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**Symposium 13 (S13): Key Processes in the Growth & Cropping of Deciduous Fruit & Nut Trees**

**Monday · August 12**

**Location: Crowne Plaza Hotel, Ballroom B**

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**1100–1140**

**S13–0–1**

**ROOT RESPONSES TO LOCALIZED DROUGHT**

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While fruit crops are frequently irrigated to enhance fruit quality and quantity, there is a dearth of information on how various irrigation practices affect root growth and activity. We have conducted research in apple, citrus and grape on root responses to exposure to dry soil and responses following re-irrigation. In locally dry soil, root growth in all species seems to be restricted. Exposure to dry soil does not necessarily kill roots. In citrus and grape, for example, we have found little evidence that exposure to dry soil accelerates root mortality. In apple, results have been mixed. In some species, like citrus, roots rapidly recover fully in their capacity for water and phosphate uptake following re-irrigation. Similar work still needs evaluation in deciduous crop species. The implications of different responses of roots to dry soil and re-irrigation will be discussed.

**1140–1200**

**S13–0–2**

**EFFECT OF TIMING OF ROOT PRUNING AND ROOT IBA APPLICATION ON LEAF MINERAL CONCENTRATION AND CANOPY LIGHT INTERCEPTION OF 'COX'S ORANGE PIPPIN' APPLE TREES**

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The effects of timing of root pruning and application of IBA to roots of 15-year-old 'Cox's Orange Pippin'/M9 were investigated. The trees were maintained in a weed free strip and received overhead irrigation. The treatments applied were: 1 Control; 2 RP on 9 May (RP1); 3 RP on 29 June (RP2); 4 RP1 + 5000 ppm IBA, and 5 RP2 + 5000 ppm IBA. Root pruning was carried out by trenching and cutting (35 cm deep), 70 cm from the tree; trenches were refilled within 6 h. IBA was sprayed immediately after RP with a handheld sprayer. The experiment was a randomized complete block design with 7 replicates. RP1 (9 May) significantly reduced leaf N, K, and Ca concentrations measured on 4 June with respect to control treatment, while IBA had no significant effect. On 3 August, the main effect of both RP treatments was to significantly reduce leaf N, P and K concentrations. Trees that received RP2 treatment had significantly lower leaf Mg and Ca concentrations than those that received RP1. The mean area of mid-season growth leaves was significantly reduced by RP. For this variable, a significant interaction occurred between IBA application and RP timing; thus, IBA application decreased mean leaf area at RP1, but it had the opposite effect when applied at RP2. The effect of treatments on canopy development were indirectly established by measuring non-intercepted radiation through two visible radiation sensors placed on 21–29 June under each tree at 30 cm above ground level and 30 cm from tree trunk. Non-intercepted radiation was not affected by RP treatments when measured before RP2. Afterwards both RP treatments, as well as IBA application reduced canopy development. Finally, when radiation interception was measured again before harvest, only RP timing significantly affected this variable. Results will be discussed with respect to the interaction between roots, canopy development and tree nutrition.

**1200–1220**

**S13–0–3**

**NITROGEN- AND WATER-USE EFFICIENCY OF SWEET CHERRY (*PRUNUS AVIUM*, L.) CV. 'RAINIER' GROWN ON 'MAZZARD' AND ON 'GISELA' DWARFING ROOTSTOCKS**

