydrin in three hardy (LFT of -40 °C to -60 °C) and three tender (LFT of -15 °C to -21 °C) species indicated a ~4 to 7 fold greater ability by the hardier species to accumulate this dehydrin. The 25 kD dehydrin was present and accumulated to higher levels in cold acclimated leaves of Kalmia, however, it was not detected in cold acclimated leaf tissues of *Vaccinium macrocarpon*, *Pieris floribunda*, and *Arctostaphylos uva-ursi* suggesting that this dehydrin may be present only in those Ericaceous plants that are closely related to Rhododendron.

1220–1240
S04–O–4
WINTER RYE ANTIFREEZE PROTEINS ARE NOT CRYOPROTECTIVE, RATHER THEY MODIFY THE GROWTH OF ICE IN PLANTS

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Antifreeze proteins (AFPs) bind to the surface of ice and thus modify the growth of ice crystals. In overwintering plants, AFPs accumulate in the apoplast where ice forms during freezing, suggesting that their major function is to modify the growth of ice during the freezing process. However, AFPs in other overwintering organisms have been reported to play a cryoprotective role through interactions with proteins and membranes. To better understand the role of rye AFPs, we examined the ability of AFPs to protect the function of rabbit lactate dehydrogenase (LDH) and spinach thylakoids subjected to freeze-thaw cycles. Winter rye AFPs were added to solutions of LDH, which were then frozen and thawed and LDH activity was assayed. In these experiments, LDH activity was higher in the presence of rye AFPs, but the protection was no greater than that observed in the presence of BSA. Thus, the cryoprotection of LDH by rye AFPs was due to the nonspecific effects achieved by increasing the protein concentration of the solution. Spinach thylakoids frozen and thawed in the presence of rye AFPs lost the ability to stack in the presence of Mg ions, whereas thylakoids frozen in aqueos solution retained the ability to stack. In this case, the presence of rye AFPs during freezing and thawing was injurious. We then examined the freezing process in rye leaf sections by infrared thermography. After nucleating with ice on the leaf surface, nonacclimated rye leaves froze continuously. In contrast, cold-acclimated rye leaves that had accumulated AFPs in the apoplast froze at a lower temperature and the freezing process occurred in two distinct steps. We conclude that the rye AFPs do not play a cryoprotective role in the plant, rather they influence the freezing process in the tissues by interacting with ice.

1340–1440
S04–P–5
IN VITRO SELECTION OF ACTINIDIA DELICIOSA CLONES TOLERANT TO NACL AND THEIR MOLECULAR AND IN PLANTA ECOPHYSIOLOGICAL CHARACTERIZATION

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Excess of salt in the soil or in the water resources is an ever-increasing problem that significantly affects crop productivity throughout the world. In recent

years attempt have been made to supplement conventional breeding, directed toward the production of salt-resistant plant, by using in vitro techniques and exploiting the variability existing in tissue or cell culture with successfully results. Thus, we addressed our work to obtain kiwifruit plants tolerant to NaCl through in vitro selection of calli and their regeneration. Callus was induced from leaf pieces of in vitro grown plants of *Actinidia deliciosa* (cv Tomuri) on a Gamborg et al basal medium supplemented with naphtalenacetic acid (NAA) (10.74 mM), kinetin (4.60 mM) and 85.5 mM NaCl. The concentration chosen for the selection was 85.5 mM for Tomuri. Selected calli were transferred on a regeneration medium consisting in the same basal medium in which only zeatin (9.12 mM) was present as growth regulator. Lines obtained from Tomuri tolerant calli were evaluated for 4 subcultures for their tolerance adding NaCl to the medium at the same concentration used for callus selection. Tolerant lines which did not show any chlorosis, vitrification and leaf curling were considered tolerant. At the end of the selection 6 clones of the cv Tomuri maintained their tolerance and were acclimatized The molecular characterisation of 2 clones (one sensitive and one tolerant) was performed through RAPD analyses using 20 10-mer primers, revealing polymorphisms between the 2 clones. Ecophysiological response was evaluated in planta measuring leaf gaseous exchange (net photosynthesis, leaf transpiration), stomatal conductance, leaf fluorescence of chlorophyll-a and ion content in roots and leaves, in natural environment and in climatic chambers. These experiments were performed on control and NaCl-treated plants.

1340–1440

S04–P–6

ISOLATION OF TWO GENES SIMILAR TO DREB1/CBF FROM THE SWEET CHERRY AND THEIR ANALYSIS BY TRANSFORMATION INTO ARABIDOPSIS

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DREB1 (dehydration responsive element binding protein 1)/CBF (C-repeat binding factor) up-regulate the expression of a group of genes designated as COR (cold regulated)/RD (responsive to dehydration) genes in Arabidopsis resulting in the acquisition of cold-acclimation. Our purpose is to investigate the relationship between the freezing tolerance and the gene expression of a group of genes homologous to COR/RD genes and its regulator genes in woody plants, especially in the sweet cherry. We have isolated three DREB1/CBF-like genomic clones from the sweet cherry. Two (D2A and D2B) of them were deduced to have a complete ORF. Each putative protein had an EREBP/AP2 DNA binding domain motif, a potential nuclear localization signal in the N-terminal. The EREBP/AP2 conserved domain of the D2 proteins showed a high identity (74% to 79%) with that of each DREB1/CBF protein. In addition, the TATA-box and G-box sequences, and the MYB- and MYC-recognition sites were predicted in the 5'-region of each gene. The expression of the D2 genes was induced by low temperature in the sweet cherry. Therefore, we changed the names of D2A and D2B to CIGA (cold induced gene A) and CIGB, respectively. The Constitutive overexpression of the DREB1/CBF genes in transgenic Arabidopsis plants induces the expression of the COR/RD genes without a low temperature stimulus and enhances the freezing tolerance. To investigate the effects of the CIGA and CIGB proteins against low temperature, we transformed the binary vector carrying fusion of the enhanced CaMV 35S promoter and the CIGA or CIGB into Arabidopsis by the floral dip method. In CIGB, eighteen kanamycin-resistant transgenic Arabidopsis plants have been obtained. Among them, the dwarf phenotype was observed. The transgenic progeny is currently being studied for the existence and expression of the CIG genes, and effects on freezing tolerance.

1340–1440

S04–P–7

HIGH TEMPERATURE STRESS INDUCES LOW-MOLECULAR WEIGHT HEAT SHOCK PROTEIN EXPRESSION IN STRAWBERRY PLANTS

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The strawberry is a temperate crop that is very sensitive to high temperatures. High temperatures are known to reduce fruit size, fruit weight, and overall plant growth. However, there are very few studies on the effect of high temperatures on protein expression in strawberry plants. This study was conducted to determine the effects of high temperature stress on protein expression of leaves and flowers of strawberry plants. 'Nyoho' and 'Toyonoka' plants in full bloom were exposed to 20 °C (control), 33 °C, and 42 °C for four hours, and protein expression analyzed by 2-D PAGE and Western blotting on proteins separated by SDS-PAGE. In both leaves and flowers, 2-D PAGE revealed a noticeable decrease in the intensity of most protein spots at 33 °C compared with the control (20 °C). At 42 °C, most protein spots were no longer visible, but several protein spots intensified and new spots appeared. The new protein spots were estimated to have molecular weights from 16 to 26 kDa in flowers and 19 to 29 kDa in leaves. More new spots were detected in flowers than in leaves in both cultivars, and 'Nyoho' flowers had more new spots than 'Toyonoka'. Western blot analysis using the pea HSP18.1 antibody showed that at least one band in leaves and two bands in flowers with similar sizes as those deduced from some of the new protein spots were heat shock proteins. The intensity of the reaction to the antibody increased as the temperature was increased in both flowers and leaves. These results show that low-molecular weight heat shock proteins (lmw HSPs) can be induced by high temperature stress in strawberry. A larger amount of the lmw HSPs were induced in flowers than in leaves and 'Nyoho' flowers produced more lmw HSPs than 'Toyonoka'. This suggests that lmw HSPs play a role in preventing protein degradation in flowers, which are the more heat-sensitive organs. This could also mean that 'Nyoho' flowers are more tolerant to heat stress than 'Toyonoka'.

1340–1440

S04–P–8

APPLICATION OF MECHANO-DWARFING STIMULI TO ARABIDOPSIS FOR MUTANT-SCREEN DEVELPOMENT

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Various forms of mechanical stress were applied to flats containing hundreds of vegetative *Arabidopsis thaliana* (L.) Heynh. seedlings of the C-24 ecotype with the goal of obtaining uniform growth reduction relative to undisturbed controls. Candidate mechano-treatments include static impedance (perforated plates), dynamic compression and flexing (roller), dynamic frictional contact and flexing (brushes), and seismic vibration. Mechanical treatments were applied alone or in combination while varying the intensity, duration, and time of daily stress application. Simultaneous treatments in the greenhouse and a controlled environment were inconclusive due to soil and nutrient complications. Impedance treatments enhanced rosette size, productivity, and water status of seedlings grown in a standardized plant-growth environment. Brushing tended to damage younger seedlings, but substantially reduced leaf area and dry weight of older seedlings without causing damage. Rolling also reduced growth in leaf area but tended to damage leaves to an extent related to the weight of the roller. Combinations of stress treatment tended to negate individual effects or to have no synergistic effects. Subsequent studies under low-intensity fluorescent plus incandescent lighting conditions, along with standardized mineral nutrition, increased hypocotyl elongation while reducing overall leaf expansion. Seedlings subjected to brush treatments under these conditions were reduced in height and dry weight as compared to unstressed controls. Present approaches include varying light level and quality, nutrient strength and composition, and use of inert growing medium to obtain upright seedling growth for mass mechano-dwarfing of *Arabidopsis*. The successful mechano-stress regime will be used to screen T-DNA insertional mutants for TCH-gene knockouts. (Research supported in part by NASA: NAG2-1389.)

1340–1440

S04–P–9

MAIZE CHLOROPLAST PROTEIN SYNTHESIS ELONGATION FACTOR, EF-TU, PREVENTS THERMAL AGGREGATION AND INACTIVATION OF CITRATE SYNTHASE

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The chloroplast protein synthesis elongation factor EF-Tu is a protein that is

involved in the elongation of polypeptides during the translational process. Recent evidence, however, suggests that, in maize (*Zea mays* L.), this protein may have other functions in addition to the conventional role that it plays in polypeptide elongation. One of these functions is in protein re-folding and protection of polypeptides from heat denaturation. We tested the hypothesis that maize EF-Tu protects heat-labile proteins from heat-induced damage by acting as a molecular chaperone. Citrate synthase (CS) was used as a model heat-labile protein. Recombinant maize EF-Tu was expressed in Escherichia coli and purified under non-denaturing conditions. Fluorescence spectroscopy and [3H]GDP exchange assay showed that the purified EF-Tu was in its native and physiologically active form. The EF-Tu protein prevented aggregation of CS at 41 °C and 45 °C and irreversible inactivation of CS at 38 °C, 43 °C and 45 °C. These findings demonstrate that maize EF-Tu can function as a molecular chaperone in vitro.

1340–1440

S04–P–10

MOLECULAR GENETIC AND PHYSIOLOGICAL ANALYSIS OF THE COLD-RESPONSIVE DEHYDRINS OF BLUEBERRY

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The blueberry industry in the United States suffers significant losses every year due to environmental factors with a dehydrative component, such as drought and freezing stress. In fact, an increase in cold hardiness has been identified as one of the major needs of the blueberry industry. Therefore, a goal of our laboratory has been the cloning and characterization of expression of cold-responsive genes from blueberry. We have been using a systematic molecular genetic approach to identify genes that are up-regulated during cold acclimation and, more recently, have begun using a genomic approach to identify a larger number of genes that are expressed during cold acclimation. Three dehydrins (group of proteins induced by environmental stimuli that have a dehydrative component) of 65, 60, and 14 kDa are the predominant up-regulated proteins in cold acclimated floral buds of blueberry. Recent expression studies indicate that: 1) blueberry dehydrins are induced by cold stress in all organs examined but by drought stress in primarily stems; 2) dehydrin accumulation correlates positively with cold tolerance but not with drought tolerance; and 3) dehydrin expression in blueberry cell suspension cultures is different from that in whole plants. Furthermore, several cDNA clones representing members of the dehydrin gene family have been isolated including a clone encoding the 60 kDa dehydrin. Finally, a genomic approach to the study of cold-responsive genes in blueberry has been undertaken. Analysis of expressed sequence tags (ESTs) from a subtracted cDNA library, representing genes expressed at a higher level during cold acclimation than before acclimation, is underway.

1340–1440

S04–P–11

TOWARD THE IDENTIFICATION OF CANDIDATE GENES INVOLVED IN THE SIT TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) MUTANT BY USING CDNA-AFLP ANALYSIS ISOGENIC LINES

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Tomato is a relevant economic plant species that is well characterized among crops. Tomato has a relatively small genome (Arumuganathan & Earle, 1991-Plant Mol Biol Rep 9, 208–219) and efforts are in progress to obtain the complete sequence (www.tigr.org/tdb). Cultivated tomato is known for its low level of polymorphism, and AFLP is a technique capable of detecting more than 50 loci in a single PCR reaction. Abscisic acid plays an important role in many aspects of plant growth and development as well as in adaptation to abiotic stresses (Zeevaart & Creelman 1988 -Ann Rev Plant Phys Plant Mol Biol 39, 439–473). The isolation of the genes related to ABA pathway will be essential for determining the role of ABA. Tomato sit mutant was obtained by X-ray (Stubbe,1957-Kulturpflanze 5,190) and it is deficient in ABA biosynthesis. The aim of the present study was to detect polymorphic fragments between the mutant sit in background Money Maker and its isogenic line by cDNA-AFLP (Bachem et al 1996–Plant J 9,745-753). Ninety primer pairs were tested that resulted in a total of ~8.000 AFLP fragments; 253 polymorphic fragments between the isogenic lines were isolated. Different Transcript-Derived Fragments (TDFs) were cloned and sequenced. These sequences were used for similarity search in public genomic databases. Cloned TDFs with similarity to sequences linked to sit gene will be mapped for chromosome walking experiments. For this purpose, an interspecific F2 population between sit and *Lycopersicon pennellii* was obtained. The cross will allow data integration with molecular map obtained by Tanskley et al (1992-Genet 132, 1141-1160). Isolation of TDFs as differentially expressed sequences is proposed as a way for detect new ESTs around specific trait for an integrated approach to isolate genes of interest. GenEST software (Quin et al 2001–Nucl Acid Res 29, 1616-1622) was used in order to predict TDFs size carried on tomato sequences coming from genome databases.

1340–1440

S04–P–12

EXPRESSION ANALYSIS OF GENES ENCODING AQUAPORINS DURING THE DEVELOPMENT OF PEACH FRUIT

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Water absorption is very important for growth and development of fruit. Rapid enlargement of fruit is induced by increased water absorption to cause cell expansion. Excess absorption results in decrease in sugar concentration and fruit cracking reducing fruit quality. Recent studies revealed that water channel proteins named aquaporins are responsible for controlling the water permeability of biomembranes in many plants. To understand the molecular mechanisms of water absorption by fruits and the functions of aquaporins in these processes, we isolated four clones encoding aquaporins from peach fruits (*Prunus persica* Batsch) by RT-PCR with degenerated primers. Two (Pr-gTIP1 and Pr-gTIP2) of those have high homologies to tonoplast intrinsic proteins (TIPs) which are located in the vacuolar membrane. Others (Pr-gPIP1 and Pr-gPIP2) have high homologies to plasma membrane intrinsic proteins (PIPs) which are located in the plasma membrane. Genome gel DNA blot analysis indicated that each of those genes exists in the peach genome as a single copy. The amino acid sequence of Pr-gTIP1, deduced from the full sequence of the cDNA, was highly homologous to those of tonoplast intrinsic proteins (TIPs) isolated from other plants, especially to that from pear fruits. The amino acid sequence also indicated that Pr-gTIP1 contained two NPA (asparagine, proline and alanine) motifs, which are part of the pore structure of water channels. RNA gel blot analysis revealed that Pr-gTIP1 is highly accumulated in flesh at an early stage and a late stage of fruit development. The results suggest that Pr-gTIP1 gene was involved in rapid expansion of the fruit cells. By contrast, Pr-gPIP1 was expressed during fruit development continuously. From these results, Pr-gTIP1 and Pr-gPIP1 may have different functions and work cooperatively for fruit development.

1340–1440

S04–P–13

STRESS TOLERANCE IN TRANSGENIC TOMATO (*LYCOPERSICON ESCULENTUM*) SEEDLINGS THAT OVERPRESS MN-SUPEROXIDE DISMUTASE

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Reactive oxygen species (ROS), such as hydrogen peroxide, superoxide radical and hydroxyl radicals, are inevitable by-products of biological redox reactions. ROS can denature enzymes and damage important cellular components. Superoxide dismutase (SOD) catalyzes the breakdown of superoxide into O_2 and H_2O_2. The effect of increased Mn-superoxide dismutase (Mn-SOD) on stress tolerance was studied using transformed tomato (*Lycopersicon esculentum*) plants. Overexpression of a Mn-SOD in transgenic tomato enhanced seedling growth, compared to wild-type (WT) plants, under a variety of environmental stresses (High temperature, salt, and chilling). A novel Mn-SOD was detected by native PAGE in transformed plants but enzyme activity varied among different indepen-

dent lines. Seeds obtained from transgenic plants could germinate at low temperature (9 °C) in the dark whereas seeds from WT plants could not. Seedlings from transgenic plants showed resistance to the superoxide-generating herbicide methyl viologen, high and low temperature stress, and salinity stress.

1340–1440

S04–P–14

GENETIC RELATIONSHIPS BETWEEN COLD, SALT AND DROUGHT TOLERANCE DURING SEED GERMINATION IN TOMATO

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Seeds of BC1 progeny of a cross between a slow germinating *Lycopersicon esculentum* breeding line (NC84173) and a fast germinating *L. pimpinellifolium* accession (LA722) were evaluated for germination under cold stress, salt stress and drought stress, and in each treatment the most rapidly (first 5%) germinating seeds were selected. Selected individuals were grown to maturity and self-pollinated to produce BC1S1 progeny. The selected BC1S1 progeny from each experiment were evaluated for germination in each of a non-stress (control) and the three stress treatments, and compared with germination rate of non-selected BC1S1 progeny. Selection for rapid seed germination was effective under all three stresses, and significantly improved progeny germination rate under cold, salt and drought stress conditions. The results support the suggestion that the same genes contribute to rapid seed germination under cold, salt and drought stress. Furthermore, the selected BC1 progeny from each treatment and 119 non-selected BC1 individuals of the same cross were subjected to marker analysis using 105 RFLP clones. A trait-based marker analysis (TBA), which measures differences in marker allele frequency between selected and unselected populations, was used to identify marker-linked QTLs. Some QTLs were identified that affected germination under all three stress conditions and others that were stress-specific. The overall results indicate the presence of genes (QTLs) that affect germination under different stresses and those that affect germination under specific stress conditions.

1340–1440

S04–P–15

QTL COMPARISON OF SALT TOLERANCE DURING SEED GERMINATION AND VEGETATIVE GROWTH IN A *LYCOPERSICON ESCULENTUM* X *L. PIMPINELLIFOLIUM* RIL POPULATION

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A total of 145 F_9 recombinant inbred lines (RILs) of a cross between a salt sensitive *Lycopersicon esculentum* breeding line (NC84173) and salt tolerant *L. pimpinellifolium* accession (LA722) were evaluated in replicated trials for salt tolerance during seed germination (time to 50% germination) and vegetative growth (plant survival under salt stress). There was no significant phenotypic correlation between the speed of seed germination and plant survival under salt stress. The RILs were also genotyped for 130 restriction fragment length polymorphism (RFLP) markers, covering 1,381.5 cm of tomato genome with an average marker distance of 10.7 cm. Marker analysis identified QTLs for salt tolerance during seed germination on chromosomes 2, 3, 4, 8, 9 and 12 and QTLs for salt tolerance during vegetable stage on chromosomes 3, 4, 5, 7, 8, 9 and 12. Mostly different QTLs were detected for salt tolerance during these two stages of plant development, suggesting the involvement of different genes with salt tolerance during seed germination and vegetative stage in this population. Other supporting evidence indicates that salt tolerance during seed germination in tomato is poorly correlated with salt tolerance during later stages of plant development.

1340–1440

S04–P–16

THE CLONING AND CHARACTERIZATION OF ALPHA-GALACTOSIDASE PRESENT DURING COLD ACCLIMATION AND DEACCLIMATION IN PETUNIA

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Low temperatures severely limit the geographical range and productivity of many crops, therefore increased knowledge of the genetic and biochemical mechanisms regulating tolerance to low temperatures has potential for major beneficial impact on agricultural production. Alpha-galactosidase is a key catabolic enzyme of raffinose family oligosaccharide (RFO) involved in the cold hardiness pathway, cleaving the terminal-linked moiety from galactose-containing oligosaccharides. A cDNA clone PETGAL, was isolated from *Petunia* x *hybrida* cv Mitchell leaf RNA by RT-PCR using degenerate oligonucleotide primers designed to amplify plant alpha-galactosidases. The putative alpha-galactosidase cDNA sequence has high nucleotide homology (>80%) to other known alpha-galactosidases. Southern blot analysis suggests that alpha-galactosidase represents a single gene or small gene family. RNA gel blot analysis was used to evaluate alpha-galactosidase mRNA levels during cold acclimation and at various periods of deacclimation, in various plant tissues and throughout plant development. Increases in alpha-galactosidase transcript at one hour after deacclimation correspond with increases in alpha-galactosidase activity suggesting that warm temperature may regulate RFO catabolism by increasing the transcription of the alpha-galactosidase gene. Arrhenius relationships also showed the dependency of alpha-galactosidase activity on warm temperature. The evidence presented here suggests that warm temperatures induced and/or increased alpha-galactosidase activity in leaves. This rapid loss of hardiness in petunia makes it a useful model system to study rapid changes in metabolism that occur during cold acclimation and deacclimation.

1440–1520

S04–O–17

ENGINEERING SALT TOLERANT CROPS

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Salinization of agricultural land has been an important factor affecting human history. Agricultural productivity is severely affected by soil salinity, and the damaging effects of salt accumulation in agricultural soils have influenced ancient and modern civilizations. Much of the research in plant salt tolerance aims to breed crop cultivars with high salt tolerance. This research assumes that salt tolerant cultivars will occur only after pyramiding in a single genotype several characteristics, each of one alone could not confer a significant increase in salt tolerance. Salt tolerance is a complex trait involving a number of genes and a long list of salt stress-responsive genes have been identified. Nonetheless, only recently a cellular mechanism for salt tolerance has been identified. We have produced transgenic tomato and Canola plants overexpressing a vacuolar Na^+/H^+ antiport. These plants were able to grow, flower and produce seeds and fruits in the presence of 200 mM sodium chloride. Our results demonstrate the ability of the transgenic plants to utilize salty water for growth. These results clearly demonstrate that the enhanced accumulation of Na+, mediated by the vacuolar Na^+/H^+ antiport, allowed the transgenic plants to ameliorate the toxic effects of Na^+. While the transgenic leaves accumulated Na^+ to almost 6% of their dry weight, the tomato fruits displayed only a marginal increase in Na^+ content. Moreover, in the transgenic Canola plants growing in high salinity neither the seed number nor the oil quality was affected. Worldwide, more than 60 million hectares of irrigated land (representing 25% of the total irrigated acreage in the world) have been damaged by salt. Our findings demonstrate the feasibility of producing salt tolerant transgenic plants that will not only produce edible crops, but could also be used for the reclamation of saline soils for agriculture use.