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This research was initiated to determine if dwarfing rootstocks have an influence on water use efficiency (WUE) and/or nitrogen use efficiency (NUE) when compared to the standard rootstocks used in the industry. Plant demand for water and N can vary during the season and is strongly dependent upon weather conditions, soil moisture, stage of plant development, as well as crop load. The objectives of this research were: 1) to evaluate NUE and WUE at different phenological stages; 2) to evaluate carbon allocation and 3) to relate the influence of carbon allocation to the NUE. The results of which can be useful in the timing and application rate of water and N. We investigated the NUE and WUE of two dwarfing cherry rootstocks (Gisela 5 and 6) and compared them to a standard rootstock (Mazzard). NUE was determined using potted plants and mature trees in the field. This presentation will focus on young non-fruiting trees in pots. One-year-old trees of cv. "Rainier", grafted on Gi5, Gi6, and Mazzard, as well as, the three rootstocks without scions were potted in 12 L containers. The soil media was a mixture of 90% sand and 10% silt and clay media. During the growing season, 15N as KNO<sub>3</sub> was applied at different times to the trees. After a period of 10–15 days the trees were harvested. Total N, 15N percentage and mass of the trees (leaves, shoot, trunk and root), were measured. Results of the performance of the different rootstocks will be presented. Research findings will be valuable for determining the NUE of dwarfing cherry rootstocks and will give a better understanding of the best management practices to optimize their nitrogen and water use efficiency.

**1220–1240**

**S13–0–4**

**IRRIGATION VOLUMES RATHER THAN PLACEMENT DETERMINES RESPONSE OF APPLE TREES TO DEFICIT IRRIGATION**

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Partial Rootzone Drying (PRD) is a new deficit irrigation strategy that has recently been developed for grapevines in Australia. Since 1995, we have been evaluating the PRD strategy for apples. In initial experiments with apple varieties 'Gala' and 'Fuji' water savings of 30 % were achieved without detrimental effects on fruit size, fruit quality at harvest and after cold storage, and yield. In a 2-year study with 'Braeburn' apples in New Zealand the PRD technique was compared to two other types of water deficit. All deficit irrigation treatments were compared to a well-watered Control. Deficit treatments received 50 % of the irrigation volume applied to the Control, but differed in timing and/or placement of irrigation. Three further multi-year studies were initiated in the spring of 2001. Two studies were set up with 'Fuji' apples in Washington State, USA, and one study with 'Gala' apples in Colorado, USA. In each of those latter studies the PRD regime was compared to a well-watered Control and a season-long deficit regime (DI). Both, PRD and DI were irrigated at 50 % of the control's volume. In contrast to PRD, where only half the root zone was watered, the DI and Control treatments were irrigated over the full root zone. This paper presents the main results achieved with PRD on apples since 1995. Irrigation systems used in the various studies included micro-sprinkler, drip, and sub-surface drip irrigation. Results so far suggest very few differences between PRD and other forms of deficit irrigation when the same quantity of water is applied (but see Lombardini et al., abstract submitted to IHC 2002). Results also indicate that water savings of up to 50 % can be achieved without negative effects on fruit size, quality, and yield.

**1340–1440**

**S13–P–5**

**MINERAL NUTRITION AND THE GROWTH OF CHESTNUT TREES**

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All seven species of chestnuts (genus *Castanea*) and their hybrids are grown

in the north-eastern United States. Both timber and nut trees are being bred at the State Experiment Station in Connecticut. The minerals in natural and amended soil are being compared with those in leaf samples, and correlations sought with the growth of the trees. After two seasons, no significant differences can be seen in the growth of a test group of hybrid trees on three sites, even though available nutrients differ greatly. Calcium content of tissues has been suggested as a factor in chestnut resistance to the chestnut blight pathogen. Initial sampling showed that the soil which was pH 3.6 had 235 mg/kg calcium and leaves had 3841, at pH 4.5 soil also had 235 mg/kg but the leaves had 4975, and at pH 4.7 the soil had 767 mg/kg calcium and leaves had 10, 210.

**1340-1440**

**S13-P-6**

**SPRING GROWTH OF ALMOND NURSERY TREES DEPENDS UPON BOTH NITROGEN RESERVES AND SPRING NITROGEN APPLICATION**

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June-budded 'Nonpareil/Nemaguard' almond plants were fertigated with five nitrogen (N) concentrations (0, 5, 10, 15, and 20 mM) from July to September. The plants were sprayed with water or 3% urea in October, harvested after natural leaf fall, and stored at 20 °C. One set of plants were destructively sampled in January for N reserves (total N content), and the remaining plants were transplanted into a N-free medium in the spring after cold storage and supplied with N-free Hoagland solution or Hoagland solution containing 15N-NH<sub>4</sub>NO<sub>3</sub> for 70 days after budbreak. Fertigation and foliar urea applications altered N reserves of almond nursery plants. Plants fertigated with higher N concentrations had higher N reserves in both stem and root. Foliar urea application increased stem and root N at each given N fertigation concentration. Both N reserves and spring application of nitrogen were used during the growth of almond nursery plants in the spring. The amount nitrogen reserves used for new shoot and leaf growth depended on the total amount of N reserves. Plants with higher levels of N reserves used more of these reserves for new growth than plants with lower N reserves. Spring applied N used for new shoot and leaf growth depended on the total reserve nitrogen available. Trees with low levels of nitrogen reserves primarily used nitrogen from spring applied N for new shoot and leaf growth. Therefore, this study confirms the importance of both reserve nitrogen and spring applications of N for regrowth performance of almond nursery plants during establishment in the spring. Application of N in the spring can improve almond nursery tree performance, especially for the trees with low reserve N level.

**1340-1440**

**S13-P-7**

**EXPERIENCES WITH THE BIOREGULATOR PROHEXADIONE-CA USED IN APPLE AND PEAR ORCHARDS**

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Prohexadione-Ca is the active ingredient of a bioregulator registered under the trade name Regalis 10W in some European countries and, as Apogee in the USA. Prohexadione-Ca inhibits certain steps in the biosynthesis of gibberellins and it may transiently intervene in the phenylpropanoid metabolism. The induction of pathogen resistance by prohexadione-Ca is attributable, at least in part, to changes in the spectrum of flavonoids and other phenols in the treated plants. The experimental product BAS 125 10W (a.i.: 10% prohexadione-Ca) was used for testing its growth regulator potential and its activity in eliciting systemic acquired resistance (SAR) with special respect to fire blight. Trees of 7 hard cider apple cultivars in a young orchard (planted in 1997, on rootstock MM.106) were treated during 3 years at a range of concentrations (a.i.) from 55 ppm to 250 ppm, depending on the timing and number of treatments in a season. The considerable inhibition of shoot growth was highly significant in each year and in trees of all of the cultivars investigated. Decreases in the lengths, rather than in the numbers of internodes were responsible for the retarded shoot growth. Treatments carried out in 1998 and 1999 did not

influence flowering, fruit set and yield in the subsequent years. Treatments with the product also brought about significant changes in the growth characteristics of mature trees of the apple cv. 'Jonathan' and, occasionally, in shoot growth of some pear cultivars. The possible role of prohexadione-Ca in the management of fire blight was tested in two mature pear orchards (2000) and in a high-density young apple orchard (2001). In comparison with the checks (controls), the incidence of shoot blight in one of the pear orchards was significantly reduced by treatment with prohexadione-Ca. Prohexadione-Ca also proved to be more effective than benzoethiadiazole as Bion 50WG. Promising results concerning prevention of shoot blight were also recorded in young trees of apples 'Jonica', 'Jonagold deCosta', 'Sampion', 'Freedom' and 'Elstar'.

**1340-1440**

**S13-P-8**

**THE USE OF PROMALIN ON ONE-YEAR OLD APPLE TREES (CV CATARINA)**

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Apple culture has increased quickly in Southern Brazil over the last 20 years. Plant growth, yield and fruit quality are directly influenced by many factors related to environmental condition and orchard management. The non-bearing time must be as short as possible, and to aid in precocious cropping the availability of one-year old plant material with several lateral branches is of great importance. The trial reported here was carried out in a commercial nursery, in the region of Pelotas, Brazil, on the apple cv Catarina/Marubakaido. Promalin® (GA 4+7 + BA) was tested at four concentrations of: zero, 500, 1000 and 1500 mg·L<sup>-1</sup> with the objective of evaluating its effect on the production of lateral shoots (branches) in one-year-old nursery apple tree. Spray solutions were applied in the apical portions (40 cm) of the plants. After 160 days, branch length, number of developed buds, number buds/branch and trunk diameter were evaluated. The use of Promalin at the highest concentration increased the number of sprouted buds and promoted the production of trees with compact foliage, and with a reduction in branch length. We conclude that Promalin was effective in producing high quality trees.