1520–1540

S04–O–18

THE DEVELOPMENT OF MULTIPLE STRESS RESISTANT CAULIFLOWER USING MUTAGENESIS IN CONJUNCTION WITH A MICROSHOOT TISSUE CULTURE TECHNIQUE

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The tolerance of crop plants to stress is important in many regions of agriculture. In particular, tolerance to salinity and drought is crucial in dryland and semi-dryland agriculture in eastern Mediterranean regions. In other regions

tolerance to frost is important especially during early spring growth. Resistance to stress is known to be multi-allelic and is often negatively correlated with yield factors. Thus progress by conventional plant breeding is often slow or non-rewarding. Other methods of manipulating stress tolerance are now being sought including mutagenesis, tissue culture selection and transgenosis. This paper reports the success of a system of mutagenesis of cauliflower. Cauliflower microshoots were prepared following the protocol of Kieffer et al (1995, 2001) to produce over 20,000 micro-shoots per experiment. Microshoots were treated with the chemical mutagens NMU and NEU and then selected for resistance to hydroxyproline. Following selection, shoots were grown in-vitro and subsequently weaned to in-vivo conditions, grown on and seeded. Selected and control plants were assessed for proline content, hydroxyproline resistance, salt resistance and frost resistance. Proline was significantly elevated in most selections whilst in-vitro but levels fell when plants were weaned in-vivo although levels were still above those of the controls. The selected plants showed a range of tolerance levels to the 3 stresses assessed and cross resistance was common. The most salt resistant plants were also more frost tolerant.

1540–1600
S04–O–19
IMPROVED TOLERANCE TO SALINITY AND HEAT TEMPERATURE IN TRANSGENIC TOMATO OVEREXPRESSING ASCORBATE PEROXIDASE (APX)

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The potential role of cytosolic ascorbate peroxidase (APX) in the protection against salt stress and heat stress was examined using transgenic tomato plants Transformants were selected by using Kanamycin resistance and confirmed by PCR, Southern and Northern analysis. Several independently-transformed lines were obtained and evaluated for resistance to oxidative stresses. The total leaf APX activity in the transgenic was about several folds that of the control under non-stressed conditions. After exposure of shoots cold, heat and paraquat stress, these plants showed higher survival rate and lower electrolyte leakage than untransformed controls as evaluated by either visual scoring or electrolyte leakage measurement. The transgenic seeds could germinate at 9 °C in dark. The shoot cultures could grow in the medium containing 0.20 M NaCl. The transgenic shoots could develop roots after 5 days treatment at 40 °C. We also found that the fruit are resistant the UV-B light. The results show that the presence of transgenic APX had clear effects on tolerance to the oxidative stresses.

1600–1620
S04–O–20
J-DOMAIN PROTEINS IN TOMATO AND STRAWBERRY ARE HEAT SHOCK PROTEINS AND ARE HIGHLY INDUCED IN REPRODUCTIVE TISSUES

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In eucaryotes, a large number of proteins contain a conserved J-domain, corresponding to the N-terminal 75 amino acids of *E. coli* DnaJ. DnaJ in *E. coli* is a heat stress protein. DnaJ homologues in eucaryotes are frequently referred to as Hsp40. In plants, J-domain proteins have been implicated in responses to a wide range of environmental stimuli. However, there is significantly more complexity to the function of these proteins than just acting as molecular chaperones during stress responses. Recent analysis of the Arabidopsis genome showed that there are 89 J-domain containing proteins belonging to 51 distinct sub-families in this plant (Miernyk, 2001 Cell Stress and Chap. 6:209). A full-length cDNA (leDJA1) from tomato encoding a 46.8 kD protein with over 70% amino acid identity to known plant Hsp40 sequences was identified. Low levels of leDJA1 transcript were seen in seedlings, young leaves, and stems during normal plant growth. In comparison, leDjA1 mRNA is present in great abundance in fruit from immature green stage and continuing throughout ripening. leDjA1 message accumulation increases upon treatment of young leaves at 37 °C or 42 °C. mRNA levels decrease to control levels after one hour at 37 °C but continue to increase past 8 hours of treatment at 42 °C. Antibodies were raised to a synthetic peptide consisting of 15 amino acids of the leDjA1 sequence containing the HPD tripeptide found in all J-domains. Separate antibodies were raised to the carboxyl (variable) region of leDjA1. Preliminary experiments with these antibodies showed that in strawberry, as in tomato, specific J-domain proteins are highly expressed in reproductive structures beginning early in floral bud development. We are working to identify genes encoding the reproductive structure J-domain proteins and the heat induced Hsp40s in tomato and strawberry in order to understand the mechanisms by which the plant cell uses the conserved J-domain motif for such apparently diverse functions.

1620–1640
S04–O–20–A
TO BE ANNOUNCED

1640–1700
S04–O–20–B
TO BE ANNOUNCED

Tuesday · August 13

1100–1140
S04–O–21
THE SCIENCE AND PRACTICE OF STRESS REDUCTION IN MANAGED LANDSCAPES

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Managed landscapes are an intricate blend of woody and herbaceous ornamentals, turfgrass, organic and mineral groundcovers, and a vast array of manufactured elements or "hardscape". When properly designed, installed and maintained, "built landscapes" provide countless economic and quality-of-life benefits for people in rural, suburban, and urban areas. But the continuum from drafting table to finished landscape often is poorly defined and fraught with challenges, frustrations, and misconceptions. This opening session will review the most recent approaches for creating functional and sustainable landscapes by minimizing or alleviating abiotic stress along the continuum from plant production to maintenance of recently installed and established plants. Topics for discussion include nursery crop production techniques for enhanced transplant success, stress-reducing installation and post-plant maintenance methods, selection and use of superior taxa for stressful environments, and intervention/rescue treatments for established plants with compromised root systems.

1140–1200
S04–O–22
COLD HARDINESS ESTIMATES FOR TEN HYDRANGEA CULTIVARS

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The susceptibility of *H. macrophylla* and *H. serrata* to freezing temperatures limits flowering potential in southern and northern regions. Early fall acclimation and late spring deacclimation are essential for flowering in areas prone to untimely frosts in the fall, late winter, or spring. Identifying cultivars with increased cold adaptability would significantly enhance the marketing potential of *H. macrophylla* as a reliable flowering shrub, and provide germplasm for breeding hardier forms. *Hydrangea macrophylla* (Thunb.) Ser. 'All Summer Beauty', 'Ayesha', 'Dooley', 'Endless Summer', 'Générale Vicomtesse de Vibraye', 'Mme. Emile Mouillère', 'Mariesii Variegata', 'Nikko Blue', and 'Veitchii', and *H. serrata* (Thunb. ex J.A. Murr.) Ser. 'Bluebird' were evaluated for midwinter cold hardiness, acclimation, and deacclimation to quantify cold tolerance. Uniform stem segments were collected monthly from Oct. to March and subjected to progressively lower temperatures from –3 °C to –27 °C under laboratory conditions. Controls were maintained at 4 °C throughout the experiment. Repre-

sentative samples were removed in 3 °C increments, and following incubation at 4 °C for 10 to 12 d stems were visually inspected for oxidative browning to determine the lowest survival temperature (LST). *Hydrangea macrophylla* 'Endless Summer', 'Mariesii Variegata', and 'Veitchii' acclimated later than all other cultivars. 'Générale Vicomtesse de Vibraye' acclimated first, and was cold hardy to –6 °C by 28 Sept. Maximum cold tolerance in all cultivars occurred on 5 Jan. and was within a 6 °C range. 'Endless Summer' was the least cold hardy (–18 °C) while 'Dooley', 'Générale Vicomtesse de Vibraye', 'Mme. Emile Mouillère', and *H. serrata* 'Bluebird' possessed the greatest cold hardiness (–24 °C) on 5 Jan. Deacclimation in all cultivars began after the 5 Jan. collection date. On 1 Mar., 'Ayesha' and 'Mariesii Variegata' survived only 4 °C while all other cultivars survived at least –6 °C.

1200–1220
S04–O–23
PHOTOINHIBITION IN MANGOSTEEN (*GARCINIA MANGOSTANA* L.)

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Anatomical and physiological aspects were investigated in mangosteen leaves grown in different shading conditions. Mangosteen seedlings were grown under four shade treatments (25%, 40%, 55% and 100% of sunlight) for two years. Plants grown in full sun showed the symptoms of photo-damage. Palisade and spongy tissue were thinner in 100% full sun leave than in 55% and 40% full sun, despite growing in a higher light intensity condition. Chlorophyll content both per area and weight, leaf area, leaf number, height and dry weight of those plants were significantly less than of plants grown in lower light intensity coditions. Chlorophyll fluorescence study showed that maximum quantum yield of photosystem in full sun leaves declined grammatically compared with leaves grown under lower light intensity. The reduction of maximum quantum yield was related to an increase of F subscript 0, which means photo-damage. Photosynthesis light response curves of leaves growing under different degrees of shading in a canopy of mature tree also confirmed photoinhibition in mangosteen leaves. Leaves grew under shade outside the canopy but not experienced direct sunlight showed no signs of photo-damage with the highest response curve of photosynthesis, followed by the curves of leaves experienced a half day direct sunlight, leaves exposed to direct sunlight all day and leaves grew in deeply inside the canopy, respectively. Shading and canopy management for young and mature trees are discussed.

1220–1240
S04–O–24
EFFECTS OF SUPRA-OPTIMAL TEMPERATURE ON *COREOPSIS* AND *GAILLARDIA*

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Coreopsis grandiflora 'Sunray' and *Gaillardia* x *grandiflora* 'Goblin' are commonly grown in the southern United States because of their ease of culture, tolerance to heat and long blooming season. High temperatures often cause early decline resulting in a life cycle similar to that of annuals. Objectives of this experiment were to determine the effects of high temperature combinations (30, 35 and 40 °C) on photosynthesis, carbohydrate allocation and growth of *Coreopsis* and *Gaillardia* over a seven month period. The greatest effects on plant growth rate (PGR) and relative growth rate (RGR) occurred when plants were moved into the hot temperature treatment (HTT, 40 °C) from either the mild temperature treatment (MTT, 30 °C) or the warm temperature treatment (WTT, 35 °C). The PGR and RGR of *Gaillardia* control plants were only affected by movement to HTT, whereas *Coreopsis* displayed adverse effects in both WTT and HTT. Shoot growth was unaffected unless plants were moved into HTT. Root growth was more sensitive to higher temperatures and was affected at an earlier age than shoot growth. This research indicates that *Gaillardia* are more heat tolerant than *Coreopsis*. Both species are affected by temperature over 35 °C. The MTT *Coreopsis* and *Gaillardia* had a significantly greater photosynthetic rate (Pn) than the WTT and HTT after one month. There were few significant differences in Pn between temperature treatments and rotations the remaining 6 months. The Pn decreased by 50% the last 2 months of the experiment. Starch concentrations were greater in *Coreopsis* and *Gaillardia* shoots when grown under MTT and plants transferred from WTT or HTT to MTT.

1340–1440
S04–P–25
EFFECTS OF COMMERCIAL PARKING LOTS ON SIZE OF SIX SOUTHWEST LANDSCAPE TREES

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Landscape trees in commercial parking lots provide shade as well as enhance aesthetic value. However, planting location might compromise tree growth and function. We studied the effect of commercial parking lots on the size of six established landscape trees (*Brachychiton populneus, Fraxinus velutina, Pinus canariensis, Pinus halapensis, Prosopis chilensis,* and *Ulmus parvifolia*) in Phoenix, AZ, USA. During Summer 2001, tree canopy volume, height and trunk diameter at breast height (DBH) of trees were evaluated in parking lot medians surrounded by asphalt, and in adjacent perimeter planter beds in 15 commercial parking lots. For all tree species, mean canopy volume, height, and DBH was reduced by 73, 36 and 41%, respectively, compared to trees in adjacent perimeter planter beds. Size of *Pinus halapensis* and *Ulmus parvafolia* was most negatively affected by median planting location, while size of *Brachychiton populneus* and *Prosopis chilensis* was least affected by median planting location. For all trees, an infrared thermometer was used to measure summer midday surface temperatures along four (north, east, south and west) gradient transects (.45, 1.22, 3.05, and 7.62 m) away from the tree trunk base. Temperatures of asphalt surfaces around median trees were up to 35 °C higher than temperatures of vegetated and non-vegetated surfaces around adjacent perimeter trees.

1340–1440
S04–P–26
THE RELEVANCE OF LEAVES AND PHOTOSYNTHESIS FOR SUCCESS IN ROSE PROPAGATION

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Leaves are essential in the propagation of roses by softwood leafy cuttings. However, about the principles behind that, there is no unequivocal explanation in literature. We investigated the hypothesis that the supply of carbohydrates would represent the main factor. To validate this hypothesis variations in photosynthesis and carbohydrate content of cuttings were created by reducing leaf area, light intensity, light integral or CO_2 concentration in the air. The consequences in terms of survival percentage, rooting, dry weight accumulation and carbohydrate dynamics were followed during the first 21 days of propagation. Leaf removal, leaf covering, reduced light integral and CO_2 depletion had a quantitative negative effect on survival, rooting and further growth of cuttings. Auxins did not promote rooting when leaves were covered or removed. Dry matter was distributed uniformly over leaf and stem of cuttings after 21 days of propagation, but under limited photosynthesis the stem retained the largest percentage of new synthesized dry weight. Perhaps contradictory, was that, although current leaf photosynthesis was limiting survival and rooting, qualitative and quantitative analysis by iode staining revealed that cuttings were accumulating starch in both stem and leaves, mostly after 7 days of propagation. This may be explained by the fact that the weak sink of starch accumulating organelles becomes the major sink relatively to the limited sink activity of the new roots and the new axillary primary shoot which accounted for less than 15% of the total dry weight of cuttings. We concluded that although a rose cutting is a typically sink-limited plant system, current photosynthesis is a major determinant of rooting and growth, and thus of success in rose propagation.

1340–1440
S04–P–27
EFFECT OF LIGHT QUALITY ON THE GROWTH OF LETTUCE AND PANSIES

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Low light levels in greenhouses and growth chambers often produce poor quality plants. The role of red and far-red light, and phytochrome are well understood, but little is known about the effects of other wavelengths of photosynthetically active radiation. We examined lettuce (*Lactuca sativa*) and pansy (*Viola* x *wittrockiana*) growth at equivalent, low photosynthetic photon flux under 7 colored filters (blue, dark blue, teal, yellow, red, purple, and green) and sunlight (clear filter). The phytochrome photostationary state (PSS) was not a good predictor of plant stem elongation or dry mass response to the filters. Filters transmitting a high percentage of blue light, but lower PSS, produced plants that were equivalent or higher in fresh and dry mass than the control. Plants receiving low blue light levels were etiolated, with the degree of etiolation increasing as the amount of blue light decreased. Plants receiving low levels of blue light also had smaller and less dense root systems than those receiving higher levels. Alterations in leaf and stem anatomical structures were also evident as levels of blue light decreased.

1340–1440
S04–P–28

THE USE OF ANTI-TRANSPIRANTS TO EXTEND THE SHELF LIFE OF TABLE-TOP CHRISTMAS TREES

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Live miniature conifers are growing in popularity as table-top Christmas trees. Many of these trees are being sold by mass merchandisers under indoor environmental conditions. This type of environment is stressful to the trees due to low light levels, high vapor pressure deficit (VPD), and prolonged drying of the root zone. In this trial, we compared the effect of anti-transpirants on extending the shelf life of table-top Christmas trees. We selected *Picea glauca* var. densata, *P. omorika*, and *Abies procera* 'Frijsenborg Blue' as the plant species to be studied due to their performance as table-top Christmas trees in previous trials. Two separate growth chambers were set up for the experiment in order to obtain a high and a low VPD environment. The anti-transpirants were applied prior to the plants entering the growth chambers. Whole plant water use was determined by periodic weighing. Per unit leaf area transpiration rates were determined by gas exchange measurements with a LI-COR LI6400 Portable Photosynthesis System. Transpiration rates differed among species and treatments. Implications for the development of post-harvest strategies for table-top Christmas trees will be discussed.

1340–1440
S04–P–29

FALL TRANSPLANTING RESULTS IN EARLIER SPRING ROOT GROWTH OF SUGAR MAPLE AND NORTHERN RED OAK

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Description of early post-transplant root growth will help formulate best transplanting strategies for landscape trees. In this experiment, early post-transplant root growth dynamics of sugar maple (*Acer saccharum* Marsh. 'Green Mountain') and northern red oak (*Quercus rubra* L.) were determined. Field-grown 4-year-old trees were transplanted bare-root into outdoor root observation containers (rhizotrons) in Oct.1997, Nov.1997, or March 1998. All trees were grown in the rhizotrons until Oct. 1998 and then transplanted with undisturbed rootballs back to field soil and grown for an additional two years. October-transplanted trees of both species began first post-transplant root extension earlier and generally accumulated root length on rhizotron windows faster than Nov.- or March-transplanted trees. Median date for beginning root extension for sugar maples was 48, 22, and 0 d before budbreak for Oct.-, Nov.- and March-transplanted trees, respectively. Median date for beginning root extension for northern red oak was 4, 21 and 14 d after budbreak for Oct.-, Nov.- and March-transplanted trees, respectively. Height and trunk diameter growth were similar for all treatments within each species for three years after application of treatments. We conclude that the root regrowth characteristics of northern red oak heighten transplant risk and that early fall transplanting will result in earlier first season post-transplant root growth for sugar maple and northern red oak. Earlier post-transplant root growth will likely increase resistance to stress imposed by harsh landscape environments.

1340–1440
S04–P–30

ULTRASTRUCTURE OF NODULES FROM *ALNUS MARITIMA*

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

1340–1440
S04–P–31

EFFECT OF MIST, SOIL WATER POTENTIAL (YSOIL) AND STEM WATER POTENTIAL (YSTEM) ON ROOTING OF STEM CUTTINGS OF LOBLOLLY PINE (*PINUS TAEDA* L.)

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Two experiments, one using hardwood stem cuttings and one using softwood stem cuttings (June) of loblolly pine, were conducted in January and June, respectively. Two mist regimes, a control and a low regime consisting of 40% less mist, were the main plots and four soil water potential treatments were the sub-plots. Four soil water potential treatments [-1.8 (wet),–2.6 (medium), and–3.6 (dry) kPa, and a control] were created using containers of various heights filled with coarse builders' sand. Tensiometers maintained the three treatments by controlling the frequency of sub-irrigation added to each treatment. The control medium consisted of 2 peat: 3 perlite (v/v), however sub-irrigation was not added. There were four replications per mist level. Approximately 60 cuttings were placed in each plot. Stem water potential (Ystem) and soil water potential (Ysoil) were measured destructively on 1 cutting per plot at 5 AM and 2 PM each week for 5 weeks. Rooting percentage was recorded after 10 weeks. Ysoil, Yshoot and rooting percentage were correlated to determine the most significant relationship among variables. Mean rooting percentage for January and June was 23% and 47.5%, respectively. The effect of mist and soil water potential as well as their interaction had a significant effect on Ystem for both trials. Ystem decreased with decreasing Ysoil. In January the effect of Ystem on rooting percentage depended on the mist regime. Rooting percentage increased as Ystem decreased (became more negative) for cuttings under the control mist, whereas rooting percentage of cuttings in the low mist decreased as Ystem decreased. In June rooting percentage decreased as Ystem decreased for cuttings in both mist regimes. The greatest rooting percentage for both experiments occurred in an intermediate range of Ystem (- 0.4–-0.75 MPa), indicating that cuttings of loblolly pine may need to experience stress in order to initiate adventitious roots.

1340–1440
S04–P–32
FINE ROOT FREEZING INJURY AND REGROWTH IN FOUR DECIDUOUS TREE SPECIES

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Freezing stress injury to fine roots during mid-winter thaw-freeze events may contribute to branch die-back and decline in deciduous tree species. Little is known, however, about the freezing tolerance of fine roots in deciduous tree species or about fine root regrowth following freeze injury. Using a laboratory assay of electrolyte leakage, we compared the freezing tolerance of fine roots (<1 mm diameter) in four species, *Acer saccharum* (sugar maple), *Fraxinus americana* (white ash), *Fraxinus pennsylvanica* (green ash) and *Gleditsia triacanthos* var. inermis (thornless honeylocust), on three dates between January and March, 2001. For each date, whole plants of each species were also frozen to temperatures that resulted in at least 50% ion leakage from fine roots to determine the effect of freeze damage on subsequent fine root regrowth. We also examined the relationship between bud break and root regrowth for each species. When frozen to –5 °C, fine roots of the four species differed significantly in electrolyte leakage: roots of *F. pennsylvanica* consistently ranked lowest in electrolyte leakage while those of *A. saccharum* and *F. americana* generally had the highest levels of leakage; electrolyte leakage from roots of *G. triacanthos* varied with date. While the four species differed significantly in rates of root growth, freezing whole plants at root-damaging temperatures did not affect rates of root growth. Also, there was no consistent effect of root freezing injury on days to bud break for any species. Whole plant freezing to root damaging temperatures did result in significant differences between species in the number of days between bud break and first appearance of new fine roots.

1340–1440
S04–P–33
CHANGES IN ANTHOXANTHIN CONCENTRATIONS AND ACTIVITIES IN ANTIOXIDATIVE ENZYMES IN A CATTLEYA (ORCHIDACEAE) HYBRID GROWN UNDER DIFFERENT UV CONDITIONS

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To clarify effect of UV-A irradiation on antioxidative activity of Cattleya plants Slc. Estella Jewel 'Kazumura' plants were grown under UV (0.00**W**-cm^{-2}), UV (60% shade, 0.36**W**-cm^{-2}), UV-A352 (352nm UV-A lamp, 1.20**W**-cm^{-2}) and UV-A370 (370nm UV-A lamp 0.65**W**-cm^{-2}) conditions from June 1st for five months. Decreased levels of chlorophylls and carotenoids in the UV condition and UV, especially UV-A352, requisite factors to those pigment synthesis, are previously reported. We also examined antioxidative enzymes how UV-A affected those activities. UV-A352 rose dry matter of pseudobulbs, while UV decreased it. Lowered anthoxanthin levels in Cattleya leaves under both UV-A352 and UV-A370 indicate to be negatively responsible to UV stress (carotenoids increased in UV-A370). Thus, Cattleya showed different responses in pigment changes from Cymbidium. In contrast with no distinctive changes in SOD activity in leaves of the UV plot, UV-A352 plot temporarily decreased it after sudden UV-A352 exposure, but rapidly increased. APX of the UV plot showed a gentle decreasing activity after 30 days from the onset of treatment. Its maximum activity was found after one month and 2 months in the UV-A370 and the UV-A 352 plots, respectively. Catalase activities decreased in every plot with time, although they were higher in leaves of the UV-A352 and -UV plots than in those of the UV. This finding is different from results of Cymbidium leaves. Changes in SOD, APX and catalase activities in Cattleya leaves were different from those of Cymbidium. Besides, UV-A352 affected more anthoxanthins and antioxidative enzyme activities than UV-A370. These findings present natures of Cattleya that this plant can respond flexibly to various UV conditions.