**1340-1440**

**S13-P-9**

**PRUNING EFFECTS ON APICAL DOMINANCE AND YIELD OF PISTACHIO TREES**

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The experiment was conducted in the Kerman district of Iran to evaluate the effects of heading back, thinning out and pinching pruning on twenty-years-old Ohadi pistachio trees during "off" and "on" years. The trial evaluated the effects of the different treatments on the induction of lateral bud growth, number, length, diameter and angle of lateral branches in first year following treatment and effects on yields and related characters in the first and second years. A randomised complete block design of four replications was used. The results showed that heading back, especially heading back of the one-year-old shoots, significantly induced lateral shoot formation, but pinching and thinning out treatments were no different from the controls. Induction of lateral bud growth in "on" years was more than in "off" years, but the trees' reaction to heading back in "off" years was more than in "on" years. Heading back increased length and diameter growth rate of the induced branches in both "off" and "on" years, and decreased branch angles, but thinning out increased these parameters. Yields (fresh and dry weight) of one-year-old branches that were headed back were more than for the other treatments in the first year, but yields following the other treatments were lower than on controls. Heading back and thinning treatments decreased the blanking and increased the splitting percentages.

**1340-1440**

**S13-P-10**

**REDUCING SHOOT GROWTH AND SECONDARY BLOOM WITH PROHEXADIONE-CA ('APOGEE') FOR CONTROL OF VIGOR AND FIRE BLIGHT IN 'BARTLETT' PEAR**

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Fire-blight is a serious and costly problem for pear growers. Fire-blight organisms may invade Type I secondary flowers (arising from the ends of shoots) and young succulent shoot tips. We have had some success in reducing the incidence of late blooming Type I's and the occurrence of fire-blight with Apogee at 125 and 250 mL·L<sup>-1</sup>. Apogee (prohexadione calcium) retards growth by inhibiting the biosynthesis of gibberellin and may provide some resistance to fire-blight by altering the flavanoid metabolism of the infective agent, *Erwinia amylovora*. We have found that Apogee, that reduces shoot growth in 'Bartlett' pears in California, may be used to reduce the need for pruning and, therefore, may be a method for reducing Type V secondary blooms which arise at pruning sites during the growth season. Growing shoots are also a major site of fire-blight infection, and are difficult to control because the period of susceptibility is long. Reduction of shoot growth may reduce the number of fire-blight shoot infections by reducing in length the time period of new succulent growth. In our trials of 1999, 2000 and 2001 with 'Bartlett' pear, Apogee significantly reduced shoot growth with single or multiple sprays. Sprays applied 10 days after at petal fall (April 3, 1-2" new shoot growth) or on April 13 appeared effective. Later timings (April 27, May 3) were not as effective in controlling shoots that 'broke' at bloom. Apogee at 125 mL·L<sup>-1</sup> was as effective as 250 mL·L<sup>-1</sup>. Additional treatments to control subsequent flushes of shoot growth may be necessary as the activity of Apogee apparently dissipates within 2 to 3 weeks. Apogee has not affected fruit size or yield in the season of use, however, in the following season in preliminary trials we have seen increased flowering and increased or decreased production of Type I secondary flowering shoots. These and additional results as well as suggested spray strategies will be presented.