1340–1440
S04–P–34
ELEVATED PRODUCTION TEMPERATURES ADVERSELY AFFECTS SPATHIPHYLLUM

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Day temperatures in Florida foliage production structures commonly exceed 30 °C and may exceed 40 °C for one hour or longer. To determine the influence of elevated temperatures on *Spathiphyllium* cultivars, tissue culture liners of *Spathiphyllum* 'Petite' and 'Tasson' were grown for 8 weeks with day temperature maximums of 30, 35, and 40 °C with night temperatures of 21 °C. Additionally, four-month old liners of *Spathiphyllum* 'Lynsise', 'Petite', 'Starlight', 'Viscount', 0597-3, 5598, UF474-1, and UF 576-14 were transfered from a greenhouse production environment to growth chambers set at 40, 45, and 50 °C for 1.5 hours. After the heat treatment, plants were returned to the greenhouse with 16 °C night temperatures and maximum day temperatures of 35 °C. All plants exposured to 50 °C for 1.5 hours exhibited foliar damage within three days and unfurled leaves at treatment time exhibited the greatest amount. Leaf area damage ranged from 80% on leaves of 0597-3 to less than 1% on leaves of UF 474-1. Growth indices of plants subjected to constant day temperatures of 30, 35, and 45 °C showed maximum growth at 30 °C whereas growth indices of plants subjected to heat stress of 40 and 45 °C for 1.5 hours taken 45 days after treatment did not differ from greenhouse controls. All cultivars except UF576-14 had a significant reduction in growth indices when exposed to 50 °C.

1340–1440
S04–P–35
EFFECTS OF PRODUCTION LIGHT LEVEL AND PACLOBUTRAZOL MEDIA DRENCHES ON HEIGHT, SHOOT NUMBER, AND QUALITY OF FOUR *ALOCASIA* SPECIES

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Plants, which move directly from the wild into commercial propagation, without the benefit of extensive breeding and selection, often pose production-oriented problems for growers. The purpose of this work was to determine the effects of production light levels and the degree of efficacy offered by chemical control of petiole elongation in the production of Alocasia species and hybrids [*Alocasia* x *amazonica* 'Green Velvet' (André), *A. veitchii* (Lindl.), *A.* x *nobilis*, and *A.* x *frydek*]. Liners were established in 2-L containers under three light levels (920, 640, and 280 μmol·m^2·s^{-1} for five weeks. Treatments were a 200-mL drench of paclobutrazol at 2.5, 5, 10, or 20 mg·L^{-1} and an untreated control. Data were taken at 3, 6, and 9 weeks after treatment. Heights, width, shoot number, and an overall quality rating of plants produced were analyzed. The interaction of species and light level ($P < 0.001$), and the interaction of species and paclobutrazol concentration ($P < 0.002$) affected final plant height. Shoot number was only seen to be a function of species ($P < 0.001$). Overall quality of plants produced was best at 280 μmol·m^2·s^{-1}.

1340–1440
S04–P–36
THE ETHYLENE UNDERGROUND

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The effects of ethylene on such processes as fruit ripening, abscission, and senescence are well known. Ethylene also participates in a variety of responses in the root zone. For example, ethylene affects root extension, root hair development, aerenchyma formation, and root gravitropic responses. We here present evidence for the involvement of ethylene in a variety of root developmental responses to nutrient deficiency and other stresses. Using contrasting genotypes of common bean, we show that ethylene participates in the change in basal root angle in response to phosphorus deficiency. In Arabidopsis, we show that ethylene and phosphorus deficiency increase root hair density via separate pathways. Using an ethylene insensitive genotype of petunia, we show that preventing ethylene action increases susceptibility to disease, especially in plants already subjected to nutrient stress. We suggest that ethylene participates in the signaling processes for some, but not all, root developmental responses to edaphic stresses.

1340–1440

S04–P–37

CHILLING-INDUCED PROGRAMMED CELL DEATH IN MAIZE (*ZEA MAYS* L.) CULTURED CELLS

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Programmed cell death (PCD) in organisms under biotic and abiotic stress often accompanies with calcium (Ca^{2+}) overload and enhanced production of reactive oxygen species (ROS). We have demonstrated that 4 ºC chilling induced Ca^{2+} overload and enhanced ROS production in maize cultured cells (Chen and Li, 2001). We now report a study on the cytological and biochemical events that accompany with PCD in maize cultured cells during 4 ºC chilling. It was found that certain aspects of chilling injury and the death in maize cells appeared to be similar to those that occurred during pathogen-or H_2O_2-induced programmed cell death (Mittler et al. 1997, Houot et al. 2001). These included nuclear morphological changes and chromatin condensation, as evidenced by the observations of fluorescent and electron microscopy. The appearance of nuclear fragmentation by electron microscopy was associated with the cleavage of nuclear DNA into small fragments. The observed events in chilled maize cells suggest that chilling injury and the death are a process similar to PCD under other stresses.

1340–1440

S04–P–38

EFFECTS OF ROOT ZONE TEMPERATURE AND ROOTSTOCK ON THE SAP FLOW, STOMATAL RESISTANCE, TRANSPIRATION AND PHOTOSYNTHESIS IN CUCUMBER

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In order to understand the effect of root zone temperatures and rootstocks on the sap flow, photosynthesis and mineral composition of xylem sap, cucumber (*Cucumis sativus* L.) plants were grown hydroponic under the solution temperatures of 14 to 1 °C and Growth characteristics and physiological metabolism such as the sap flow rate, stomatal resistances, transpiration, photosynthesis and mineral composition of xylem sap were investigated. Growth reduced more in 'Baeksung' cucumber plants grafted on 'Superunyong' bloomless figleaf gourd than in 'Kyeulsalrichungjang' cucumber grafted on 'Heukjong' figleaf gourd when the temperature was lowered from 22 °C to 14 . The sap flow rate also reduced more by 60% at 22 °C and 22% at 14 °C in 'Baeksung#3/Superunyong' than 'Kyeulsalrichungjang/Heukjong'. The stomatal difference resistance was not significant difference at 22 °C between 'Baeksung#3/Superunyong' than 'Kyeulsalrichungjang/Heukjong', but was a little high in 'Baeksung#3/ Superunyong' at 14 °C. The transpiration rate was higher at 22 °C, but lower at 14 °C in 'Baeksung#3/Superunyong' than 'Kyeulsalrichungjang/Heukjong'. The photosynthesis was higher in 'Baeksung#3/ Superunyong' than 'Kyeulsalrichungjang/Heukjong' at 22 °C and 14 °C. The amount of bleeding xylem sap after the detopping of stem was remarkably reduced by the low solution temperature in which plants were grown. It was only one 9th when the plants were grown at 14 °C compared to plants grown at 22 °C in 'Baeksung #3/ Superunyong', but in 'Kyeulsalrichungjang/Heukjong'' was one 2nd. The concentration of NO^{3-}, H_2PO^{4-}, Ca^{2+} and SO^{4-} in xylem sap were lower significantly in 'Baeksung#3/Superunyong' than 'Kyeulsalrichungjang/Heukjong'. The concentration of NO3-, H_2PO^{4-}, and Ca^{2+} in xylem sap were lower at 14 °C than 22 °C, but the concentration of SO^{4-} was higher at 14 °C.

1340–1440

S04–P–39

ANTIOXIDANT SYSTEM AND LIPID PEROXIDATION LEVEL AS CHILLING TEMPERATURE-TOLERANT MECHANISMS IN WILD TOMATO SPECIES

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We have investigated chilling temperature-tolerant mechanisms in wild tomato species to obtain fundamental data for breeding tolerant tomatoes as well as rootstocks. *Licopersicon peruvianum* (IT 173831) and *L. hirsutum* (IT 199480) were shown to have high tolerance to chilling temperature whereas *L. cheesmanni* (IT 173936) and *L. esculentum* (cv. 'Sunroad') were sensitive. We measured level of hydrogen peroxide and membrane lipid peroxidation in the leaves that were exposed to chilling temperature (4 °C) for 12, 24 and 48 hours. In addition, the activities of catalase and peroxidase, and levels of ascorbic acid and polyamine were measured. Most of the tomato species in the present study showed that the level of hydrogen peroxide was increased during chilling. It is interesting that the chilling-sensitive tomatoes, *L. cheesmanni* and cv. 'Sunroad' (*L. esculentum*), produced particularly high level of hydrogen peroxide. Malondialdehyde production in *L. cheesmanni* was two times higher than that of chilling temperature-tolerant tomatoes, *L. peruvianum* and *L. hirsutum*, indicating that lipid peroxidation in the membrane was probably accelerated. Catalase activity was increased up to 24 hours followed by decrease in 48 hours in most of the tomatoes species. However the activity of catalase in the chilling-tolerant tomato, *L. peruvianum*, was the highest. Peroxidase activity in the chilling-tolerant, *L. hirsutum*, showed the highest. Chilling temperature tended to induce high levels of ascorbic acid, putrescine and spermine. The results indicate that high antioxidant enzyme activity and low membrane lipid peroxidation level may be closely involved in chilling tolerance of *L. peruvianum* and *L. hirsutum*.

1340–1440

S04–P–40

EFFECT OF LOW ROOT TEMPERATURE ON THE PHYSIOLOGICAL AND BIOCHEMICAL RESPONSES OF CUCUMBER AND FIGLEAF GOURD ROOT SYSTEMS

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Low soil temperature affects cucumber growth due to limited absorption of water and essential mineral nutrients. One way to avoid such difficulties is the use of figleaf gourd as rootstock for cucumber production. Figleaf gourd grows well at a relatively low soil temperature, a characteristic that is particularly useful when grafted cucumber plants are cultivated during winter. However, the mechanism of such a low temperature resistance has not been fully understood. Cucumber and figleaf gourd plants were grown hydroponically and low root temperature was imposed using coolers and heaters while optimum aerial temperature was maintained. When root temperature was gradually lowered, cucumber plants quickly loses root pressure while figleaf gourd maintains it even at 8 °C. When root temperature was raised from 8 °C to 29 °C, hydraulic conductance of figleaf gourd root system was 4 times higher than cucumber root. Vesicle shrinking measured with stop-flow fluorimeter confirmed that root plasma membranes of figleaf gourd have an ability to control water status in the cell when influenced by low root temperature. Proton-ATPase activities of isolated plasma membranes were activated in both species. However, zeta-potential (surface negativity) measured with free-flow electrophoresis showed that plasma membranes of figleaf gourd were hyperpolarized by low root temperature, suggesting the active pumping of the protons. It is concluded that the ability of water and nutrient uptake in response to low root temperature might be a crucial factor to be able to survive under low root temperature.

1340–1440

S04–P–41

WHAT LIMITS THE RATE OF NET PHOTOSYNTHESIS AS LEAF TEMPERATURE INCREASES?

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Although net photosynthesis (Pn) in both C3 and C4 plants is ultimately limited by Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco), the temperature response of Pn is not closely related to the response predicted from the kinetics of Rubisco. For example, Pn does not increase between 28 and 35 °C and, when leaf temperature exceeds about 35 °C for C3 plants or 40 °C for C4 plants, Pn is inhibited. However, activities of Rubisco, and also the key C4 enzymes PEP carboxylase and pyruvate phosphate dikinase, increase over a temperature range that causes complete inhibition of Pn. Chlorophyll

fluorescence analysis indicates that the electron transport system is not impaired at leaf temperatures that cause significant inhibition of Pn. However, fluorescence analysis did nreveal a significant impact of moderate heat stress on increasing nonphotochemical fluorescence quenching, a result indicating decreased utilization of ATP by the Calvin cycle. Heat stress also leads to increased tissue levels of ribulose-1,5-bisphosphate and decreased levels of 3-phosophoglyceric acid, indicating an inhibition of Rubisco activity. Detailed enyzme analysis indicated that the activation state of Rubisco is extremely sensitive to leaf temperature in both C3 and C4 plants. Rubisco is a light-activated enzyme whose activation state is regulated by an enzyme called Rubisco activase. Since Rubisco per se is tolerant to high temperature, our evidence suggests that the activation of Rubisco by activase is the heat-labile process. The temperature response of both C3 and C4 plants is closely related to the response predicted from Rubisco kinetics when the activation state of the enzyme at a particular temperature is accounted for. Thus, as leaf temperature increases, the rate of Pn of both C3 and C4 plants is constrained by the activation state of Rubisco.

1340–1440

S04–P–42

OXYGEN-MEDIATED COLD-ACCLIMATION IN CUCUMBER (*CUCUMIS SATIVUS* L.) SEEDLINGS

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Cold acclimation of etiolated cucumber seedlings, consisting of cooling at 12 °C for 48 hours followed by a warming period at 25 °C, led to tolerance to subsequent chilling at 2 °C. Tolerance, as evidenced by freedom from chilling injury and continued growth, developed during the warming period in a time-course manner for 12 hours but decreased with prolonged warming. A similar increase and subsequent decrease was observed also in the content of palmitic, linoleic and linolenic acids in a total lipid fraction from cucumber hypocotyl tissue. During the warming period supra-ambient oxygen stimulated whereas sub-ambient oxygen inhibited the increase in fatty acid content as well as development of chilling tolerance. A strong correlation between oxygen-mediated changes in fatty acid content and associated development of cold tolerance suggests that these processes are affected by oxygen. Cold acclimation, but not cold stress, led to an increase followed by a decrease in CO_2 evolution suggesting that a respiratory upsurge is yet another feature of cold acclimation in cucumbers.

1340–1440

S04–P–43

THE EFFECT OF CALCIUM AND CALMODULIN ANTAGONIST ON CHILLING RESISTANCE OF EGGPLANT SEEDLING

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Message transduction of Calmodulin (Ca^{2+} CaM) has been showed to be inhabited by Calmodulin special antagonist W7. To assess the effect of Calcium and W7 on chilling resistance of eggplant seedlings, seeds of eggplant variety (Fengyan No.2) were immersed in Calcium chloride (40 $\mu mol \cdot L^{-1}$) ,W7 (300 $\mu mol \cdot L^{-1}$). Cold test at the 3-leaf seedling stage was conducted in growth chambers maintaining at 5 °C with 60 $mol \cdot m^{-2} \cdot s^{-1}$ light intensity. After chilling stress for 0, 12, 24, 36, 48 h the effect of Calcium and W7 on eggplant seedlings membrane-lipid peroxidation and content of protein was studied. Remarkably increase of the electrolytic leakage and content of malondialdehyde (MDA) were observed of W7 treatment and were obviously higher than those of $CaCl_2$ treatment as time of chilling stress extended. The more electrolytic leakage and content of MDA increased, the lower chilling resistance of seedlings was. The activities of superoxid dismutase (SOD) and catalase (CAT) of $CaCl_2$ treatment were distinctly increased and were always obviously higher than those of W7 treatment as the time of stress prolonged. The seedlings with higher SOD and CAT activities could avoid or lighten membrane-lipid peroxidation in chilling stress. The content of soluble protein of $CaCl_2$ treatment was remarkably more than that of W7 treatment. The stronger chilling resistance of seedlings was, the higher soluble protein content was. The indexes to identify the eggplant seedlings resistance to chilling were significantly activated by $CaCl_2$ immersing seeds. Ca^{2+} CaM message system could stable the structure of cell membranes and made the level of membrane-lipid peroxidation decreased and made protective enzymes and protective substance increased. But after Ca^{2+} CaM combined with W7, it couldn't combined with target enzyme so that structure of cell membrane was ruined and gene expression was changed. So chilling resistance of seedlings was decreased. The experiment provided a useful evidence that Ca^{2+} CaM

1340–1440

S04–P–44

FLAVONOID BIOSYNTHESIS IN BILBERRY (*VACCINIUM MYRTILLUS* L.)

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Flavonoids are a large group of phenolic secondary metabolites widespread among plants and involved in many plant functions. Anthocyanins, a flavonoid subclass, are the main pigments in flowers and fruits where they act as insect and animal attractants. Red colors in leaves are often also due to anthocyanins. Flavonoids have found to possess protective roles in plant tissues and the production of flavonoids often increases in response to different external stress factors like drought, cold temperature, wounding or excess of UV-light. Bilberry (*Vaccinium myrtillus* L.) is a deciduous dwarf shrub, growing in Europe and Northern Asia. In Northern Europe it is among the most important wild berries. Anthocyanin pigments, that bilberry contains, have been investigated for their antioxidant properties, vascular protective activity and for their effect on improving vision in poor light. *Vaccinium* flavonoids are also recognized for their anticarcinogenic properties. We have investigated the expression of flavonoid pathway genes in relation to accumulation of anthocyanins, proanthocyanins and flavonols during berry development of bilberry. Our research interests includes also the role of flavonoid biosynthesis as response to external stress treatments in leaves and in in vitro callus tissues of bilberry.

1340–1440

S04–P–45

RESPONSE OF ANTIOXIDANT ENZYMES TO CONTINUOUS LIGHT IN *CUCURBITA*

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The varietal difference on the response to continuous light was found in *Cucurbita* and the relationship between tolerance to continuous-light and antioxidative enzymatic activity was investigated. Cultivars of *C. moschata* and *C. maxima* were grown under two photoperiod treatments; 12 h light/12 h dark (12/12 h) or continuous light (24/0 h) for 13 days from cotyledon expanded stage. Chlorosis was observed from 2nd true leaf in *C. maxima* and *C. moschata* cv. Butternut grown under 24/0 h. Cv. Butternut was more severely injured than *C. maxima*. In other varieties of *C. moschata*, chlorosis was not observed and plants grew vigorously under 24/0 h. Activities of superoxide dismutase (SOD), ascorbate peroxidase (APX) and catalase in the third true leaf were determined in cv. Butternut (sensitive to continuous light) and cv. Hyuga No14 (tolerant to continuous light). In cv. Butternut, the activities of SOD and APX under 24/0 h was 4- and 2-fold higher, respectively, than those under 12/12 h. The activity of catalase was slightly higher under 24/0 h. In cv. Hyuga No14, there were no differences in the activities of these antioxidative enzymes between the two photoperiod treatments. In cv. Butternut, the content of hydrogen peroxide in leaf was also higher under 24/0 h. In cv. Hyuga No14, there was no difference in hydrogen peroxide between the two photoperiod treatments. These results suggest that continuous-light induces oxidative stress in sensitive cultivar of *Cucurbita*.

1340–1440

S04–P–46

CHARACTERIZATION OF MIDDAY DEPRESSION IN THE AMERICAN CRANBERRY, THE IMPACT OF RADIATION AND TEMPERATURE

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Characterization of the photosynthetic response would enable modeling of

plant productivity and possibly lead to strategies for optimizing assimilation rate in this highly managed crop. However, there is a paucity of information on the photosynthetic response of the American cranberry to the two most pivotal factors: radiation and temperature. The objective of the current experiment was to characterize photosynthetic light response curve and determine the impact of radiation and temperature on cranberry midday depression. Plants of the two commercial cultivars; 'Stevens' and 'Ben Lear' were grown in containers in an irrigated section of the Philip Marucci research facility. Under controlled environment conditions the photosynthetic rate, stomatal conductance and leaf internal CO_2 concentration were measured at six light levels and five temperature settings after an hour of acclimation at each light level and at least two hours of acclimation at each temperature. In the second experiment, three plants of each cultivar were maintained well watered throughout the day while the diurnal pattern of change in photosynthetic rate, stomatal conductance and leaf internal CO_2 concentration were measured using an open gas exchange system. Measurements were made every hour from 9 am to 5 pm. The measured photosynthetic response to radiation was best simulated by a non-rectangular hyperbola with a theta value of 0.98. Simulation of photosynthetic rates did not fit the field data owing to a midday depression in photosynthesis. The impact of temperature and light on midday depression of photosynthetic rates were simulated under constant temperature and light levels in controlled environment chambers. There was a significant reduction in stomatal conductance during the middle of the day, that was correlated with the reduction in photosynthesis.

1340–1440

S04–P–47

CONTROLLED BLOSSOM FREEZING OF *MALUS* X *DOMESTICA*, *M. SIEVERSII* AND *M. CORONARIA*

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A series of controlled blossom freezing studies using field-cut flowering shoots placed in a programmable freezer with temperature reduced 1 °F/30 minutes from 35 °F to 25 °F compared survival of varieties of commercial apple (*M.* x *domestica*), seedlings of *M. sieversii*, and seedlings of native crab apple *M. coronaria*. Commercial varieties differed in frost survival and differences could not be explained by stage of blossom development. Cold preconditioning of cut shoots tended to improve blossom survival as did sorbitol preconditioning. Many *M. sieversii* seedlings survived freezing regime at balloon-full bloom comparable to commercial varieties at tight cluster-pink-balloon. *M. sieversii* tolerance to freezing declined with days in storage. *M. coronaria*, an early leafing, late blooming species, survived freezing better than 'Rome Beauty' and contained higher pedicel sugar levels. Freezing in all three species at all stages of bloom development examined through full bloom was initiated at the base of the style directly above the locule.

1340–1440

S04–P–48

CHANGES IN THE OSMOLYTE ACCUMULATION PATTERNS DURING CHILLING STRESS IN CUCURBITA SPP

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A foliar levels of glycine betaine, water-soluble sugars and proline in the two contrasting genotypes of *Cucurbita* spp, Heukjong (*Cucurbita ficifolia*, chilling-tolerant cultivar) and Jaerae 13 (*Cucurbita moschata*, chilling-susceptible cultivar). were determined during chilling stress. A comparison of the genotypes showed chilling tolerance might be corelated with an increased in the glycine betaine contents. A foliar level of glycine betaine in Heukjong was increased nearly two-fold as 0.83 micromoles per gram fresh weight than that of Jaerae 13 after 2 days of chilling stress. Glycine betaine levels in Heukjong slightly decreased thereafter, whereas that of Jaerae 13 increased as 0.70 micromoles per gram fresh weight after 8 days of chilling stress. The total water-soluble sugar contents in Heukjong did not changes 10 days after chilling stress, but then increased from 8.5 to 26.5 milligrams per gram dry weight 20 days after chilling stress. In Jaerae 13, it was increased rapidly in the beginning of chilling stress, and increased from 7.3 to 27.0 milligram per gram dry weight 20 days after chilling stress as compared with unstressed plants. Proline content in Heukjong was rapidly increased by the beginning of chilling stress, increasing from 31.7 to 868.6 micrograms per gram fresh weight 20 days after chilling stress. In Jaerae 13, it was increased from 24.5 to 622.1 micrograms per gram fresh weight 15 days after chilling stress, and then declined slightly after 15 days of chilling stress.

1340–1440

S04–P–49

HEAT STRESS INCREASES SENSITIVITY OF POLLEN, FRUIT AND SEED PRODUCTION IN TOMATOES (*LYCOPERSICON ESCULENTUM* MILL.) TO NON-OPTIMAL VAPOR PRESSURE DEFICITS

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Optimal relative humidity for tomato pollination is generally thought to be from 50-70%, but has not been well tested under controlled conditions or in combination with high temperatures. Starting two weeks before anthesis of the first flower, three tomato cultivars (*Lycopersicon esculentum* Mill.) differing in heat tolerance were exposed to mild heat stress (31/25 vs. 28/22 °C) at three relative humidity levels (30, 60, and 90%) in controlled environment chambers. These treatments represented vapor pressure deficits ranging from 0.45 kPa to 3.16 kPa during the day or 0.38 to 2.7 kPa averaged over a 24-h period. Pollen development in the anthers was followed cytologically, pollen release and germination were measured at anthesis, and seed production and fruit weight were measured as fruit matured. Fruitset, seedset, fruit weight, pollen release and pollen germination were most sensitive to high humidity (decreasing vpd) at high temperature, and were most sensitive to high temperature at high humidity. Overall treatments, optimal vpd was 2.25 kPa. Differences between cultivars in response to high humidity were less than that those for temperature responses. Leaf and flower temperatures and photosynthetic rates were measured in all the treatments. Leaf temperatures were much higher than air temperatures in both 90% rh treatments, but lower than air temperatures in the 60% and 30% rh treatments. Flower temperatures were similar to air temperatures in all treatments. Photosynthetic rates measured at ambient heat and humidity were similar in all treatments, although it was difficult to measure gas exchange accurately in the 90% rh treatment. Cytological examinations revealed pollen developmental anomalies in some, but not all cultivars at 90% and 30% relative humidity. Plant height was also affected by the treatments, with much taller plants in the high temperature, high humidity (low vpd) treatments.

1340–1440

S04–P–50

SUPEROXIDE DISMUTASE, RIBULOSE 1, 5-BISPHOSPHATE CARBOXYLASE (RUBISCO) AND PHOTOSYNTHETIC RATES OF DROUGHT-TOLERANT AND DROUGHT-SENSITIVE TOMATO CULTIVARS

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The development of drought-tolerant tomato (*Lycopersicon esculentum* Mill.) cultivars for cultivation in hot and dry climates is a long-term research objective. To achieve this end, eco-physiological and biochemical studies on tomato drought tolerance were carried out. The effects of water stress on superoxide dismutase (SOD) in several drought-tolerant and drought-sensitive tomato cultivars were examined. In most of drought-tolerant cultivars, the increase in SOD activities by water stress was more rapid and greater than drought-sensitive cultivars. Under well-watered conditions, drought-tolerant cultivars showed significantly higher SOD activities (456.00 $\pm$ 2.1 unit/mg protein) than drought-sensitive cultivars (442.00 $\pm$ 1.7 unit/mg protein). Rubisco activity was reduced by water stress, but the reduction was more rapid and greater in drought-sensitive King Fukuju (KF,

45-55%) than tolerant TM 0126 (TM, 20-25%). Similar trends were observed for water stress effects on photosynthetic rates (Pr) to those on rubisco activities. The ability of TM to minimize the reduction in Pr under water stress may be related to its ability to maintain higher rubisco activities. It appears that drought-tolerant tomato cultivars have both an ability to tolerate water deficit and to recover rapidly after re-watering. Our studies suggest that SOD activities should be considered as a screening tool for developing tomato drought tolerance. The importance of the SOD defense system in tomato drought tolerance was confirmed.

1340–1440

S04–P–51

EFFECTS OF MODERATELY ELEVATED CHRONIC TEMPERATURE ON REPRODUCTIVE DEVELOPMENT OF TOMATO PLANTS

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Fruit yield, microsporogenesis, and gene expression in the anther of tomato (*Lycopersicon esculentum* Mill.) plants were examined under moderately elevated temperature stress. Plants were treated under 28/22 and 32/26 °C with natural light. Among the cultivars examined, NC8288, showing high temperature sensitive cultivar in previous experiments, indicated the most adverse effects of elevated temperatures on yield, pollen production, release, and germination. Also, pollen release and germination appeared to be the primary factors to limit yield under moderately elevated temperature stress. Temporal and spatial gene expression in anther of high temperature susceptible and tolerant cultivars under different temperatures and were discussed.

1340–1440

S04–P–52

SEED TREATMENT WITH PACLOBUTRAZOL IMPROVED TOMATO SEEDLING TOLERANCE TO DROUGHT AND HEAT

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Initial laboratory and greenhouse studies revealed that treating seeds of 'Marglobe' tomato (*Lycopersicon esculentum* Mill.) with 50 mg·L^{-1} Paclobutrazol (PB, Bonzi®) growth suppressant either as a soak (24 hours, 22 °C) or during matric priming for 3 days (-1 MPa 22 °C) reduced seedling growth without affecting germination or emergence relative to responses of non-treated seeds. Higher PB concentrations decreased rate and/or percentage of germination/emergence. By 21 days after planting in plug trays in the greenhouse, seed soak relative to priming resulted in lower shoot dry weight and leaf area, but higher root dry weight and leaf water potential. Plants then were subjected to factorial treatments of drought (by varying the irrigation frequency for 10 days) or subsequent heat (25 °C to 50 °C for 1 hour then held at 50 °C for 4 hours). Before stress imposition, 24 hours and 10 days after the end of the heat treatment, plant growth, water relations, chlorophyll concentration and electrolyte leakage were measured. Compared to plants from non-treated seeds, plants from seeds soaked with 50 mg·L^{-1} PB were 40% shorter and had 45% higher root : shoot dry weight ratio, fewer leaf lesions, less stem damage, and greener foliage (more plant responses will be reported later). Since PB application by soaking seeds or spraying seedlings (10 mg·L^{-1}) gave similar plant growth and ability to tolerate drought and heat. stresses, seed treatment with PB would appear to be an effective alternative to foliar application in tomato bedding plant production.

1340–1440

S04–P–53

GENETIC CONTROL OF FATTY ACID DESATURATION DURING COLD ACCLIMATION AND DE-ACCLIMATION OF BIRCH

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Among the metabolic modifications induced by a low temperature exposure, increase in fatty acid (FA) unsaturation of membrane lipids is a common feature that allows the membranes to retain their functional fluidity. Linoleic (18:2) and linolenic acids (18:3) have been shown to be the most modulating FAs upon low-temperature exposure in several plant species, and the 18:3 ratio increased in poplar stem tissues in correlation with freezing resistance (Yoshida S. (1974). Contrib. Inst. Low Temp. Sci. Series N 18: 1-43). To understand the mechanism of this increased FA unsaturation, the correlation between frost tolerance, modification of membrane lipids, and the expression of the genes involved in the desaturation of 18:2 to 18:3, the w -3 fatty acid desaturase (w -3 fad) genes is studied in birch. Three groups of w-3 fad clones, homologous to the Arabidopsis fad7/8 (group I and II) and fad3 (group III) were isolated from a birch cDNA library. Analysis of birch seedlings exposed to low temperatures in greenhouse showed that: 1) Cold acclimation was inducible in greenhouse conditions and a decrease in the photoperiod strongly enhanced the process; 2) The 18:3 FA content increased in leaves and stem by 15% at the expense of the 18:2 FA after three days; and 3) Genes of group I appeared cold induced in both stem and leaves, whereas the genes of group II, mainly expressed in untreated leaves, appeared down regulated after the downward shift in temperature. Bark samples from adult birch trees were collected at tree different latitudes in Finland (64 49', 66 30', 68 09') every three weeks in year 2001 to follow the cold de-acclimation in spring and de-acclimation in fall in outdoors conditions. Frost tolerance, water and chlorophyll content, membrane lipid composition and expression of some w -3 fad genes, and their relation to frost tolerance will be presented.

1340–1440

S04–P–54

YIELD REDUCTION IN GREEN BEAN UNDER HIGH TEMPERATURE CONDITIONS

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High temperatures during the reproductive growth stage resulted in a yield reduction in the green bean (*Phaseolus vulgaris*). We studied on the heat sensitive stage and physiological process affected by heat stress using green bean grown in a greenhouse and the field. Pod set ratio was decreased by heat stress applied on the flowering day, 1 day before flowering and 8-11 days before flowering. The reduction of pod set ratio by heat stress 8-11 days before flowering was associated with the occurrence of sterile pollen. The structural abnormalities of the microspore were associated with tapetal degeneration. Anther indehiscence occurred when pollen stainability was decreased to lower than 20% under high temperatures. Pollen tubes stained by aniline blue were observed in the ovule under optimum conditions, but hardly observed under heat stress. Heat stress at flowering stage blocked pollen tube elongation in the style. Pod yield, flower number, pollen stainability and pollen tube elongation were examined using heat-tolerant and heat-sensitive cultivars of green bean grown in the field. Heat-sensitive cultivars showed few pod yields in the summer cropping. Flower number increased in the summer cropping than in the spring cropping. Pod set ratio was decreased as the temperature increased, but it was higher in the heat-tolerant cultivar than in heat-sensitive one. Heat-sensitive cultivars showed low pollen stainability and only small number of pollen tubes were observed in the ovule. Both normal pollen development in the anther and normal pollen tube elongation in the style were necessary to set pod under high temperatures. The heat-tolerant cultivar showed a superior ability in those factors.

1340–1440

S04–P–55

SOME FATTY ACID DESATURASES FROM AFRICAN VIOLET (*SAINTPAULIA IONANTHA*) RELATED TO CHILLING SENSITIVITY OF PLANT

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African violet (*Saintpaulia ionantha*) originated in Africa, which is hypersensitive to chilling temperature, appears brown-yellow spots (called leaf spots) on the leaf surface, as chilling injuries within about two weeks following foliar watering. This leaf damage is due to an abrupt drop in leaf temperature by overhead irrigation with cold water. Because the appearance is valuable for an ornamental plant, African violet, and we grow many chilling sensitive crops from the tropical

zone and the subtropical zone, the study on chilling injury is important. The fatty acid composition of membrane lipid is closely related to chilling sensitivity of plants. The plant species with high ratio of unsaturated fatty acid composition can keep their membranes fluid under chilling temperature, therefore they are tolerant to chilling. We have isolated some c-DNAs encoding fatty acid desaturases from c-DNA library of African violet (cv. Tomahawk) leaf, which grew at 23 °C, PPFD 50 $\mu mol \cdot m^2 \cdot s^{-1}$, and 16 h-photo period. It has recognized that they shared high sequence similarities with omega-3 fatty acid desaturases and omega-6 fatty acid desaturases of potato (*Solanum tuberosum*), soy bean (*Glycine max*), and sesame (*Sesamum indicum*) by subsequent isolation and sequencing full-length c-DNAs. Southern analysis has revealed that African violet has genes encoding these fatty acid desaturases. Furthermore, Northern analysis have carried out to decide their localizations and to compare the expression within cultivars and different stage of leaf development. Finally, we considered the relationship between the severity of leaf spot injury and the fatty acid composition of leaves by gas chromatography analysis.

1340–1440

S04–P–56

DIFFERENTIAL INDUCTION OF PROTEINS AND KUNITZ-TYPE POTATO PROTEINASE INHIBITOR BY HEATING AND CHILLING TREATMENTS IN POTATO PLANTS (*SOLANUM TUBEROSUM* L.)

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A differential induction of proteins was monitored from potato plants (*Solanum tuberosum* L.) by the heat or cold treatment. Proteins of 18-kDa to 22-kDa were induced in 2 hours after the chilling treatment at 4 °C, whereas proteins less than 14-kDa were significantly reduced. Under heating treatment at 45 °C, approximately 22-kDa, 27-kDa and 80-kDa proteins were significantly induced. An induction of Kunitz-type potato proteinase inhibitor (KPPI) was examined by heating or chilling application. The 27-kDa KPPI, which is leaf specific, was induced in 2 hours at 45 °C. A protein size of approximately 22-kDa was induced in response to both chilling and heating treatments. This 22-kDa protein failed to cross-react with antibody against 22-kDa KPPI, indicating its novelty produced under the temperature extremes. These results suggest that heat shock may induce KPPI by the same pathway as does wounding. Though earlier findings on the function of KPPI, it may be assumed that KPPI in plants serve as a wide-range defense protein against environmental stresses including high temperature.

1340–1440

S04–P–57

CHILLING STRESS AND PHYSIOLOGICAL CHANGES IN *SORBUS DOMESTICA* GROWN IN VITRO: ANTIOXYDATIVE SYSTEM AND CARBOHYDRATE ADJUSTEMENT

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Microcuttings of *Sorbus domestica* were grown in vitro at 23 °C on a Murashige and Skoog medium supplemented with 0.3 $mg \cdot L^{-1}$ cytokinin (Benzylaminopurine) and compared with shoots grown under different chilling conditions: 10 °C and 4 °C. These conditions were applied to the shoots for 7 days. Microcuttings under low temperature showed a reduced growth but all of them survived. Changes in different stress markers, i.e. lignin content, antioxidative enzymatic system, soluble carbohydrates and morphological traits, were observed. Accumulation of lignin and altered antioxidative activity (catalase and Halliwell-Asada system) were recorded within the first days of treatment and the amplitude of the response was correlated with the intensity of the stressor. Soluble carbohydrate levels were determined using high performance anion exchange chromatography coupled with pulsed amperometry detection. In *Sorbus domestica* grown in vitro, some monosaccharides such as fructose seemed to accumulate under chilling stress whilst others like glucose didn't. The same observations could be done for disaccharides with a cold-linked accumulation of lactose but not of sucrose. Surprisingly glycerol accumulated in shoots kept at 4 °C. Observed physiological changes are discussed in relation with the measured growth performance. The obtained results will offer a new model system for studying the correlation between physiological plant responses and gradual abiotic stressing conditions.

1340–1440

S04–P–58

ECOLOGICAL TOLERANCY OF FRUIT CROPS IN DIFFERENT CLIMATIC ZONES OF UKRAINE

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The Ukrainian system of ecological monitoring for horticultural plantations is in action since 1996. This network consists of 16 control points covering practically all the main agroecological zones (Carpathians, Marshy Scrub, Partially Wooded Steppe, Steppe, Crimea). The widely distributed in Ukraine cultivars of pip, stone, small fruit, and nuciferous crops are the objects of monitoring. The following indices are registered: 1) agrometeorological conditions (temperatures, humidity, precipitation, fog etc.); 2) agrotechnical conditions (soil types, irrigation, mineral and organic fertilizers, pesticides etc); 3) phytosanitary conditions (pests, infectious and physiological diseases); 4) dangerous natural phenomena (extremal temperatures, heavy glazed frosts, autumn and spring frosts, droughts, dry and hot winds, heavy showers and hailstorms, soil over- and underflooding etc.); 5) technogenic influences (air, soil, and water contaminations); 6) phenological observations; 7) data about the yield. The monitoring data showed that the main losses in horticulture production during 1999-2000 were caused by spring frosts, which were on the soil surface from -0.5 till -11 °C at various regions of Ukraine. The level of damaging was following (%): pip 10-90, stone 20-100, small fruits 10-70, nuciferous 10-100 depending on a region and on a plant tolerancy. The varietal tolerancy of the main fruit crops was determined. An apple-tree turned out to be the most tolerant fruit crop under agroecological conditions of Ukraine. It takes 70% in total orchard structure. The catalogue of apple varieties that are the best for growing in different regions is formed on the basis of monitoring observations.

1340–1440

S04–P–59

OVEREXPRESSION OF A CYTOSOLIC ASCORBATE PEROXIDASE GENE IN APPLE IMPROVES RESISTANCE TO HEAT STRESS

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During normal aerobic metabolism, molecular oxygen can undergo a series of univalent reductions to produce a variety of oxygen intermediates such as the superoxide radical. The presence of these reactive oxygen species (ROIs) can lead to peroxidation of cellualar membranes, denatured proteins, and cause lesions in DNA. Various types of environmental extremes can result in a dramatic increase in oxidative stress. Plants have evolved an array of antioxidant enzymes (AO), such as ascorbate peroxidase (APX) and superoxided dismutase (SOD) to scavenge ROIs and detoxify them. In the present study, we have overexpressed a cytosolic APX gene, derived from spinach, in apple in order to determine if this improves resistance to environmental stress. 'Royal Gala' apple was transformed using Agrobacterium and the APX gene was placed under the control of a dual 35S promoter. At least twenty transgenic lines were identified using PCR. These lines were then rooted and placed in a growth chamber in preparation for field planting. Thus far, several lines have been demonstrated in laboratory tests to have improved resistance to heat stress. When leaf disks were placed at 44 °C for 14 h, disks from wild-type plants exhibited 100% electrolyte leakage, whereas transgenic lines exhibited 40% to 75% leakage, depending on the specific line. Further responses to cold, salt, and UV stress are in progress.

1440–1520

S04–O–60

MECHANISM OF INJURY BY AND ACCLIMATION TO ENVIRONMENTAL STRESSES IN TENDER PLANTS: STRATEGIES FOR IMPROVING STRESS RESISTANCE

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Environmental stresses such as chilling and frost cause large economic looses in tender vegetable and fruit crops. Traditional breeding approaches have led to only limited progress in improving hardiness of these plants. By combining physiological, biochemical and molecular approaches together with classic breeding we have made some progress in bringing frost hardiness from wild to cultivated potatoes. Furthermore, by separating various components of hardiness e.g. tolerance, avoidance and ability to acclimate it has been possible to individually select for these traits and make progress. Some of the ideas to making these improvements stemmed from the understanding of mechanisms of injury and acclimation. Many factors including cooling and warming rates, duration and length of stress and presence of light influence the survival. Visual symptoms of injury by these stresses include water soaked appearance and loss of turgor. Classic studies in the 1970's demonstrated that these symptoms result from injury to membrane ATPase that results in leakage of cellular solutes including ions, sugar and amino acids. Later it was shown that this injury is reversible and recovery of injury possible. A loss of membrane calcium is associated with the injury and recovery process. This has opened opportunity for mitigating stress injury. Many investigations focused on the alteration of membrane lipids resulting from changes in the physical properties in the specific domains (viscosity, hexagonal phase) and/or peroxidation of lipids by free radicals. Changes in the lipid composition and physical properties especially in the phoshotidylethanolamine species (from 18:1 to 18:2) support this idea. This has led many to attempt at creating transgenic plants by modifying desaturases. Injury by several environmental stresses has common symptomology. It is not thus, surprising that membranes are target of alteration by several stresses. Furthermore, during acclimation to one stress cross adaptation of other stresses has been demonstrated. Strategies for improving resistance to mitigating injury due to these stresses will be discussed.

1520–1540
S04–O–61
HEAT SHOCK PROTEINS AND CHILLING INJURY IN FRUITS AND VEGETABLES

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We have shown that if harvested tomatoes were held at an elevated temperature (38 to 40 °C) before storage at 2 °C, they did not develop chilling injury while non-heated tomatoes held at 2 °C developed chilling injury and did not ripen normally. This observation has since been extended to other harvested commodities including apple, avocado, citrus, cucumber, mango, pepper and others. The heat treatment can be as short as 20 sec and as long as 3 days and effective temperatures can range from 37 to 62 °C. Among other processes affected by high temperature stress, all the above treatments induced heat shock proteins, which remained present in the fruit during low temperature storage. Two molecular approaches have been used to see if heat shock proteins alone can confer resistance to both high and low temperature on tomato fruit tissue. One was to transform tomatoes with an Arabidopsis heat shock factor gene, AtHSF, to increase the general level of heat shock proteins without stress. The second was to transform tomatoes with tom111, a chloroplastic heat shock protein. Behavior of the transformed plants and fruit under stress conditions will be presented.

1540–1600
S04–O–62
TO BE ANNOUNCED

1600–1620
S04–O–63
EFFECTS OF TEMPERATURE ON COQ10 CONTENT AND MEMBRANE PROPERTIES OF TWO DIFFERENTIALLY CHILLING-SENSITIVE SPECIES

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Ubiquinone (CoQ10 or Coenzyme Q10) functions as an electron carrier in the respiratory chain of mitochondria in both plants and animals. It has been shown to act as an antioxidant in animal tissues and in vitro through inhibition of lipid peroxidation in membranes. The purpose of this study was to explore a relationship between CoQ10 content and membrane properties in seedling species with different sensitivities to chilling temperatures. The two species of plants chosen for this study were mung bean (*Vigna radiata* L.), a chilling-sensitive species, and pea (*Psisum sativum* L. cv. Lincoln), a chilling-tolerant species. The plants were germinated and grown in the dark at 20 °C. Removal of seedlings occurred prior to chilling, after three days at 10 °C, and after an additional three days at 5 °C. In all assays the cotyledons were removed prior to examination. Lipid peroxidation was measured using a modified TBARS assay. Electrolyte conductivity was used as an indicator of membrane leakiness. Respiratory oxygen and carbon dioxide levels were analyzed with a GC. Cytochrome c oxidase activity was measured as an indicator of the activity of the main respiratory pathway. CoQ10 was extracted from plant tissue and analyzed with an HPLC with detection at 290 nm. Differences in CoQ10 contents and membrane properties between these two differentially chilling-sensitive species will be discussed.

1620–1640
S04–O–64
CALCIUM DEFICIENCY-INFLUENCE ON CALCIUM DISTRIBUTION AND ANTIOXIDATIVE SYSTEM OF PEPPER AND TOMATO PLANTS

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Deficiency of calcium increases the incidence of physiological disorders in numerous plant species, e.g. bitter pit in apple fruits. Ca^{2+} plays a pivotal role in membrane stabilization and in the regulation of enzyme synthesis, e.g. proteinkinases or -phosphatases. Disturbance of these processes cause cell and membrane degradation as a consequence of oxidative processes and insufficient calcium in cell membranes. A possibility for the reduction of the incidence of physiological disorders is the exogenous application of calcium solutions. For improving penetration of calcium ions, adjuvants, e.g. oils and surfactants, such as Agnique RSO were used. The aim of the study was the reduction of blossom-end rot in tomato and pepper fruits by exogenous application of $CaCl_2$ solutions. Additionally, the influence of calcium deficiency on calcium distribution and the antioxidative defence system was investigated. For our investigations greenhouse grown tomato and pepper plants were used. Experiments were carried out at the Dept. of Horticulture, Bonn Univ. Samples of leaves and fruits were collected at 3 sampling dates and at harvest date. The incidence of blossom-end rot, the calcium content and distribution and the effect on the antioxidative defence system was investigated. Ca-deficiency had a significant reduction of the fluorescence value Fv/Fm in leaves and fruits as a result. The incidence of blossom-end rot was significantly reduced to about 50% of the control by preharvest application of the $CaCl_2$ formulation at a 8 days-interval. This positive biological effect was most probably brought about by the increase of cell wall- and membrane bound Ca content in the fruit as documented by Ca analysis.

1640–1700
S04–O–65
EFFECT OF CALCIUM DEFICIENCY IN SOLUTION ON GROWTH AND COLD RESISTANCE OF GRAFTED EGGPLANT SEEDLINGS

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Ca^{2+} message system involved in stabling the structure of cell membranes and increased the resistance of plants. To assess the effects of calcium on growth and chilling resistance of seedlings, grafted and own-root eggplant seedlings were cultured in solution of Calcium sufficiency and calcium deficiency respectively. Cold test at the 3-new-leaf stage of grafted seedling was conducted in growth chambers maintaining at 5 °C with 60 $mol \cdot m^{-2} \cdot s^{-1}$ light intensity. After chilling stress for 0, 12 ,24, 36, 48 h the effect of Calcium on eggplant seedlings, the contents of protein, sugar and calcium were studied. The results showed that under the calcium-deficient condition the growth of seedlings was seriously inhabited. The contents of total soluble protein, boiling stable protein, soluble sugar, cell inner soluble calcium and combined calcium of calcium deficiency of grafted and own-root eggplant seedling leaves were distinctly lower than those of calcium sufficiency under low temperature condition. The contents of total protein, boiling stable protein, soluble sugar, cell inner soluble calcium and combined calcium of grafted seedlings were all obviously higher than those of own-root

seedlings after undergoing the same time of stress. The study suggested that the higher carbohydrate contents of grafted seedlings might be caused by contents of the cell inner calcium variations. The variations of calcium contents were perhaps the main reason that the grafted seedlings were higher cold resistance than own-root seedlings. The indexes to identify the eggplant seedlings resistance to chilling were significantly activated by Calcium culture. As a result calcium played an important role in increasing the contents of carbohydrate and enhancing cold resistance.