**1340-1440**

**S13-P-11**

**INVESTIGATION OF GRAFT COMPATIBILITY OF SOME TURKISH QUINCE ROOTSTOCKS (S.Ö.) USING PEROXIDASE ANALYSIS**

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Isozyme analysis is one of the recent methods used to predict graft incompatibility. 2 anodal isoperoxidases (Rf=0.88 and Rf=0.68) were determined as marker bands that could be associated with pear/quince graft incompatibility or compatibility in our previous works. This study was initiated to survey the graft compatibility characteristics of some Turkish clonal quince rootstocks called "S.Ö." using these isoperoxidase markers. These clones are selected according to yield, growth characteristic and graft compatibility using biochemical and anatomical analyses in previous works. Known compatible (Beurre Hardy) and incompatible (Bartlett) pear scions were grafted on QA and 13 S.Ö. quince clones by T budding. Bark tissues were collected from the union 4, 8 and 12 weeks after grafting. Bark tissues were also collected from unbudded rootstocks and current year shoots of the two pear scions. Samples were ground in liquid N<sub>2</sub> and stored in -80 °C until used. Isoperoxidase profiles of the samples were visualized by starch gel electrophoresis and some isoperoxidase bands that are associated with graft compatibility of the S.Ö. clonal quince rootstocks were determined.

**1340-1440**

**S13-P-12**

**BRANCH INDUCTION AS INFLUENCED BY APPLICATION TIMES AND FREQUENCY OF PLANT GROWTH REGULATOR APPLICATIONS TO 'FUJI' APPLE NURSERY TREES**

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The application of plant growth regulators (PGR) for promotion of feathering is one of the expensive operations in apple nursery tree production. In order to reduce application times of PGRs, 600 ppm 6-benzylaminopurine (BAP) or 2% Promalin were sprayed three times at 10-day intervals or twice at 15-day intervals to one-year-old 'Fuji' on M.9 T337 rootstocks. The effects of reduced applications were compared with those of controls, in which PGRs were applied four times at 7-day intervals. In a trial with BAP, induction of feathers was increased through more frequent applications at shorter intervals, namely 17.1 feathers with four applications, 13.6 with three, and 10.9 with two applications, respectively. In

a trial with Promalin, there was no significant difference in feathering between the three treatments, namely 15.6 feathers with four applications, 14.5 with three and 15 with 2 applications. The results suggest that application times could be reduced by Promalin treatment with longer intervals in 'Fuji' apple nursery production, but not when using BAP treatments.

**1340-1440**

**S13-P-13**

**MECHANISM OF IRON ABSORPTION BY APPLE TREES**

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Iron chlorosis is a worldwide physiological disorder affecting fruit trees, including apple, which has a severe impact on growth, production and fruit quality of tree fruits. Based on the results of 13 years research including studies relating to tree biology, anatomy, rhizosphere, physiology, and biochemistry, this article compares the differences of Fe-efficient or -inefficient genotypes of apple in iron absorption, and suggests the likely mechanism of iron absorption by apple trees.

**1340-1440**

**S13-P-14**

**LONG-TERM PERFORMANCE OF OWN-ROOTED 'CHANDLER' WALNUT COMPARED TO 'CHANDLER' WALNUT ON PARADOX ROOTSTOCK**

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Micropropagated ungrafted 'Chandler' walnut trees were compared to 'Chandler' trees conventionally grafted onto seedling Paradox rootstock in a trial planted in 1991. Micropropagated own-rooted English walnut cultivars may have potential in areas where commonly used rootstocks (*J. hindsii* and *J. hindsii* x *J. regia*) are undesirable because of cherry leafroll virus; they may also represent an economical alternative to conventionally propagated trees. From 1995 through 2000, own-rooted 'Chandler' had significantly greater trunk circumference and yield than did 'Chandler' on Paradox rootstock. In 1998, low vigor and dieback was observed on some own-rooted trees. Root samples taken from trees with dieback were negative for Phytophthora but positive for lesion nematode (*Pratylenchus vulnus*). Over the course of the trial, soil nematode populations on own-rooted trees were consistently higher ( $P = 0.05$ ) than on Paradox, while no significant differences were found among nematodes within roots. Nematodes were present in soil samples taken from all trees and from the roots of all but two Paradox trees. Despite growth problems due to lesion nematode on some trees, own-rooted 'Chandler' has continued to outperform 'Chandler' on Paradox rootstock. No crown gall infections have been found on own-rooted trees although six trees on Paradox rootstock have this disease. The commercial feasibility of growing 'Chandler' on its own roots is a possibility based on six years of cumulative yields.