1800–1830
S04–O–66
USING INFRARED THERMOGRAPHY TO STUDY ICE NUCLEATION AND PROPAGATION IN PLANTS

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Infrared thermography has provided new details about the freezing process in most of the plant species in which it has been used. It offers a distinct advantage over other methods of studying ice nucleation and propagation in that it allows one to directly visualize the freezing process. This is done in a non-intrusive manner which overcomes any influence of attached objects, such as thermocouples, on the pattern of freezing. As a result of a number of studies, several new possibilities for enhancing frost protection have been identified as having good potential. Selection of cultivars with thicker cuticles or providing an externally-applied, hydrophobic barrier, may provide a way of blocking extrinsic ice formation from propagating into a plant and initiating a freezing event. In particular, the application of a hydrophobic particle film to the surface of tomato plants have provided frost protection and prevented tomato plants from freezing despite the presence of ice on the external leaf surface. Selecting for the presence of barriers to ice propagation in woody plants, that allow expanded flowers or inflorescences to supercool despite the formation of ice in stem tissues, may also be a practical approach for enhancing cold hardiness during spring frosts. We have also obtained evidence that the expression of transgenes coding for insect antifreeze proteins in transgenic Arabidopsis can enhance supercooling in plants in the absence of extrinsic ice nucleation. Examples of the factors involved in ice nucleation and propagation in plants, as observed with infrared thermography, will be presented along with recent applications of this technology.

1830–1900
S04–O–67
FACTORS AFFECTING THE FREEZING TOLERANCE OF PLANTS IN A CONTROLLED FREEZE TEST

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To measure the development of freezing tolerance in plants it is essential to have a reliable and simple screening procedure. Also, the screening procedure must mimic the major stresses encountered e.g. prolonged freezing as experienced in the winter versus short term frosts experienced during active growth. Unless the appropriate stress is applied, the appropriate plant response will not be measured. The test should also measure the ability of the plant to repair and resume normal growth. The following will be discussed in relation to predicting freezing tolerance: methods of acclimation including light and temperature; the nature of the freezing stress applied under controlled conditions compared to the field; rate of cooling; duration of the freezing event; significance of electrolyte leakage; ice nucleation temperature; ice nucleation site; wet versus dry tissue; role of INA+ bacteria evaporative cooling; repair and regeneration factors affecting ice crystal growth and whole plants versus excised parts vs cell suspension cultures versus protoplasts as they relate to survival.

1900–1910
S04–O–68
GELISTA: A NEW TOOL FOR TESTING FROST HARDINESS BY STEM DIAMETER VARIATIONS

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Freezing avoidance was observed by diameter variations on walnut in the field. To evaluate frost acclimation, potted trees or stem segment were submitted to various freezing experiments in a climatic chamber. The diameter variations associated with the freeze-thaw cycles were similar for all conditions. Quantitatively, the maximum shrinkage appears related with stem diameter (thickness of the bark) in different size stems. The wood showed only small variations (≈15%) with the freeze-thaw cycle and water transport between the bark and wood was not necessary for most of the freeze-induced shrinkage to occur. Considering the amount of stem shrinkage associated with summer drought in walnut, the amount of contraction of the bark with freezing is actually much less than might be predicted by water relations theory. Reversible stem shrinkage was obtained for a living tissue, but not for autoclaved tissue. In this case, swelling was observed with the freeze and this swelling could be explained by bark alone, and due to water expansion with the liquid solid phase change. Similar swelling was observed during September for stem segment and in October for potted plants. By comparison with autoclaved treatment, we analysed this result in terms of cell death due to non-acclimated trees. Our results showed no reversible shrinkage of bark in this case and water lost after one cycle at -10 °C and in each case, freezing injury on bark, with discoloration of tissues, was observed after few cycle at the same temperature. Given that the diameter fluctuation patterns were dramatically different for acclimated versus non-acclimated plants, and for living versus autoclaved tissues LVDT sensors could represent a novel, non-invasive approach to testing frost hardiness.

1910–1920
S04–O–69
ADAPTATION TO COLD TEMPERATURE AND RESPONSE TO FREEZING IN ROSES

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In France, Roses exhibited freezing tolerance by acclimation in the fall and deacclimation in the spring. This involved a sequence of active processes that result in well-defined changes in cellular composition (starch level in particular). At the same time, the response to freezing by dehydration of cells showed that Roses present also freezing avoidance. We developed a new simple tool for testing cold hardiness and compared it with the classical LT_{50} test (electrical leakage conductivity). The new test gave similar results. The small quantity of necessary vegetable matter for its utilisation and the rapidity of the observed reply allow to envisage the utilization of this new tool in breeding programs and in this study for two varieties more or less frost resistant was compared.

1920–1930
S04–O–70
ESTIMATING COLD HARDINESS IN CUT ROSES (*ROSA HYBRYDA* L.) BY EXOTHERM ANALYSIS

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Thermal analysis was conducted to estimate the cold hardiness of cut roses (*Rosa hybrida* L.) 'Rote Rose' and 'Tineke' according to the exotherm, which results from the freezing of supercooled tissues in the organism. Both of the cultivars showed the only high temperature exotherm (HTE) that occurred at -5 °C up to keep below -20 °C, without occurring the low temperature exotherm (LTE). The HTE occurred at -5 °C in leaves and stems by shoot part, while it did at -2.6 °C in roots. HTE in stems caused the destructive damage to the vascular system, however it didn't result in fatal frost damage to the whole plant. On the other hand, as the root temperature fell below the freezing point of -2.6 °C, 60 percent of treated plants died in freezing injury. It could be estimated that the deadly freezing injury in cut rose plants be closely related to the death of root tissues.

1930–1940
S04–O–71
INFLUENCE OF LONG-TERM AND SHORT-TERM TEMPERATURE DROPS ON PLANT RESISTACE

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It is known that the temperature drop affects plant morphogenesis. At the same time both short-term drop and long-term decrease in temperature can cause increase in cold resistance. This is of importance for the growing of plant seedlings, and for the plant transplantation in the open. The aim of this investigation was to compare the dynamics of cucumber and corn plant resistance during the short-term and long-term temperature drops. The experimental design included following temperature treatments: during the first series of experiments the young cucumber plants (seedling stage) and the corn plants (stage of the first leaf) were exposed to diurnal low temperature treatment 12 °C for 3-5 days. During the second one, the cucumber plants were exposed to short-term temperature drops for 1-6 h or for the whole night during 6 days, and the corn plants–for 12 h during 3 days. Cold plant resistance was estimated by measuring the temperature that caused chloroplast destruction and cytoplasm coagulation in 50% of palisade parenchyma cells of a leaf disc after a 5 min freezing in a microrefrigerator (LT_{50}). The comparative analysis of plant cold resistance dynamics in both series of experiments has shown differences between treatments. The cucumber cold resistance started to increase already after several hours after the beginning of long-term treatments, and the maximum was reached at the end of the first–beginning of the second day. Further increase in exposition up to 5 days did not influence the resistance. The level of cucumber cold resistance in experiments with short-term temperature drop at the end of the third day was the same as that at the long-day treatment, but it increased twice at the end of 6 day. The same results have been obtained in experiments with corn plants. These results allow to conclude that additional mechanisms of plant cold resistance participate in plant response under the effect of diurnal temperature fluctuations.

1940–1950
S04–O–72
RELATIONSHIP BETWEEN STOMATAL DENSITY AND IONIC LEAKAGE AS INDICATORS OF COLD HARDINESS IN OLIVE (*OLEA EUROPAEA* L.)

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Screening different cultivars of olive (*Olea europaea* L.) for cold hardiness is one of the major objectives in numerous breeding programs and research projects. Selection by stomatal density is based on the fact that winter injury is frequently caused by desiccation of the plant tissues. In fact according to studies, plants have great difficulty in absorbing water when the temperature drops below _ °C and this process may stop entirely if the soil freezes. Leaf samples of one year old olive cultivars of 'Cornaiki', 'Mission', 'Roghani' and 'Zard' were taken and exposed to cold temperatures by 4 °C per h stages to 0, -4 , -8, and -12 °C. By the electrolyte leakage studies, the lethal freezing temperature (LT_{50}) of cultivars was found and the cultivars were classified as hardy, semi-hardy and not hardy. The number of stomata in the leaves of cultivars rated as hardy were significantly lower than those of cultivars rated semi-hardy and not hardy. Stomatal numbers of the cultivars in the intermediate class fell within the range of the hardy and not hardy cultivars. The number of stomata may well constitute a simple and effective selection criterion for screening olive plants for cold hardiness especially in early stages of plants, for breeding purposes.

Thursday · August 15

1100–1140
S04–O–73
SALINITY STRESS AND MECHANISMS IN DEFENSE OF ION HOMEOSTASIS

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Increasing soil salinity, the spin-off of irrigation, can severely reduce crop productivity, which makes it paramount that we understand the mechanisms in defense of ion homeostasis. These mechanisms are ubiquitous qualities of all plants, whether they are tolerant or not–protection of protein structure, osmotic adjustment, scavenging of reactive oxygen species, redox control, and ion uptake and compartmentation. The difference between salt stress tolerance and sensitivity seems to be the timing for mounting a defense at different developmental stages, and how strong and specific any response can be initiated and sustained.

1140–1200
S04–O–74
VEGETABLE CROP DIVERSIFICATION IN AREAS AFFECTED BY SALINITY: THE CASE OF PEPINO (*SOLANUM MURICATUM*)

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The increase of water and soil salinity is one of the main problems for vegetable crop production in arid and semiarid areas. Salinity constrains the horticultural development in areas of great economic importance, like the Southeast of Spain, which houses the biggest concentration of greenhouses in Europe. Several actions, including an improved soil and water management, the use of varieties tolerant to salinity and the introduction of new crops with a higher resistance to salinity, can help to alleviate this problem. The introduction of new crops resistant to salinity not only can make easier the handling of this problem, but also represents an alternative for the diversification of vegetable crop production, can contribute to a more sustainable horticulture, and to a higher stability of yield and farmers' income. Pepino (*Solanum muricatum*) has excellent prospects for its cultivation in areas affected by salinity. In particular, pepino clonal hybrids are specially interesting because they have a great vigor, and also display a high developmental homeostasis for yield traits. Results obtained in several experiments in different growing cycles show that under saline conditions (irrigation with 8 dS/m water), parthenocarpic clonal hybrids give good yields (>65 t/ha), higher than those of non hybrid cultivars under non saline conditions, and have an improved yield stability, resulting from a lower variation in yield among growing cycles and years. Furthermore, when grown under saline conditions, pepino has a higher earliness (around 15 days) and sugar content (about 20%) than under non saline conditions. These works show that as happened with the pepino, vegetable crop diversification with other new crops with a high tolerance to salinity can be of great interest for areas affected by this problem.

1200–1220
S04–O–75
ROOTSTOCK AFFECTS SODIUM AND CHLORIDE UPTAKE BY PEAR (*P. COMMUNIS*) TREES IRRIGATED WITH SALINE WATER

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Soil salinity is an increasing problem in horticultural crops, however little information is available on salt tolerance of pear (*P. communis)* trees when grafted on different rootstocks. This issue was addressed in the present study, where the ability of young trees of cv. Abbé Fétel, own-rooted or grafted on two quince (*C. oblonga*) rootstocks, MC and Sydo, and one clonal pear OHF 40, to take up and partition sodium (Na) and cloride (Cl) was also tested. Two salinity levels (control at 1.5 dS/m and saline water at 5.0 dS/m) in the root medium were obtained by addition of sodium chloride in the water, daily supplied by drip irrigation to the potted trees. Salinity did not affect root and shoot growth of trees grafted on quinces and OHF 40, while it depressed by around 35 % biomass accumulation of own-rooted trees. Leaf Na and Cl were twice more concentrated with 5 dS/m salinity than controls when trees were grafted on quinces, while no effect of salinity was recorded when root system belonged to P. communis. In all genotypes, total Na uptake was of similar magnitude of Cl uptake. When irrigated with saline water, trees on quinces significantly increased their Na and Cl uptake (from 1.5 to 3 fold increase), differently from those own-rooted or grafted on pear OHF 40. Roots accounted for most Na and Cl taken

up, but more Cl than Na was partitioned to shoots and leaves. Leaf turgor and osmotic potential were unaffected by salinity, but differed among rootstocks. Although data refer only to one vegetative season and to young trees, they indicate a fairly good ability of cv. Abbé F. to tolerate irrigation with saline water when grafted on pear and quince rootstocks. Roots of *P. communis* were able to avoid significant increase of Na and Cl uptake under salinity (exclusion mechanism) while quince rootstocks did not. Increased leaf concentration of Na and Cl when trees were grafted on quinces, however, was not incompatible with normal shoot growth.

1220–1240

S04–O–76

MECHANISM OF SALT TOLERANCE OF TWO OLIVE CULTIVARS (*OLEA EUROPAEA* L.) CULTIVRS AS RELATED TO ELECTROLYTE CONCENTRATION AND TOXICITY

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A pot experiment was conducted to investigate the response of two olive cultivars ' Nabali Muhassan' and ' Frantoio' to osmotic stress and specific chloride toxicity. The plants were irrigated with multicomponent electrolyte solution of increasing salinity and two ionic compositions. Irrigation water salinity was increased at 10 molc/m^3 increment to a maximum of 100 molc/m^3 at constant stiochiometric ratio of 1:1 and 3:1 for C1:SO_4 or 1:1 for Ca:Mg and fixed Na adsorption ratio of 5. The solutions were applied at a rate sufficient to bring about a 30% leaching fraction when the tensiometer reading reaches 50 cbar. The results indicated that Na and chloride accumulation in leaf, shoot , and root of both cultivars significantly increased, however, K and Ca concentration decreased with increasing electrolyte concentration of the irrigation water. Increasing proportion of chloride in the irrigation solution increased leaf chloride content. 'Frantoio ' was more efficient than 'Nabali Muhassan' in restricting accumulation of Na and chloride in leaf. In addition, Mg content was not affected by the salinity stress . It seems that exclusion of Na and chloride from leaves is the main mechanism of salt tolerance in 'Farantoio'. Water use efficiency of the two cultivars was drastically reduced with increasing chloride proportion and electrolyte concentration of the irrigation water. At high salinity level, 'Nabali Muhassan' was less efficient in using water. The present investigation demonstrates a considerable variability for salt tolerance in both olive cultivars and selection to salt stress is feasible by choosing a cultivar that has the ability to maintain a high K/Na ratio in its leaves ; and response to salinity stress is affected by interaction of cultivar, ionic composition and electrolyte concentration rather than the single effect of each.

1340–1440

S04–P–77

VARIATION OF TISSUE-CULTURED BANANA (*MUSA* SPP. CV. DWARF CAVENDISH) EXPLANTS IN VIVO

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Somaclonal drought resistance and Ex vitro phenotypic characteristics (height, standing leaf No., harvesting time and flowering time) of tissue-cultured explants of banana (*Musa* spp. Cv. Dwarf Cavendish) were significantly difference with conventional (sucker-propagated) banana plants in field. Growth rate of banana tissue-cultured plants was less than sucker-propagated plants after transplanting to the field. In vitro banana plants were shorter than sucker-propagated plants throughout almost 13-month vegetative growth cycle. Vigorous and higher rate of growth of sucker-propagated plants results in significantly higher and earlier flowering and harvesting. There were significant differences between drought resistance and field performance of tissue-cultured and sucker-dried banana plants. More than 2000 hr. of both tissue-cultured and sucker-drived banana plants was damaged (from 20% to 100%) in the Southern of Iran (province of Sistan and Baluchestan, where is the main banana cultivation in Iran), due to severe drought during 1999-2000. Tissue-cultured banana plants were significantly more susceptible to drought and destroyed than conventional plants.

1340–1440

S04–P–78

EFFECTS OF WATER STRESS ON DYNAMICS OF GROWTH, WATER BALANCE AND SAP FLUXES THROUGH PHLOEM AND XYLEM IN TOMATO FRUITS

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In order to examine the response of tomato (*Lycopersicon esculentum* Mill.) plants to water stress, we investigated the dynamics of expansion growth and components of water balance in growing fruits under the well-watered and the water deficit conditions. Individual fluxes of phloem sap and xylem sap through the pedicel were successfully calculated, with cooperative applications of the multiple chamber system for measuring rates of growth and gas exchange in the fruits and the heat-ring method for inhibiting phloem transport. Under the well-watered condition, most (84%) of sap flux toward the fruit contributed to fruit expansion, and the residual sap flux (16%) was lost for transpiration from the fruit and the calyx. The most dominant component of fruit water balance was phloem sap flux since major part (70%) of sap delivered into the fruit was brought by phloem transport. On the other hand, xylem transport made less contribution to the fruit expansion, and xylem sap flux exhibited large fluctuation during the measurement. Under the water deficit condition, the fruit growth rate was depressed to 36% of well-watered plants, while phloem sap flux into the fruit was kept at 65%. In particular, xylem sap flux under the water deficit exhibited no contribution to the fruit expansion. Sap backflow through the xylem from the fruit frequently occurred under the water deficit condition, although the fruit volume was kept increasing. Then, the fruit expansion under water deficit was sustained by phloem sap influx. Our study quantitatively confirmed that the water deficit results in smaller tomato fruits with higher sugar concentrations and higher incidence of blossom-end rot, and demonstrated the occurrence of xylem sap backflow from tomato fruits.

1340–1440

S04–P–79

HIGH TEMPERATURE AND DROUGHT STRESS SUPPRESS THE PHOTOSYNTHESIS AND CARBOHYDRATE ACCUMULATION IN 'SATOHNISHIKI' SWEET CHERRY

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Effect of temperature and soil moisture level on the photosynthesis and carbohydrate accumulation in 'Satohnishiki' sweet cherry was studied. Trees were grown under moist [soil moisture tension (SMT) <6 kPa] and dry (SMT <40 kPa) conditions in sunlit growth chambers controlled at 25/15 °C and 35/25 °C from early July to mid-September. Leaf photosynthetic rates under moist soil conditions were considerably higher than those under dry soil conditions throughout the experimental period. Under both soil conditions, low temperatures slightly increased the photosynthetic rate compared to high temperatures. Both high temperatures and dry soil conditions accelerated leaf abscission, and considerably reduced the dry weight of the tree harvested in winter. Starch concentration of the trees grown under low temperature conditions and high temperature/wet soil condition was higher than that under high temperature/dry soil condition. These results revealed that high temperature combined with dry soil moisture in summer reduces the photosynthetic activity, and results in decreasing the carbohydrate accumulation. However, it is also indicated that even at high temperatures, if the trees are irrigated sufficiently, photosynthetic rate is relatively high and nonstructural carbohydrate concentration is almost the same level as that at low temperatures.

1340–1440

S04–P–80

PHYSIOLOGICAL RESPONSE OF TOMATO FROM INDUCED SODIUM CHLORIDE STRESS

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The major problem for small-scale Ethiopian farmers is field salinity in semi-arid areas induced by poor irrigation practices. This adversely affects vegetable production. The aim of this project is to understand and seek agronomic solutions. Tomato seeds obtained from Ethiopia were germinated in a growing room at 20 °C ±1 °C in Rockwool at Univ. College, Dublin and were potted into 10-cm plastic pots; transferred to the glasshouse and grown for four weeks. During this time the plants were irrigated with four Sodium chloride (NaCl) treatments: (0, 500, 1000, 1500 mg·L^{-1}). Following this, they were planted out into 5 L pots in the glasshouse. Plants were either further treated with more concentrated salt solutions (2000, 2500 and 3000 mg·L^{-1}) or remained at their original levels. A completely randomised design was used. The following parameters were measured–total yield, number of fruits by size, acidity, solubility and pH of puree. There was a significant reduction in fruit yield between treated and untreated plants. However, when plants from different salt levels were compared irrespective of concentration, there was no significant difference; similarly, there was no interaction between the lowest and highest level. This suggested that where plants are salt acclimated, salt tolerance is induced. When fruit size was measured, salt concentration had no effect on fruit size with equal numbers of fruits occurring in each size category with the exception of the 51 mm to 60 mm category where a highly significant number of fruits were harvested from the lower concentration. When pH, acidity and soluble solids were evaluated, no significant difference in the interaction occurred, whereas the main effect post transplanting gave a significant difference among treatments. Thus, as the levels of salt were increased in the compost, so did the acid concentration and soluble solids increase significantly. However, the pH value remained significantly unchanged.

1340–1440

S04–P–81

PHYSIOLOGICAL RESPONSES OF ONION (*ALLIUM CEPA* L) EXPOSED TO DROUGHT

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Twenty-one day old onion seedlings were subjected to various drought regimes by withholding water. Soil moisture potential, leaf water potential, growth, photosynthesis, stomatal conductance, leaf transpiration, water use efficiency, membrane function, nature and accumulation of quaternary ammonium compounds were all investigated. Withholding water for 21 days reduced soil water potential to -1.23MPa. While withholding water to various days caused soil water potential to decline, there was no parallel reduction in leaf water potential. Growth, Cs, Tl and membrane integrity as measured by tissue capacitance and membrane injury index all reduced significantly as external water potential declined. Pn increased despite a declining root zone water potential. An increase in Pn and a decline in Tl resulted in maintenance of WUE. Glycinebetaine was identified but it did not accumulate in response to water deficit. A threshold for decline in growth, Cs, Tl and membrane integrity was -0.43MPa. Onion seedlings appear to tolerate drought through increasing WUE.

1340–1440

S04–P–82

ALLEVIATION OF SALINITY DUE TO SEA WATER INTRUSION BY USING POTASSIUM FERTILIZATION IN SATSUMA MANDARIN TREES BUDDED ON TWO DIFFERENT ROOTSTOCKS

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Several techniques are used for alleviation of salinity and among these techniques, tolerant rootstocks and fertilization receive a special attention. From this point of view, a field experiment was set up in 1995 at Ege Univ. (Bornova-Izmir) in the western part of Turkey to determine the effects of K fertilization and rootstocks. To represent the sea water intrusion prevailing in the main growing area, irrigation water was applied at different salinity levels. The trial was established as 3x2.5 m between and on-row distance with *Satsuma mandarin* (cv. Owari) nursery trees budded on Trifoliate Orange (*P. trifoliata*) and Troyer Citrange. Irrigation was applied at five levels (0.65-2.00-3.50-5.00-6.50) of saline water and three levels (0-100-200 g K_2O per tree) of potassium was applied. Fertigation trial was performed by drip through a triple line source. To determine the effects of salination on gas exchange capacity of citrus plants and to bring out the alleviation effects of potassium fertilization and different rootstocks, phtosynthesis and transpiration measurements were performed by a portable photosynthesis system and water use efficiency was determined as the ratio of unit photosynthesis per unit transpiration. The effects of fertigation and rootstocks on stomatal conductance and density and succulence was also determined as some physiological parameters. Canopy growth modelling and leaf area index (LAI) of the plants were measured by a digital plant canopy imager and whole plant gas exchange capacity was investigated. Obtained data from the study was evaluated statically by SPSS and as a result of the researchwork, significant adverse effects of salinity yield and on gas exchange capacity and the preventive effects of fertigation and rootstock usage was determined.

1340–1440

S04–P–83

EFFECTS OF ELEVATED CO_2 AND NITROGEN SUPPLY IN THE FALL ON RESERVE CARBOHYDRATES AND NITROGEN AND GROWTH PERFORMANCE OF APPLE NURSERY TREES

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One-year-old Gala/M.26 trees were grown at ambient or elevated CO_2 (1000 ppm) for 60 days in the fall. At each CO_2 level, plants received 10 mM soil N, 3% foliar urea, or no nitrogen at all (Controls). One set of plants from each treatment were destructively harvested just before budbreak for reserve carbohydrate and nitrogen analysis. Remaining plants were regrown with no nitrogen or 10 mM N for 50 days the following spring. Elevated CO_2 did not affect reserve carbohydrate concentrations, but increased tree size and subsequently the total amount of reserve carbohydrates. N applications in the fall significantly increased N content and total amount of N accumulated in the tree, but reduced reserve carbohydrates. At the same N supply level, CO_2 enrichment in the fall did not improve tree growth the following spring. Regardless of reserve carbohydrate status, trees with high N reserves had a larger total leaf area and higher photosynthesis and photosystem II quantum efficiency than those with low N status in the spring. Spring N supply only slightly increased shoot and leaf growth. It is concluded that the initial growth of apple nursery trees in the spring is mainly determined by reserve nitrogen and is not limited by reserve carbohydrates.

1340–1440

S04–P–84

COMBINED EFFECT OF SALINE STRESS AND WEEDS ON FIELD-GROWN GREEN BEAN CROP: AGRONOMIC AND PHYSIOLOGICAL ASPECTS

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Horticultural crops are often exposed to abiotic and biotic stresses that may decrease photosynthesis and plant dry mass accumulation because of limitation in stomatal conductance and reduction in CO_2 concentration at the mesophyll level. We studied the combined effect of abiotic (salt treatment) and biotic (weed) stresses on agronomic and physiological response of field-grown green bean plants (*Phaseolus vulgaris* L., cv. King). A severe salt stress was induced after plant establishment, by daily drip irrigation of plant rows with water containing 1% (weight/volume) of commercial salt. Irrigation restored evapotranspired losses. The presence of weeds were allowed withholding manual control. The aim was to assess whether weeds may compete for salt uptake, and thus minimize the toxic effect of salt on bean plants. We measured mesophyll conductance to CO_2 by simultaneous measurements of chlorophyll fluorescence and leaf gas exchange; metabolic activity was estimated on leaf disks stored in liquid nitrogen, measuring enzymes activity involved in photosynthetic processes. Linear radiometers, connected to a data logger, measured the amount of daily incident radiation (PAR) intercepted by plants in half an hour intervals. Few days after the beginning of salt stress, significant reductions in conductances and photosynthetic rates were observed in comparison with control (no salt and no weed). Other physiological and morphological plant traits

were affected later. The presence of weeds appeared to slow down the negative effect of salt stress on bean plants.

1340–1440

S04–P–85

FIELD-GROWN CHARD (*BETA VULGARIS* L.) UNDER SOIL WATER STRESS CONDITIONS: EFFECT ON ANTIOXIDANT CONTENTS.

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Horticultural crops are often exposed to drought stress which impairs photosynthesis and growth. Stress conditions may stimulate the antioxidant metabolism protecting the photosynthetic apparatus exposed to stress. We studied the relative reductions in plant yield, and changes in photosynthetic parameters and antioxidant contents in a rainfed chard crop (*Beta vulgaris* L. cv. Adriatica) as compared to a well watered crop (100% ET crop) and mild stressed one (50% ET crop). The severity of water stress was estimated by monitoring the leaf water potential with a pressure chamber. To assess whether water stress reduces photosynthesis, gas exchange was measured with a portable system (LI-COR 6400). In order to evaluate the effect of stress on CO_2 internal concentration, mesophyll conductance to CO_2 was estimated by simultaneous measurements of chlorophyll fluorescence and leaf gas exchange under field condition and with a portable system. Leaf-disk samples were collected at week intervals to measure antioxidant content. Dry mass accumulation was measured on 10 plants per treatment at each sampling date. Linear radiometers, connected to a data logger, measured the amount of daily incident radiation (PAR) intercepted by plants in half an hour intervals. Few days after the beginning of water stress, significant reductions in stomatal and mesophyll conductance and photosynthetic rate were observed. Other physiological and morphological plant traits appeared to be affected later. Antioxidant contents were inversely related to photosynthetic rates, therefore confirming that they may effectively defend plants against stress conditions.

1340–1440

S04–P–86

PHYSIOLOGICAL AND HORTICULTURAL RESPONSES OF CRANBERRY (*VACCINIUM MACROCARPON* AIT.) TO SANDING, FERTILIZATION, AND IRRIGATION METHOD

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A study was initiated on a commercial 'Stevens' cranberry bed to examine interaction of sanding, nitrogen fertilization, and irrigation. Within irrigation treatments, combinations of sanding depth (0, 1.3, 2.5, and 3.8 cm) and N rate (0, 33.5, and 67 kg/ha) were applied to individual plots. Irrigation treatments received grower-initiated irrigation (irrigated) or sprinkler irrigation only when the soil moisture dropped below 45 cm from the bed surface (cut-off). Overall, the depth of the water table averaged 20 cm deeper in the cut-off irrigation treatment compared to full irrigation, resulting in significantly deeper rooting in those plots at all levels of sanding treatment. Despite the increased energy devoted to root production in the cut-off treatment, yield was not reduced. Increased rooting in the cut-off irrigation treatment was expected to relate to increased cropping in the second year. The irrigated treatment showed a decreased ability to retain fruit (significantly more uprights that flowered but retained no fruit), especially in the 3.8 cm sand plots. Sanding decreased the percentage of light intercepted by the canopy in the season of sanding and was associated with decreased yield. Light interception remained below that in unsanded plots until late in July but then recovered, indicating that the yield suppression should not carryover into the second year. However, the anticipated increases in yield for the year following sanding were not realized. The only sanded treatment with increased yield over year 1 was the 3.8 cm inch sand in the sprinkler cut-off area. Further, cumulative yield (years 1 and 2) was greater in unsanded controls than in any sanded treatment except the 1.3 cm sand treatment in the cut-off area. In general, reduced irrigation was associated with increased yield, while sanding was associated with yield loss.

1340–1440

S04–P–87

WATER USE OF AN APPLE ORCHARD IN A COOL HUMID CLIMATE: MEASUREMENT AND MODELING

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For irrigation, water use of crops is usually estimated from grass reference evapo-transpiration (ETo) multiplied by published crop coefficients (kc). This method is assumed to adjust crop values in different climates. However, the use of kc may not be accurate in cool, humid climate, and for tall crops well coupled to bulk air. The aim of this work was to measure actual water use in apple orchard in New York, and compare it with published kc values from different climates. Measurements of water use in dwarf apple trees were made with heat pulse sap flow gauges calibrated with whole-tree gas exchange chambers (to overcome the problems related to the velocity-to-flow assumptions). Since chambers modify the tree microclimate, data for calibration have been collected in two different one-week periods during the season. Daily ETo was estimated from meteorological data acquired nearby. Results suggest the inadequacy of using kc values from arid climates in cool and humid climates since published kc values generally overestimated the measured water use rates. Also, the crop coefficient concept implies that grass and orchards behave the same in all climates; this does not seem to be true in cool humid climates. Grass-to-tree differences in advective flows, boundary layer conditions and stomatal regulation appear to result in varying transpiration rates. In conclusion, different approaches for modeling water use in apple orchard, rather than kc, should be adopted. They should in particular deal with the spatial distribution of main environmental variables, and the physiology of stomatal regulation.

1340–1440

S04–P–88

INFLUENCE OF DEFOLIATION TIMING AND SEVERITY ON CAULIFLOWER EARLINESS, YIELD AND QUALITY

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Development of high quality heads depends on adequate leaf area to cover and shield the head from sunlight in the later stages of field growth. Loss of leaf area from acts of nature, such as hail or insect feeding, may cause growth stagnation and inferior head development. Loss of leaf area may prevent adequate self-blanching or manual blanching, allowing heads to discolor in the sun causing cull quality. It is unknown what long-term effects that early, mid, or late season defoliations have on cauliflower growth and development. 'Majestic' and 'Cumberland' cauliflower transplants were field planted in spring, 2001. Cauliflower foliage was defoliated at the 25, 50, and 75% severity by cutting individual leaves at 11 (early), 39 (mid), or 48 (late) days after transplanting. Cumberland experienced yield reductions of160 to 319 kg/ha after 25 to 50% defoliation occurred at any time. Majestic, on the other hand, suffered yield losses of 2,235 to 3,673 kg/ha at 25 to 50% defoliation levels. Seventy-five percent defoliations of Majestic and Cumberland reduced yield 1,916 and 5,430 kg/ha, respectively, even though 75% late season defoliation did not reduce head weight or diameter. Cumberland's head density was unaffected by defoliation, but Majestic's density decreased with defoliation severity. Defoliation level at any time or degree did not kill plants and reduce stands in comparison to the controls. We feel that a 10% yield loss is unacceptable commercially. Majestic suffered more than 10% weight loss with as little as 25% defoliation. Weight reduction for Cumberland was no more than 2% with even up to 50% defoliation. With 75% defoliation, Cumberland fell below our level of acceptability with a 15% weight reduction, but, the more sensitive Majestic suffered a 27% weight reduction at the same defoliation level.

1340–1440

S04–P–89

XYLEM SAP BACKFLOW FROM TOMATO FRUIT UNDER WATER DEFICIT CONDITION

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The occurrence of xylem sap backflow from fruit is known in several woody crops. In tomatoes, it is not generally accepted that the xylem backflow occurs in the plant, although our preliminary experiments revealed that the expanding fruit under water deficit condition loses slight water through xylem backflow. In this investigation we confirmed the occurrence of xylem backflow from the fruit using the fluorescent dye, Lucifer Yellow CH (LYCH), which is unable to cross the plasmalemma, as a tracer for apoplastic movement of water. For introduction of LYCH into the fruit, a small hole was made in the side of the fruit, which reached to the center of the fruit. About 0.1 mL of 1% LYCH solution was poured into the hole in the dark period. The plant was exposed to the light (PPFD, 250 $\mu mol \cdot m^{-2} \cdot s^{-1}$) for 6 hours, and then transections of the peduncle and the stem were soon observed with the fluorescent microscopy. The intense fluorescence of LYCH was observed in xylem region only. In well-watered plants, the LYCH slightly flowed out from the fruit. In water deficit plants, the LYCH centripetally moved more than 100 mm, and it consequently reached to the stem. Result indicated that the xylem sap flows back from the fruit during the daytime under the water deficit condition. The finding involves complicate process of sugar and calcium accumulation in the developing tomato fruit.

1340–1440

S04–P–90

PISTACHIO ROOTSTOCKS INFLUENCE SCION GROWTH AND ION RELATIOS UNDER SALINITY AND BORON STRESS

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The performance of pistachio trees (*Pistacia vera*, cv 'Kerman') on three rootstocks (*P. atlantica*, *P. integerrima* and UCB-1, a *P. atlantica* x *P. integerrima* hybrid) was evaluated with two-year-old trees grown in sand-tank lysimeters under combined sulfate-chloride salinity and boron stress for six months. Four salinity treatments were imposed by irrigating the plants with waters at electrical conductivities (ECiw) of 3.5, 8.7,12, or 16 dS/m each containing 10 $mg \cdot kg^{-1}$ B. Kerman growth response was evaluated based on increase on total leaf area, increase in trunk diameter and total above-ground biomass production. All growth parameters decreased as salinity increased, but were not significant until ECiw exceeded 12 dS/m. However, growth of Kerman on P. atlantica and UCB-1 was considerably better than on *P. integerrima* at 16 dS/m. The onset and severity of foliar injury differed among scions and treatments and was attributed primarily to B toxicity, rather than the effects of salinity. Concentrations of B in injured leaf tissue ranged from 1000 to 2500 $mg \cdot kg^{-1}$. Leaf injury decreased with increasing salinity, although leaf-B was not significantly reduced suggesting an internal synergistic interaction between B and other elements. However for *P. vera* on *P. integerrima*, the highest level of salinity produced the greatest injury, possibly as a combination of B plus Cl and/or Na toxicity. Leaf transpiration, stomatal conductance, and chlorophyll concentration of *P. vera*, determined by steady-state porometry, were also reduced to a greater degree by combined salinity and boron when budded on *P. integerrima* than on the other two rootstocks.

1340–1440

S04–P–91

DROUGHT STRESS RESISTANCE IN SOME PISTACHIO ROOTSTOCKS

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A fundamental study was conducted to investigate different aspects of drought stress in pistachio. It was done on seeds (osmotic stress) and seedlings (water withholding) and germination rate under osmotic stress, growth indices, leaf water potential, and proline content during stress were evaluated and measured. Pistachio seeds could germinate under about 14 bar osmotic pressure. Proline could not play an important role in resistance of resistant stocks and accumulated in most sensitive stock and it was resulted that its accumulation in sensitive stock and dryness stage could be related to proteolytic activities in leaf cells rather than involvement in resistance mechanisms. Pistachio leaf cells could preserve leaf water potential at high level. Among growth indices, shoot fresh weight was affected by stress. Dry weight of root and shoot were not affected significantly.

1340–1440

S04–P–92

THE STOMATAL COMPLEX AND EPICUTICULAR CHARACTERISTICS OF CROWN ROT DISEASED *AGAVE TEQUILANA* WEBER (AGAVACEAE)

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Agave tequilana Weber crop. represent a very important industry in Mexico, because of the tequila production. This industry has suffer because of *A. tequilana* diseases. Therefore, the importance of studying the characteristics of this Agave which may have an influence to internalize foliar agrochemicals. The objective was to analyze the foliar morphology of the epidermis with particular interest in epicuticular characteristics and organization of the stomatal complex in healthy and apparently diseased plants from young and adult individuals. The leaves which were sampled from the middle part of the plant rosette and were prepared by LM, TEM and SEM studies, those plants were collected in Tequila, Jalisco, Mexico. Observations were made on type and spatial distribution of stomata complex, in cuticle morphology and characteristics of the spongy mesophyl. Stomata complex corresponds to the tetracystic morphology, with four neighborhood cells on the leaf surface. These cells form a cavity and right bellow them are the guard cells forming a suprastomatal chamber. Data from young and adult plants healthy and diseased, were taken for several characteristics showing significative differences in the shape and quantity of wax and in the presence or absence of oxalic acid like crystals in parenchyma cells. Diseased plants have a great quantity of wax and crystals whit diversely shapes, a potential indicator of an abiotic stress which may predisposes the plant to the disease. Cuticle morphology and thickness were described and measured. Stomatal density and stomata index were calculated, as well as interstomatal distance and clustering. For each complex, we measured size of the whole complex and other special features as: channel of neighborhood cells; stomatal pore; shape and size of guard cells and subestomatal chamber and a brief description of spongy mesophyll cells adjacent to stomatal complex.

1340–1440

S04–P–93

PHYSIOLOGICAL RESPONSES OF THE AMERICAN CRANBERRY TO CHANGES IN SOIL WATER POTENTIAL, PHOTOSYNTHETICALLY ACTIVE RADIATION AND TEMPERATURE

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The stomata of the American cranberry (*Vaccinium macrocarpon* Ait.) have been described as xeromorphic. These highly cutinized structures occur only on the abaxial surface, and have been purported to respond slowly to changing light, temperature and moisture conditions. Measurements of soil water potential in the field have suggested that there is a decline in soil water potential around midday on days with high evaporative demand. The objective of the current experiment was to determine the impact of radiation intensity, temperature and changes in soil water potential on leaf water potential, stomatal conductance and net photosynthesis. Two commercial cultivars; 'Stevens' and 'Ben Lear' were grown in containers in an irrigated section of the Philip Marucci research facility. Plants were acclimated for an hour under six light levels and five temperature levels prior to measurements of photosynthetic rate, stomatal conductance and leaf internal CO_2 concentration. In another experiment the plants of the two cultivars were grown in PVC tubes fitted with plastic mesh end caps on the bottom. The insides of the tubes were lined with fabric cloth on the bottom and filled with sand. The tubes were then placed in water filled buckets to allow the soil water potential to be manipulated by changing the water level in the buckets. The soil water potential treatments consisted of a constant soil water potential and one which varied diurnally. The response of the two cranberry cultivars were monitored for stomatal conductance, leaf carbon exchange

rate and leaf internal CO_2 concentration. There was a significant correlation between stomatal conductance and net photosynthesis. Response to radiation intensity and temperature suggests that photosynthesis and stomatal conductance increase with photosynthetically active radiation and temperature. However, under a prolonged exposure to high temperature and light levels both photosynthetic rates and stomatal conductance declined.

1340–1440

S04–P–94

CROP LOAD AS A MODIFYING FACTOR IN CROP EVAPOTRANSPIRATION MODEL FOR IRRIGATION SCHEDULING

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Accurate irrigation scheduling is the most important factor to avoid drought stress of plants or water wasting in irrigated orchards. Many irrigation scheduling models include an 'irrigation threshold' based on the drought sensitivity or water demand of the orchards. Using correct crop coefficient is critical for real estimation of plant water use in evapotranspiration model. The aim of this study was to determine the real crop coefficient in an apple orchard 'Florina'/M.26 in two consecutive ('on' and 'off') years. The average foliage area was 5.6 m^2/tree in 1998, and it was 15,0 m^2/tree in 1999, while the crop load was 15.0 and 3.0 kg/tree, respectively. Crop evapotranspiration was calculated by Penman-Monteith FAO equation using Kc=0.9, the proposed value for apple. Using the crop evapotranspiration, it was possible to estimate the soil water depletion (DRi). It was clear, comparing these estimated DRi with measured soil water values, that the model overestimated the evapotranspiration. To determine the right Kc value, the crop evapotranspiration was calculated using lower crop coefficient, and iterative calculation was proceeded to Kc=0.45 in 1998 and Kc=0.50 in 1999, when estimated and measured soil water values did not differ significantly. Foliage area (or the leaf area index) is the most common factor considered as a 'water demand factor' in irrigation scheduling models. However, in commercial orchards (mainly in orchards established with alternate bearing varieties) crop load is one of the main factors modifying actual growth vigour of trees. Fruits have a great influence on tree water balance by means of direct (increasing water demand) and indirect (decreasing vegetative growth) ways, so considering crop load is essential for proper irrigation sceduling in orchards.

1340–1440

S04–P–95

EFFECTS OF SALINE IRRIGATION WATER ON GROWTH AND YIELD OF TOMATO CROP CULTIVATED IN A MEDITERRANEAN AREA

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About 25 million hectares, representing 10% of irrigated areas in the world, are affected by high soil salinity levels that can limit the crop yields. In Europe salinized crop lands are mainly located in the countries around the Mediterranean basin. The goal of this research is to evaluate the productive and physiological response of the tomato crop to the irrigation with saline water. The field trial was carried out in 2001 at Metaponto (MT) in Southern Italy (lat. 40°24' N; long. 16°48' E) on clay loam soil (Typic Epiaquerts according to Soil Taxonomy). Tomato plants (7071 Tomito cultivar) were transplanted on three adjacent plots (each one 144 m^2) submitted, during the whole season, to different irrigation waters: fresh (EC: 0.6 $dS \cdot m^{-1}$), saline (EC: 4.2 $dS \cdot m^{-1}$) and alternated fresh-saline water. The salinity was imposed by irrigating with water artificially salinizated, using commercial salt (97% of NaCl). Irrigation water was supplied by means of localized irrigation method. Meteorological data were recorded hourly by an automated data-logger located close to the experimental area. During the growing period four samplings were carried out. In each sample 4 plants were collected and the following biometric characteristics were determined: crop height, number of leaves, fresh weight of stem, leaves and fruits, leaf area, dry weight of stem, leaves and fruits. Finally, at each harvest (17 and 31 July and 16 August), the weight, the number, dry extract, sweet content and acidity of mature fruits were measured. From our observations it resulted that the yield of fruit obtained with plants submitted to saline water during the growing period, with respect to the plants submitted to fresh water, decreased of 24% as a consequence of fresh weight and number of fruits.

1340–1440

S04–P–96

EFFECTS OF DROUGHT STRESS ON CHLOROPHYLL FLUORESCENCE AND XANTHOPHYLL CYCLE COMPOSITION OF APPLE LEAVES

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Potted Gala/M.26 trees were irrigated at 100% evapotranspiration (ET, controls), 40% ET, or 20% ET for 13 days, then followed by a recovery period of 6 days at 100% ET. Leaf gas exchange, chlorophyll fluorescence, and xanthophyll cycle components were measured at 2 to 3 day intervals. As water stress developed, net photosynthesis, stomatal conductance, and quantum efficiency of photosystem II (PSII) all gradually decreased. Non-photochemical quenching increased in response to water stress, leading to a decrease in the efficiency with which excitation energy was transferred to PSII reaction centers. The percentage of the xanthophyll cycle pool present as zeaxanthin and the ratio of zeaxanthin to chlorophyll increased in response to water stress. Photochemical quenching coefficient remained unchanged during the first 10 days of stress and then decreased at the end of the stress period. Predawn PSII efficiency showed no response to water stress, indicating that PSII reaction centers were not damaged. At the end of 6-day recovery period, no difference was found between controls and water-stressed plants in all the parameters measured. These results are consistent with the hypothesis that xanthophyll cycle dependent thermal dissipation is up regulated to protect apple leaves from photooxidation under water stress.

1340–1440

S04–P–97

ETIOLOGY AND PHYSIOLOGY OF STAIN, A 'FUJI' APPLE PEEL DISORDER

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Stain is a peel disorder of 'Fuji' apples that usually develops during storage. The disorder typically occurs on the blush side of the fruit often at the margin of sunburn. Stain appears to be induced by sunlight as bagging reduces the incidence of stain. To determine when the injury leading to stain occurs, fruit were bagged at 14-day intervals from July through October, then bags were removed 14 days later. All fruit were harvested in late October and stored at 0 °C. The incidence of stain decreased relative to non-bagged fruit in fruit bagged in late September and October. Exposing fruit to UV-B light under laboratory conditions can induce stain-like symptoms. Fruit harvested at 14-day intervals from July through October, exposed to UV-B light then stored at 0 °C developed the most stain when harvested in late September and October. The development of stain following postharvest UV-B treatment is temperature dependent. Stain incidence increases as storage temperature decreases following postharvest UV-B treatment. A postharvest dip in 2 or 4% $CaCl_2$ or infiltration with 2% $CaCl_2$ significantly reduces stain during air storage. Other treatments (DPA, AVG, 1-MCP, methyl jasmonate) do not consistently reduce stain development. Storage in low O_2 (1-2 kPa) with up to 5 kPa CO_2 reduces stain development compared to fruit stored in air.

1340–1440

S04–P–98

PERFORMANCE OF GRAIN AMARANTH VARIETIES IN TWO CONTRASTING AGRO-ECOLOGICAL AREAS IN MALAWI UNDER DROUGHT STRESSED CONDITIONS

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Understanding yield performance of grain amaranths in various agro-ecologies is vital for variety selection and improvement startegies. Yield trials of ten grain amaranth varieties {*A. hypochondriacus, A. tricolor, A. cruentus* R-158 (2), *A. cruentus* K-283 (11), *A. cruentus* R-109 (7), *A. cruentus* K-758 (12), *A. montegazzianus* (10), *A. hypochondriacus* x *A. hybridus* (14), *A. hypochondriacus* x *A. hybridus* (15) and *A. cruentus* (10)} were carried out under a range of drought

stresses in two contrasting agro-ecological sites in Malawi during the dry season of 1999. There were significant differences ($P < 0.05$) in grain yield and yield components between varieties. Drought susceptibility index (S) indicated that the two dwarf varieties were drought tolerant (S = -1.23 at a warm and dry location). However, the yield potentials (measured in irrigated treatments in the same field) of the dwarf varieties were very low in both sites (Bunda, hot and dry site and Kasinthula, warm and dry site). Short growth durations exhibited by dwarf varieties suggested drought escape mechanism and induced more grain production as a survival mechanism. Stability analysis showed that *A. cruentus* (10) was stable across the two sites and was the best for grain production. Yield components increased greatly in the hot and dry site suggesting that vegetative production was at the expense of grain yield. One factor determining grain yield was drought stress imposed at flowering stage.

1340–1440
S04–P–99
INFRARED AND ULTRAVIOLET LIGHT INJURY OF APPLE FRUITS

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Unripe apple fruits, cultivars Golden Delicious (clone of Smoothee), Red Spur and Granny Smith were irradiated with ultraviolet (UV)-C, UV-B, infrared (IR) or combination of UV and IR for different periods. UV-B irradiation discolored fruits of Granny Smith and Red spur, but it had no effect on Golden Delicious fruits, whereas UV-C irradiation at all cultivars caused injury and color change. Washing and removing the wax of cuticle of fruit skin slightly increased UV-C injury on Golden Delicious fruits. The symptom of UV-C injury especially on Golden Delicious and Granny Smith fruits was similar to solar sunburn while high temperature injury was not. Golden Delicious apple fruit was more resistant to high temperatures than Red Spur apple fruit. Red Spur fruit was more sensitive to UV-C than Golden Delicious and Granny Smith fruits. Incubation of UV-C irradiated fruits under white light completely inhibited UV-C injury. It seems that the role of UV portion of sunlight is more important than high temperatures (IR radiation) on fruit sunburn.

1340–1440
S04–P–100
PRELIMINARY STUDY ON PHYSIOLOGICAL REASONS OF ALMOND FRUIT DROP

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Almond is one of the most important horticultural products and even the word, the majority of suitable Iranian areas are cultivated under irrigation systems or rain-fed forms. Shahr-e-kord City is one of these examples, where the causes of fruit drop which is one the limiting factors for development and cultivation of almond in this area. Studies to examine these issues, including almond kernel damaged by a kernel feeder bee, are going on now. Research is in progress in Chaharmahal Va Bakhtiary province (e.g. Shahr-e-kord City), and Khorasan province (e.g. Kashmar, the koh-e-Sorkh) orchards. The first elementary research showed that the majority of fruit have formed cracks in the young fruit and their green colour changes to yellow gradually, than the texture of the fruit becomes soft and shrink, respectively. Afterwards the fruits will fall by any shakings of the branches. There are gums formation inside of some fruits. It seems that the difficulty of pollination and fertility are not the factors for this cause, because all the fallen fruit have embryo and kernel. The rate of falling fruit is severe in Shahr-e-kord City early June and in some of the orchards would be up to 70% of this cause. The rate of falling fruit is much lower in the koh-e-Sorkh Kashmar, estimated below 5%. According to this investigate, between these two areas shows that climatic conditions is one of the most important factors for the cause. The research will be done in order to investigate the physiological mechanisms of the falling, in which it focused on the climatic conditions, management, and the effect of different genotypes, etc.

1340–1440
S04–P–101
PHOTOSYNTHETIC PERFORMANCE OF WILD TYPE STRAWBERRY ECOTYPES (*FRAGARIA* SP) DIFFERING IN SALT SENSITIVITY

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While cultivated strawberry (*Fragaria* x *ananassa*) is considered as salt sensitive crop, its progenitors *Fragaria chiloensis* and *Fragaria virginiana* differ in their salt sensitivity, with *F. chiloensis* being more salt tolerant than *F. virginiana*. Although some morphological characteristics may contribute to this difference, inconclusive results have been drawn about the photosynthetic performance of these species. The potential of a plant to tolerate high soil salinity has been correlated with its ability to sustain adequate photosynthetic rate (A) under saline conditions. We investigated the photosynthetic characteristics of the salt tolerant *F. chiloensis* (ecotype FRA-24) and the salt sensitive *F. virginiana* (ecotypes NC 95-25-1 and MR-10) when grown under salt stress conditions. Plants were grown in a greenhouse under natural light, relative humidity 50-75% and temperature 20-30 °C during the summer. Six plants per ecotype and treatment were watered at least once per day, with 100 mM NaCl solution ensuring adequate leaching and preventing excess salinity, while another set of plants was watered with tap water and used as control. Although toxicity symptoms were evidence at the second week of treatments in both ecotypes of *F. virginiana*, *F. chiloensis* did not show visible symptoms during the experiment. Runner production was reduced by 70% in NC 95-25-1 and 50% in MR-10 while only 10% reduction was observed in FRA-24. Gas exchange analysis indicated that NaCl had an adverse effect on photysynthetic carbon assimilation (A). At early stages of salt imposition, reduction in stomatal conductance limited A in all ecotypes tested, although the most severe reduction was observed in FRA-24. Carboxylation capacity showed a slight reduction in both NC 95-25-1 and MR-10 at the third week of the experiment but not in FRA-24. Electron transport capacity was not affected by the salt treatment in all three ecotypes. The practical implication of the study will be discussed.

1340–1440
S04–P–102
ENVIRONMENTAL STRESSES THAT CAUSE SUNBURN OF APPLE

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We have identified two types of sunburn in apple and their causes. One type (sunburn necrosis) is caused by thermal death of epidermal and subepidermal cells when the peel reaches 52 ± 1 °C. A necrotic spot appears on the sun-exposed side of the fruit. Electrolyte leakage increases significantly with necrosis, indicating that membrane integrity is lost during thermal death. The second type (sunburn browning) is sublethal and results in a yellow, bronze, or brown spot on the sun-exposed side of the fruit. The fruit surface temperatures (FST) that cause sunburn browning vary between 45 °C and 50 °C depending on cultivar. This is based on sunburn induction tests (attached fruit heated under controlled conditions in the field) and also on observations of natural sunburn of fruit to which thermocouples were attached throughout the season. Maximum FST exceeded 45 °C on 22 days in 2000 and on 23 days in 2001 in our orchard. Sunlight was required for sunburn browning. Protecting fruit from UV-B radiation usually prevented sunburn browning. The FST reached a maximum between 1500 and 1700 Daylight Savings Time, and was affected by several meteorological parameters. Maximum daily air temperatures were highly correlated with maximum FST (r = 0.90**) on those days. Mean daily air temperatures between 1100 and 1700 were also highly correlated (r = 0.88**) with maximum FST. Mean solar radiation between 1100 and 1700 also was highly correlated (r = 0.65**) with maximum FST. Mean wind velocity and mean relative humidity (RH) between 1100 and 1700 were inversely correlated (r = -0.24** and -0.66**, respectively) with maximum FST. During 2000 and 2001, we found that FST never exceeded 45 °C on days when maximum air temperature was below 30 °C. When maximum air temperature exceeded 35 °C, maximum FST almost always exceeded 45 °C. When maximum air temperature was between 30 and 35 °C, solar radiation, wind velocity and RH also were important determinants of maximum FST.

1340–1440
S04–P–103
EXPRESSION ANALYSIS OF GENES ENCODING AQUAPORINS DURING THE DEVELOPMENT OF PEACH FRUIT

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Water absorption is very important for growth and development of fruit. Rapid

enlargement of fruit is induced by increased water absorption to cause cell expansion. Excess absorption results in decrease in sugar concentration and fruit cracking reducing fruit quality. Recent studies revealed that water channel proteins named aquaporins are responsible for controlling the water permeability of biomembranes in many plants. To understand the molecular mechanisms of water absorption by fruits and the functions of aquaporins in these processes, we isolated four clones encoding aquaporins from peach fruits (*Prunus persica* Batsch) by RT-PCR with degenerated primers. Two (Pr-gTIP1 and Pr-gTIP2) of those have high homologies to tonoplast intrinsic proteins (TIPs) which are located in the vacuolar membrane. Others (Pr-gPIP1 and Pr-gPIP2) have high homologies to plasma membrane intrinsic proteins (PIPs) which are located in the plasma membrane. Genome gel DNA blot analysis indicated that each of those genes exists in the peach genome as a single copy. The amino acid sequence of Pr-gTIP1, deduced from the full sequence of the cDNA, was highly homologous to those of tonoplast intrinsic proteins (TIPs) isolated from other plants, especially to that from pear fruits. The amino acid sequence also indicated that Pr-gTIP1 contained two NPA (asparagine, proline and alanine) motifs, which are part of the pore structure of water channels. RNA gel blot analysis revealed that Pr-gTIP1 is highly accumulated in flesh at an early stage and a late stage of fruit development. The results suggest that Pr-gTIP1 gene was involved in rapid expansion of the fruit cells. By contrast, Pr-gPIP1 was expressed during fruit development continuously. From these results, Pr-gTIP1 and Pr-gPIP1 may have different functions and work cooperatively for fruit development.

1340–1440
S04–P–104
IRRIGATION WATER MANAGEMENT AND TOPPING ON THE PERFORMANCE OF OKRA

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Limitations of space and water affect the availability of okra especially in the dry season in urban areas. Okra (*Abelmoschus esculentus*) grown in plastic bags on the field were investigated under different irrigation regimes in the wet and dry seasons. Three irrigation frequency levels designed to maintain the soil matric potential within the ranges -060 to -075 hPa; -075 to -090 hPa and -090 to -105 hPa were studied. Tensiometers installed in the root zone were used to monitor conditions of the soil moisture. Based on crop water requirement computations, standard cups of 473 cm^3 and 476 cm^3 were used per bag at each irrigation during the wet and dry seasons respectively. The topping (apical debudding) factors were no topping, topping at four and six weeks after sowing respectively. A 3 x 3 factorial laid in a randomised complete block design with three replications was used in each season. Topping resulted in an increase of 2.2 t/ha and 4.5 t/ha fruit yield in the wet season and dry season respectively. Topping in combination with high irrigation frequency produced fruit yield of 37.3 t/ha and 52.7 t/ha in the wet and dry seasons respectively. Topping increased crop water use efficiency by 6.6% in the wet and 11.5% dry seasons. Water use efficiency (WUE) in the wet season decreased with increasing irrigation frequency from 8.1 to 17.6 kg/m^3 for the highest frequency and the least frequency respectively. In the dry season moderate irrigation frequency had the highest WUE of 11.5 kg/m^3. Optimum crop water requirements of 337.16 mm and 480.33 mm for the wet and dry seasons in combination with topping at four or six weeks after sowing are recommended for okra production under the conditions investigated.

1340–1440
S04–P–105
INFLUENCE OF DROUGHT STRESS ON PROLINE CONTENT OF THE SEEDLING LEAVES FROM SOME IRANIAN PISTACHIO ROOTSTOCKS

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Seedlings of four Iranian pistachio rootstocks grown in plastic bags were subjected to different irrigation intervals and the effect of drought stress on proline content of the leaves was studied. Rootstocks included 'Sarakhs', 'Fandoghi', 'Qazvini' (all three from *Pistacia vera*) and 'Khinjuk' (*Pistacia khinjuk*) and irrigation treatments were 1 days and 7 days intervals as well as a permanent withholding treatment. According to the results, proline content of the leaves was not different between the stocks at the beginning of the experiment. However, there was significant difference between the stocks in their proline content after the first week of the experiment. Meanwhile, for irrigation intervals the treatments could result to significant difference four weeks after the start of experiment. Although, regardless of the irrigation treatment, a fluctuation of proline was observed in the stocks along the experiment, however 'Khinjuk' (the most resistant stock) showed a different pattern from the other three stocks and its proline fluctuation was steadier compared to the others. At the end of the 4th week, proline of the 'Fandoghi', the most sensitive stock, was highest under the most rigorous treatment. This was coincided with the start of wilting of its leaves. We could not find a positive relation between drought tolerance and proline content of the leaves of these pistachio rootstocks.

1340–1440
S04–P–106
DROUGHT STRESS DYNAMICS OF THE WILD BLUEBERRY (*VACCINIUM ANGUSTIFOLIUM* AIT.)

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The impact of drought stress on the wild blueberry was examined during the 2000 and 2001 growing seasons at the Nova Scotia Wild Blueberry Institute. A randomized complete block design with four treatments, five replications, and a plot size of 3 x 3 m was used. Redistribution of water beyond the outer perimeter of the plots was minimized by edging and lining the areas with 30 cm deep, 4 mm polyethylene film, and acrylic shelters were used with the water exclusion treatments during incidents of rainfall to maintain drought conditions. Two clusters of treatments were used with first cluster consisting of a naturally rain-fed treatment placed immediately adjacent to a water excluded treatment, and the second cluster consisting of a naturally rain fed treatment situated adjacent to a water excluded treatment with the adjoining perimeter being separated by a 30 cm deep 4 mm polyethylene film. Leaf chlorophyll, dark and light adapted fluorescence, upright shoot and rhizome sap flow, and yield component data were collected for the 2000 and 2001 growing seasons. The diurnal net photosynthesis, transpiration, and light adapted fluorescence and sap flow measurements of the water-excluded treatments were significantly lower at midday, and redistribution of water from the rain-fed to the water excluded treatments occurred through rhizotomous tissue. There was no significant effect of the water exclusion treatments on chlorophyll content, and despite immense differences in seasonal volumetric soil moisture content, differences in harvestable weight (i.e., g of berries per m^2) between the water exclusion and naturally rain-fed plants amounted to only 18%. Therefore results from this investigation indicate that the wild blueberry is a stress tolerant plant with a range of adaptive mechanisms to tolerate drought stress.

1340–1440
S04–P–107
PUSHING THE LIMITS IN PLASTIC TUNNELS IN THE TROPICS AND THE NEED FOR SHADE

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Zimbabwe is found in the high-altitude tropics and enjoys many hours of full sunshine. As a result, several world records have been recorded in field crop production. However in the greenhouse/tunnel ambience at 1,500 meters full sunshine can quickly be too hot and too sunny and expensive to ventilate. Cassava, a tropical staple, when passed through a virus elimination cycle can challenge any crop in the world for productivity, for conversion of sunlight and water into carbohydrate (starch). Sixty tons wet weight of tubers per hectare (20 t/h dry weight) is likely under irrigation. However to transfer from in-flask "disease-free" plantlets to field planting of rooted cuttings requires multiplication and survival. We show that plants multiplied in vitro grow well under normal (for tissue culture) or high light but survive acclimatisation ex vitro poorly in this very dry atmosphere. Under low light however (>100 $\mu m \cdot s^{-1} \cdot m^{-2}$) survival of the hardening-off procedures is >95%. In-flask multiplication however, is expensive even in Zimbabwe while under plastic multiplication is here shown to be effective and economic. However, there are special constraints associated with horticulture in the high altitude tropics. Temperatures can rise above 50o °C each day. Most field plants die, or shed all their leaves, at these temperatures. We show that tender cassava cuttings and ex vitro plantlets that are acclimatising under plastic

can survive cassava and sweet potato but also of Irish potato. Thus tender plants can survive extremes of temperature, both in-flask and under plastic, but they have an absolute requirement for lower than normal sunlight. This suggests a way to implement many tissue culture cleaning and GMO-linked projects that do not currently function effectively due to low survival ex vitro in the sub-Saharan situation of Africa.

1340–1440

S04–P–108

RADIATION STRESS IN PLANTS AND ANTISTRESS EFFECT OF LASER IRRADIATION

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Investigation of vegetative and generative organs of fruit crops showed the development of universal adaptive syndrome–stress induced by high doses of ionizing radiation. It is preceded by extreme decrease of cell viability (up to 20-30% of standard levels) and increase of variability of this trait. Transition to a stress state is characterized by abnormal increase of resistance and re-establishment of the initial level of variability. Structural re-arrangements under the effect of de-stabilized factors can be detected on the basis of variability of correlated function of coherent radiation dispersed by investigated tissue. Radiation of helium-neon laser of low-intensity prevents the development of syndrome caused by ionizing radiation. It is due to the reparation processes being intensified and resulted in increase of biosystems homeostatic resistance threshold. Plants radiated by laser showed significantly more strong viability than stress endured ones.

1340–1440

S04–P–109

EVALUATION OF PLANT AND SOIL MOISTURE SENSORS FOR THE DETECTION OF DROUGHT STRESS IN RASPBERRY

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Nine different methods were used to test the accuracy, ease of use and precision of the instruments to monitor and predict drought stress in the red raspberry plant. Five direct methods included: leaf water potential (PMS 600 pressure bomb), leaf photosynthesis (LI-COR, LI-6200 portable leaf photosynthesis system), chlorophyll fluorescence (Hansatech FMS 2) and leaf stomatal conductance and transpiration (LI-1600 porometer). The four other methods monitored plant stress indirectly by monitoring soil moisture status or remote sensing principles. The soil moisture methods included: tensiometer, gravimetric (weighing) and volumetric (HydroSense) while the remote sensing method used a spectroradiometer (GER-3700). The best instruments to detect early signs of drought stress in the plant included the pressure bomb, leaf porometer and leaf photosynthesis of which the last two are non-destructive. Measurements within the soil that were closely associated to plant stress included the gravimetric method and the HydroSense. Of these, the HydroSense was the most versatile. The limitations of the tensiometer in very dry soils render it impractical for drought studies. Preliminary results with the spectroradiometer based on measurements acquired in the 400-2500 nm range at a fine spectral resolution showed that control plants had significantly lower reflectances than stressed plants, mainly in the near-infrared and shortwave infrared regions. However, future studies are necessary with this methodology to enable detection of smaller magnitudes of drought stress.

1340–1440

S04–P–110

EFFECTS OF WATER AND SALT STRESS ON ION AND WATER UPTAKE OF PROCESSING TOMATO GROWN IN SAND CULTURE

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The combined effect of increasing concentrations of NaCl in the irrigation water and deficit irrigation on yield, water uptake, fruit quality and fruit chemical composition was investigated in processing tomato (*Lycopersicon esculentum* Mill., hybrid HC01). The research was carried out in drainage lysimeters (1 m^2 x 0.7 m) filled with a coarse-textured soil (84.4% sand). Salinity treatments consisted of two NaCl concentrations in the irrigation water [0, and 0.25 (w/v) equivalent to electrical conductivities (ECw) of 0.5 and 4.4 $dS \cdot m^{-1}$, respectively]. Salinity treatments were factorially combined with two watering regimes obtained by irrigating at -45 (HW) and -70 kPa (LW) of soil water potential. Amounts of water applied at each irrigation event were such to reach soil water capacity and a moderate drainage in the sink. Treatments were initiated on June 11, after ensuring the establishment of the plantlets with a single irrigation with non-salinized water. The cumulative amount of water applied from the beginning of the growing season to harvest (August 3) was 340 mm for the HW treatment and 205 mm for the LW treatment. Tomato fruits were harvested on August 3. Water and salt stress affected negatively plant growth, yield and fruit mean weight. Increasing water salinity from 0.5 $dS \cdot m^{-1}$ (non-salinized control) to 4.4 $dS \cdot m^{-1}$ resulted in both reduced fruit size and fruit water content, whereas it caused an increase in soluble solids, sodium and chloride concentrations. Titratable acidity increased upon irrigation with saline water. In addition, salinity reduced, P, K, Mg and NO_3 fruit concentrations. Data show that it is possible to improve fruit quality of tomato, with an acceptable yield reduction, by irrigating with saline water containing NaCl up to 0.25% (w/v). A moderate salt stress also improved other desirable characteristics for the processed tomatoes industry without major yield reductions (i.e. TSS, low nitrate content and acidity, antioxidant activity). Deficit irrigation increased fruit quality in processing tomato, particularly by increasing fruit soluble solids levels, hexoses concentration, citric acid and potassium content. These results support the contention that deficit irrigation and irrigation with saline water may be feasible crop water management options for producing high quality tomatoes.

1340–1440

S04–P–111

RESPONSE OF TWELVE OLIVE CULTIVARS TO SODIUM CHLORIDE SALINITY

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The effects of NaCl salinity on growth and leaf Na and Cl concentration of 12 olive (*Olea europaea* L.) cultivars (Koroneiki, Mastoidis, Kalamata, Amphissis, Kothreiki, Megaritiki, Lianolia Kerkiras, Valanolia, Throubolia, Adramitini, Chodrolia Chalkidikis and Aguromanaki) were studied. One year-old plants were grown in 8.5 L pots, filled with sand-perlite mixture (1:3), for five months and were irrigated with half-strength Hoagland solution containing 0, 25, 50, 100 and 200 mM NaCl. The total plant leaf area was reduced significantly above 25 mm NaCl, ranging from 69% for Kalamata to 87% for Throubolia at 200 mM NaCl. The plant dry weight (root+shoot) was also reduced significantly above 50 mM NaCl, ranging from 8% for Kalamata to 77% for Throubolia at 200 mM. The above ground part of the plant was more depressed than the root by the increase of salinity in the rooting medium. The concentration of Na and Cl was higher in roots than the other parts of the plant (shoot and leaves) and increased with increasing salinity. In cvs Kalamata and Lianolia Kerkiras leaf Na and Cl concentration was very low for all salinity treatments indicating the existence of an inhibition mechanism at root level. Salt injury symptoms (leaf tip burning) appeared in most cultivars at 100 mM NaCl, becoming more severe at 200 mM due to defoliation. No injury symptoms were observed in cvs Kalamata and Lianolia Kerkiras. Our results showed that there are largre genotypic differences in salt tolerance between olive cultivars.

1340–1440

S04–P–112

ECOLOGICAL TOLERANCY OF FRUIT CROPS IN DIFFERENT CLIMATIC ZONES OF UKRAINE

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The Ukrainian system of ecological monitoring for horticultural plantations is in action since 1996. This network consists of 16 control points covering practically all the main agroecological zones (Carpathians, Marshy Scrub, Partially Wooded Steppe, Steppe, Crimea). The widely distributed in Ukraine cultivars of pip, stone, small fruit, and nuciferous crops are the objects of monitoring. The following indices are registered: 1) agrometeorological conditions (temperatures, humidity, precipitation, fog etc.); 2) agrotechnical conditions (soil types, irrigation, mineral and organic fertilizers, pesticides etc); 3) phytosanitary conditions

(pests, infectious and physiological diseases); 4) dangerous natural phenomena (extremal temperatures, heavy glazed frosts, autumn and spring frosts, droughts, dry and hot winds, heavy showers and hailstorms, soil over- and underflooding etc.); 5) technogenic influences (air, soil, and water contaminations); 6) phenological observations; 7) data about the yield. The monitoring data showed that the main losses in horticulture production during 1999-2000 were caused by spring frosts, which were on the soil surface from -0.5 till -11 °C at various regions of Ukraine. The level of damaging was following (%): pip 10-90, stone 20-100, small fruits 10-70, nuciferous 10-100 depending on a region and on a plant tolerancy. The varietal tolerancy of the main fruit crops was determined. An apple-tree turned out to be the most tolerant fruit crop under agroecological conditions of Ukraine. It takes 70% in total orchard structure. The catalogue of apple varieties that are the best for growing in different regions is formed on the basis of monitoring observations.

1340–1440

S04–P–113

EFFECTS OF DIFFERENT SODIUM CHLORIDE (NACL) CONCENTRATIONS ON THE IN VITRO GROWTH OF SOME STRAWBERRY CULTIVARS

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Meristems of cultivars Yalova-15, Yalova-416 and Tufts were cultured on basal MS and Boxes medium after surface disinfection with 0.5% sodium hypochlorite. Shoot proliferation and percentage survival were adversely affected by the addition of NaCl to the medium (0-240-440-640-840 and 1040 mg/L NaCl). The number of shoots and roots, length of root, height of plants and percentage survival (dead of plants) decreasing as the NaCl concentration increased in the range 0-1040 mg/L. Higher salt concentrations resulted in reduced growth or death of seedlings from all cultivars. Tufts plants showed higher salinity tolerance than those of Yalova-15 and Yalova-416.

1340–1440

S04–P–114

THE EFFECT OF WATER STRESS ON THE GROWTH CHARACTERS AND PLANT WATER RELATIONS IN YOUNG OLIVE PLANTS

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This research was conducted in two years in Dept. of Horticulture, Univ. of Tehran, Karaj on young olive plants to investigate the effect of available water on growth characteristics, Plant water relation and itís relation with physiological reactions. The research was carried out on split plot on the basis of complete randomized block design with three replications and three observations in each plot. In this study one year old plants of olive cultivars (Zard, Roghani, Mary, Fyshomi, Dezful and Shengeh), Planted in plastic pots on light media, Were selected and irrigated every other day for three months before treatment, In order to apply irrigation treatments, here treatments were selected (2, 6 and 12 days) and 2- day treatment was considered as control. The result indicated that vegetative growth, leaf water potential and leaf relative water content decrease when water is decreased. The cultivars showed significant differences when available water is decreased. The cultivars showed significant differences along with some vegetative characteristics such as leaf water potential and relative water content. Interaction between the irrigation on duration and cultivars were significant for ratio of dry root to shoot and leaf water potential (in the first year).

1440–1520

S04–O–115

CROP IMPROVEMENT AND PRODUCTION STRATEGIES IN ARID ENVIRONMENTS

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Environmental stress limits crop production and quality in arid zones due mainly to low osmotic potential caused by water and salinity stress or by ion toxicity. Optimization of crop production and quality for a given environment depends on our ability to control and regulate three major factors;1) soil environment with regard to water, minerals and aeration; 2) above ground environment with regard to leaf area index and light regime; and 3) reproductive to vegetative ratio and thereby crop load.The following topics will be discussed;a) Comprehensive use of micro irrigation and fertigation based on soil and plant water potential and mineral content measurements and analyses; b) Physiological effects of micro irrigation on root growth, PGR and crop production; c) Effect of crop load on fruit production and quality; and d) Cultural practices for crop production and quality under saline conditions. Exploring physiological mechanisms, enables utilization of recent advanced technologies for optimizing fruit production and quality under diverse environmental conditions. Further understanding of molecular mechanisms involved in plant response to environmental stress may result in increased production and in improved quality due to a better response to advanced cultural practices.

1520–1540

S04–O–116

STEM WATER CONTENT MEASUREMENT AS INDICATOR OF PLANT WATER STRESS FOR FRUIT TREES IRRIGATION SCHEDULING

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Several plant based measurements have been proposed as tools to schedule irrigation on fruit trees. Among others, leaf water potential, stem water potential and micromorphometric changes of plant stem have been referenced as possible indicators of plant water stress. Usage of plant or stem water potential, although very reliable are hindered because of lack of automation. Micromorphometric changes measured with automatic dendrometers, like Linear Variable Displacement Transducers, is probably the plant based measurement most often proposed although it has not yet gained wide practical acceptance due to the cost of the equipment and the difficulties of interpreting the provided data. Although it has had much lesser attention, another indicator of plant water status proposed has been stem water content (SWC). Several authors have shown long term changes in SWC according to physiological changes and soil water availability. However small in magnitude, there are just a few reports on short term changes of SWC or even diurnal changes following plant water relations linked to diurnal cycles of transpiration. Difficulties in direct measurement of SWC have prevented further utilization of this indicator. Gravimetry, Neutron probe, NMR, Time Domain Reflectometry and a diversity of different capacitive techniques, have been used to estimate SWC. Most promising are either TDR or capacitive techniques with the measurement of SWC through its relationship to dielectric constant.Experiments have been carried out in the last 4 years in adult 'Golden Delicious' apple trees potted on 100 L containers. These experiments were addressed to observe if there it was a relationship between dielectric constant and stem water potential, micromorphometric changes of stem diameter or transpiration, submitting the trees to different cycles of water stress and rehydration. Results will be presented and discussed on the light of a possible usage of SWC for irrigation scheduling of fruit trees.

1540–1600

S04–O–117

STEM WATER POTENTIAL GRADIENTS WITHIN PEACH TREES AS AFFECTED BY THE ROOTSTOCK VIGOUR

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Variation of stem water potential has been studied both in peach and nectarine trees grafted on rootstocks differing in vigour. In field grown Springcrest peach trees grafted on to Mr.S 2/5 and on to GF677 and potted Armking nectarine tree selfrooted, grafted on Mr. S 2/5 and on GF 677 was measured the variation of stem water potential along the tree at different transpiration levels. Sap flow by Heat Pulse Velocity method and high resolution (0.01 mmm) diameter changes by Linear Variable Differential Transformer transducers were measured. Trees on the weak rootstock Mr. S. 2/5 showed a lower stem water potential, trunk growth rate a lower sap flow. Results are discussed taking into account xylem idraulic archictecture parametres and morphological aspects of xylem vessels.

1600–1620
S04–O–118
WATER USE EFFICIENCY IN STONE FRUITS.

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In Italy the water used for agricultural purposes represents about 60% of its total consumption. A better utilization of this resource could provide high quantities of water for other uses, or an increase in irrigated lands. In order to maximize the use of water resources it is important to consider training system, plant architecture and particularly the distribution of light in the various parts of the canopy, as well as the irrigation system and its management. Water consumption is represented by the sum of evaporation from the soil and transpiration from the plant. Transpiration is related to leaf area, training system, ratio between exposed and shaded leaves, soil water content and ambient evaporative demand. A regards leaf area index (LAI), it varies considerably during the first 4-5 years after planting and depends on the vigour of the cultivar and rootstock, spacing between trees, training system and cultivation technique. The exposed leaves showed a WUE 3 up to 8 times higher than that of shaded ones. Shaded leaves consume 19% and 38% of the total transpired water respectively in apricot and kiwifruit during the day and, if we consider the night respiration, they do not contribute in any way to the energy balance of the whole plant. Shaded leaves are not a source but another sink for the plant and through an appropriate choice of canopy architecture and its correct management, in particular with summer pruning, it would be possible to improve the daily carbon balance and WUE. The technological innovation in irrigation have produced excellent results. In particular, micro and subirrigation have reached efficiency levels of 90–95% compared to the 50-60% of traditional methods.

1620–1640
S04–O–118–A
TO BE ANNOUNCED

1640–1700
S04–O–118–B
TO BE ANNOUNCED

Friday · August 16

0800–0900
S04–P–119
PLANTING DATE INFLUENCES GARLIC YIELD, BUT NOT TIME OF BULB DIFFERENTIATION

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In the 1999-2000 and 2000-2001 seasons, seven cultivars of stiffneck and softneck garlic (*Allium sativum* L.) were planted in Bozeman, Montana on a silty-loam soil at pH 7.5 and grown under clean cultivation. Three meter rows in each of three replications for each cultivar were set in Sept., Oct., and Nov. 1999 and April and May 2000 and again in Sept. and Oct. 2000 and april and May 2001. Time of bulb differentiation (mid-June) was influenced by neither planting date or cultivar. Yields and harvest dates were influenced by planting date in both years. Garlic planted in Sept. and Oct. was harvested earlier than those planted on later dates. Across cultivars, mean yield, number of bulbs harvested, and bulb diameter decreased with later planting dates. In both years 'Chesnok' and 'Inchellium' were two of the top three yielding cultivars, while 'Mild French', 'Spanish Roja', and 'Asian Tempest' had the lowest yields. 'Killarney Red' and 'Nootka Rose' had moderate yields in both years. The later in the fall that cloves were planted the greater the percentage of harvested bulbs graded rough, while the proportion of rough bulbs decreased with later planting in spring. Based on the results of this study 'Chesnok' and 'Inchellium' will be recommended for Sept. planting in southwest Montana.

0800–0900
S04–P–120
PHYSICAL MEASURES AND CARBOHYDRATE LEVELS OF PEAR FLOWER BUDS AND THE OCCURRENCE OF THEIR NECROSIS IN SOUTHERN BRAZIL

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The pear crop in southern Brazil, is limited by the flower bud abortion problem, specially in high fruit quality varieties, such as Bartlett, Packham's Triumph and Nijisseiki. This paper aims to report the any results of several studies developed in Brazil and in some other countries. Several factors have been suggested as involved in the phenomenon: winter temperature, physiological disturbance, nutrition and disease, etc. The period of occurrence of flower bud abortion is variable according to the cultivar, location and year. The lack of chilling has been pointed as the most important factor. In relation the nutricional aspects, the sugar contents, before blooming, varies with cultivar and local. With regard physical and morphological flower parts, in different locations, it has been observed some alterations, mainly in the number of floral primordia. The pruning of buds, in autumn, in Japanese cultivars, reduce the abortion.

0800–0900
S04–P–121
CHEMICAL TREATMENTS TO ENHANCE SEED GERMINATION IN PERIDERIDIA GAIRDNERI

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Perideridia gairdneri (Yampa), a native plant in the Apiaceae family, exhibits dormancy that inhibits seed germination. In 2001 we determined that yampa seeds need 4 to 5 months of moist stratification at 3 °C. Germination in this stratification treatment though was low. The objective this years study is to enhance germination of yampa using various chemical treatments. In September 2001, yampa seeds were collected from a population in the Bear River mountain range of Northern Utah. Tetrazolium tests were used on a portion of the seeds to assess viability. Viable seeds were graded, and then stratified in petri dishes on moist filter paper at 3 °C for 5 months. Seed treatments during stratification included controls and plus or minus various chemicals of different concentrations: KNO_3 at 0.01 M and 0.05 M, GA_3 at 0.03 mM and 0.30 mM, and Ethephon at 1.0 mM and 2.0 mM. Each treatment has 3 replications of 25 seeds. After the 5 month stratification treatment, seeds will be placed in a controlled 15 °C environment with germination observed daily. Germination percentage, rate, and uniformity for each treatment will be statistically assessed.

0900–0940
S04–O–122
MOLECULAR AND PHYSIOLOGICAL MECHANISMS OF DORMANCY REGULATION

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Dormancy can be defined as a developmental process involving a temporary suspension of visible growth of any plant structure containing a meristem. Dormancy is a survival mechanism assuring a seasonal synchronization of growth, but is also contributing to the control of plant architecture. Dormancy of seeds, bulbs and buds may certainly involve common metabolic processes, but there might also be fundamental differences due to the different roles of these organs. Knowledge of the molecular basis of dormancy is still scarce, but since it is associated with reduced rates of cell division, control of dormancy must at some level interact with the mechanisms of cell cycle regulation, which also involve hormonal signals. Several dormancy-associated genes have been identified, and some of them are involved in the regulation of cell division, some are hormone related, and others are involved in phytochrome responsiveness. In particular, the roles of hormones in different aspects of dormancy have been widely studied. Auxin and cytokinin are well known to be involved in

the regulation of dormancy of axillary and adventitious buds that is due to an inhibitory control by the shoot apex, but also other signals and factors apparently have important roles. In the seasonal cycles of growth and winter dormancy in perennial woody plants the light climate, particularly the day length, is a primary determinant acting through the phytochrome system. This is in turn interacting with gibberellin metabolism, but also abscisic acid is considered an important factor. Under conditions inducing winter dormancy communication between cells of the apical meristem ceases as a consequence of a breakdown of symplastic fields, and is re-established upon breakage of dormancy. The nature of the signals involved is unknown, but a role of hormones can be hypothesized. An overview of possible physiological and molecular mechanisms of dormancy regulation will be presented, emphasizing bud dormancy.

0940–1000
S04–O–123
TEMPERATURE EFFECTS ON RELEASING APPLE BUDS FROM DORMANCY

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The quantitative effect of various temperatures on the completion of endodormancy of apple buds was studied under controlled conditions. One-year-old containerized 'Golden Delicious' apple trees were placed in ten temperature-controlled dark chambers ranging from 0 to 200 °C for 1500 to 2400 hours. The trees were then forced at 230 °C and 16 h photoperiod for 40 days and percent of bud break was determined several times during that period. The highest level of vegetative bud break occurred at 0 to 2.50 °C; decreased slightly toward 7.50 °C and further decreased sharply toward 12.50 °C where no bud break occurred. Complete chilling negation was apparent at daily cyclic temperatures 200 °C/60 °C for 8/16 hours; 50% chill negation was apparent at 170 °C/60 °C for 8/16 hours and no chilling negation was found at 140 °C/60 °C. Compared to peach (Erez et al 1979), apple seems to respond more favorably to lower temperatures. Chilling optimum, threshold for chilling and start of chilling negation in apple were found at lower temperatures than with peach. An extremely strong apical dominance effect was noted with apple, interfering with the examination of chilling effect on lateral bud break. Earlier bud break of the terminals reduced very markedly lateral bud break. To unmask this effect, trees were laid during forcing horizontally preventing the developing of apical dominance. The strength of apical dominance seems to depend on light and temperature, under natural light regimes and lower spring forcing temperatures, weaker apical dominance having a smaller inhibition of lateral bud break was evident.

1000–1020
S04–O–124
INVESTIGATION OF THE EFFECTS OF THE LIGHT AND THE RAIN ON THE OVERCOMING OF DORMANCY IN SOME APPLE CULTIVARS

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In the temperate plants the overcoming of the dormancy is mainly determined by the temperature. However, some authors have noted that the intensity of the light and the rain can determine some influences. In fact bud burst can delay or advance in relation to the intensity of these to factors. In order to know better their actions and especially in which moment of the growing season they affect, meteorological data (temperature, intensity of light and rain) were collected, the times of bud burst of three apple cultivars (Golden Delicious, Morgendurf and Summered) were established during nine years (1992-2000) in Po valley (Italy). The temperatures were valued as Chilling Units by Richardson 's model. Light and rain data were accumulated in relation to the following periods: from the natural bud break up to the overcoming of dormancy, from the natural bud break and up to completed leaves fall, from completed leaves fall and up to the overcoming of dormancy, from October up to the overcoming of dormancy. The meteorological data were fitted with Chilling Units to know the correlation by uni-variate and multi-variate analysis. The analyses have shown that there are low negative correlations in all the cases except in the period from October up to the overcoming of dormancy, that are positive. The best result for the light in relation to Chilling Units is from completed leaves fall up to overcoming of dormancy and for the rain in relation to Chilling Units is from the bud break up to completed leaves fall. The multi-variate analysis of the three factors has showed that the interactions among Chilling Units, light and rain are higher when rain is heavy, the light is moderated and Chilling Units accumulated are low. There appears from this investigation that the rain and light can influence the overcoming of the dormancy when are linked to the temperature than alone.

1020–1040
S04–O–124–A
TO BE ANNOUNCED

1400–1420
S04–O–125
XANTHOPHYLL CYCLE POOL SIZE AND COMPOSITION IN RELATION TO NITROGEN CONTENT OF APPLE LEAVES

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It was shown previously that under high light non-photochemical quenching was up regulated to dissipate excessive excitation energy in apple leaves with low N status. The objective of this study was to determine xanthophyll cycle pool size and composition in response to N status and their relationships to nonphotochemical quenching in apple leaves. Bench-grafted Fuji/M.26 trees were fertigated with different N concentrations (0 to 20 mM) in a modified Hoagland's solution for 6 weeks to create a wide range of leaf N content (1 to 4.4 $g \cdot m^{-2}$). Both xanthophyll cycle pool size and chlorophyll content on a unit leaf area increased linearly with increasing leaf N. However, the ratio of the xanthophyll pool to chlorophyll was higher in low N leaves than in high N leaves. Under high light at midday, both zeaxanthin (Z) expressed on a chlorophyll basis and the percentage of the xanthophyll cycle pool present as Z (Z%) increased as leaf N decreased. Thermal dissipation of excitation energy, as indicated by nonphotochemical quenching of chlorophyll fluorescence, was positively related to, whereas efficiency of excitation transfer and photosystem II quantum efficiency were negatively related to, both Z on a chlorophyll basis and Z% in the xanthophyll cycle pool. These results are consistent with the hypothesis that xanthophyll cycle activity is enhanced in response to N limitation to dissipate excessive absorbed light under high light.

1420–1440
S04–O–126
CHARACTERIZING THE EVERGROWING PHENOTYPE IN PEACH

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'Evergrowing' peach is a mutant phenotype that exhibits a different growing pattern in winter than that of the wild type deciduous peach. In temperate locations, the terminal apices on evergrowing trees continue growing in winter until killed by low temperatures, whereas lateral buds become dormant. One single recessive gene (evg) controls this evergrowing trait. Three experiments were designed to characterize this evergrowing phenotype of peach. A grafting experiment confirmed that dormancy "signals" could not be transported from the dormant deciduous branches to the growing evergrowing branches on the same tree. Foliage spraying of STC, an ABA-like chemical, slightly inhibited new growth on evergrowing trees. Although this difference was not significant, it may indicate sensitivity to the exogenous ABA-like chemical treatment. Therefore, the evergrowing gene may not be an ABA insensitive mutant. Budbreak percentages in a decapitation experiment suggested a paradormancy condition for the lateral buds on evergreen trees. In this decapitation experiment, both the saturated and unsaturated fatty acids in the evergrowing terminal apices had different concentrations than those in the buds of deciduous trees. Considering the observed atypical concentrations of ABA and fatty acids in the buds and the continuous shoot growth in the terminal apices, evergrowing peach

may be a candidate model system for study of winter dormancy in woody plants.

1440–1500
S04–O–127
TEMPERATURE INFLUENCES BLIND NODE DEVELOPMENT IN PEACH

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Excessive blind node production is observed more frequently in the southern as compared to northern peach production areas. Although blind nodes may be mistaken as either bud drop (Weinberger, 1967) or bud failure (Malcolm, 1975), they are distinct since the buds in these cases develop fully before dropping. In the case of blind nodes, the buds are only initiated but never develop into mature buds (Boonprakob et al., 1996). The development of buds was followed throughout the season (March to October) on eight peach genotypes at 2 to 3 sites for each. The peach genotypes ranged in chilling requirement from 150 to 850 chilling units (CU) and the sites ranged in chilling accumulated from 200 to 900 CU. Correlation analysis was done between the percentage of blind nodes and relative growth intensity, node density, and average daily mean temperature. Blind nodes develop more readily under higher temperature conditions and during periods of less tree growth.

1500–1520
S04–O–128
STUDY OF ENVIRONMENTAL CHANGING EFFECTS AND INADEQUATE CHILLING ON SOME OF MORPHOLOGIC CHARACTERISTICS PISTACHIO TREES (IRANIAN CULTIVARS)

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A aerology data taken from kerman province, Iran have shown a temperature enhancement during current years, especially on winter's months. Pistachio trees have also shown some of signs reciving inadequate chilling requirement. In this research, environmental changing effects on some of morphologic characteristics were studied on following cultivars two different years (1997 and 2001). Early flowering cultivars: kalleh ghoochi, Sefid Pesteh Noogh, Italiaei, Khanjari; mid flowering cultivars: Ovhadi, Ahmad Aghaei, Momtaz, Amiri and late flowering cultivars: Akbari, Jandaghi, Ebrahimi, Shahpsand, and Fanoghi Riz. The results showed leaf area and the number of leaflets in major cultivars have reduced in 2001 compared to1997. In late flowering cultivars, this reduction was more noticeable than the early flowering cultivars. The number of abnormal leaves have also increased in major cultivars, but again more abnormal leaves were observed in late flowering cultivars.

1520–1540
S04–O–129
HEAT UNITS MAY EXPLAIN VARIATION IN DURATION OF BUD DORMANCY IN ZANTEDESCHIA

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Control of the growth cycle and, in particular, dormancy, is required if growers are to choose any time of year to produce flowering plants of Zantedeschia. In order to improve the predictability and accuracy of timing of dormancy in Zantedeschia, the effect of different planting seasons and cultivars were assessed using a heat unit model. Plants of cultivars 'Black Magic' and 'Treasure' were ex-flasked in July and November 1999, grown in a heated greenhouse, and sampled throughout growth. The change in production rate of both external and primordial structures were used as potential indicators of the onset of dormancy, as well as emergence data. Results of the current experiment were compared to those of two previous studies where the duration of dormancy was similarly quantified, but when grown under different environments and seasons. Plants grown out of season (July ex-flask date) in a heated greenhouse readily completed their growth cycle and exhibited some level of bud dormancy from November through to January/February. In contrast, plants ex-flasked in November exhibited dormancy from February through to April/May. When combined with previous studies dormancy collectively extended over seven calendar months (November to May), with no overlap in timing between plantings in different seasons. A heat unit model resulted in the wide differences in duration of dormancy largely disappearing. Using a base temperature of 2.1 ^{o}C, dormancy extended between 1466 and 3550 degree-days. While variation in the range of degree-days was evident between each planting date, season and cultivar, all exhibited dormancy between 2100 and 2747 degree-days. Cessation of leaf appearance was not found to be directly related to the occurrence of dormancy and, therefore, can't be recommended as a tool by growers to monitor the onset of dormancy. A heat unit model appears able to predict dormancy in Zantedeschia cultivars when grown in differing seasons and growing environments.

1540–1600
S04–O–130
MATERNAL CONTROL OF SEED DORMANCY BY TRANSCRIPTION FACTOR IN LETTUCE

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The DAG1 (Dof Affecting Germination) gene of Arabidopsis encodes a zinc finger transcription factor of the Dof family that is shown to control seed dormancy in Arabidopsis. DAG1 cDNA knockout mutant, dag1-1, produces seeds that are morphologically normal, nondormant, lack WT light requirement for germination, and maintain ABA sensitivity and GA requirement for germination. While dag1-1 mutant seeds germinate in the absence of light, exposure of the mutant to far red light inhibits germination indicating dag1-1 mutant seeds are still controlled by phytochrome-mediated pathway for germination. The expression of DAG1 is limited to the vascular tissue of the mother plant and segregation analysis results indicate that the mutant phenotype of the progeny is determined by mother plant genotype (Papi et al 2000. Genes Dev. 14:28-33). Light dormancy of lettuce is a common problem of producers that is usually alleviated by seed priming techniques. However, application of information gained in Arabidopsis research to lettuce may eliminate priming needs and provide useful insight to discerning the molecular mechanisms controlling seed dormancy. Because of its characterized photodormany and economical importance as a crop, lettuce has been selected as the model system to explore the role of DAG1 regulatory mechanism in seed germination. The study uses a combination of genomic, genetic, and molecular biological approaches to identify DAG1 homologue in lettuce. Database analysis and cDNA library screen or PCR will be used to detect the homologue followed by the characterization of temporal and spatial expression patterns. The long-term goal is to use genetic manipulation to alter the level of DAG1 homologue in lettuce to determine their effect on lettuce seed germination. Results of genomic analysis will be presented.