**1340-1440**

**S13-P-15**

**THE EFFECT OF IBA ON THE CA<sup>2+</sup> ABSORPTION AND CA<sup>2+</sup>-ATPASE ULTRACYTOCHEMICAL LOCALIZATION IN APPLE ROOTS**

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The uptake rate of Ca<sup>2+</sup> and Ca<sup>2+</sup>-ATPase ultracytochemical localization were studied by using *Malus hupehensis* Rehd seedlings and pot-cultured two-year-old apple trees ('Starkrimson'/*Malus hupehensis* Rehd) after treatment with auxin. The results showed, 2,4-D, NAA and IBA all increased the numbers of new roots, but only IBA increased the calcium content in roots and leaves. IBA increased root activity and Ca<sup>2+</sup>-ATPase and Ca<sup>2+</sup> uptake rate. The effects were more obvious with Ca(NO<sub>2</sub>)<sub>2</sub> in combination. But Ca<sup>2+</sup> uptake rates were inhibited by 2,4-DNP, the metabolic inhibitor, and the inhibition degree was higher under low Ca<sup>2+</sup> concentrations (0 ~ 0.5mmol/L) than high Ca<sup>2+</sup> concentrations (0.5 ~ 5mmol/L). The Km and Imax and a ratio (Imax/Km) all increased, and the

inhibition degrees were higher in excised root than intact roots after roots were treated with IBA. The  $I_{max}$  and  $a$  ( $I_{max}/K_m$ ) increased but the  $K_m$  after spraying IBA on leaves. 2,4-DNP inhibited the effects of IBA on  $Ca^{2+}$  absorption.  $Ca^{2+}$ -ATPase was located on the cytoplasmic membrane and the vacuolar membrane. The activity of  $Ca^{2+}$ -ATPase on the cytoplasmic membrane was increased significantly after treating by IBA.

1340-1440

S13-P-16

#### THE SIGNALING CASCADES OF WATER LOSS TO ABSCISIC ACID ACCUMULATION IN APPLE ROOTS

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The early-response of roots to water loss and the signal transduction of water loss to abscisic acid (ABA) biosynthesis were studied by polyethylene glycol (PEG6000) treatments to apple rootstocks (*Malus hupehensis* Rehd) seedlings. The results show the ABA content, the active oxygen species (AOS) producing rate, the lipoxygenase (LOX) activity and the protein kinase (PK)/phosphatases (PP) activity all increase during water loss in apple roots. The increase of PK/PP activity is the earliest and of ABA content is the latest among these events. The antioxidant and inhibitor of LOX reduce the ABA accumulation during water loss. Both exogenous  $H_2O_2$  and soybean LOX are able to increase ABA content. The  $Ca^{2+}$  chelator (EGTA),  $Ca^{2+}$  channel and anion channel blockers and the inhibitor of PK all reduce the increment of ABA after water loss. The activity of LOX and PK increases after treatment by 1-10mmol/L  $H_2O_2$  and  $H_2O_2$  is able to increase the concentration of cytosol  $Ca^{2+}$  according to the ultracytochemical localization and X-ray microanalysis. ATP is able to increase the LOX activity in extraction; PK inhibitor reduces the increase. The activity of PK rises evidently after adding the purified LOX as substrate to the PK reaction solution, and the LOX activity rises too after adding the separated PK to LOX reaction solution. It suggests that the  $Ca^{2+}$ , anion channel, protein phosphorylation, active oxygen species and LOX are all involved in the ABA biosynthesis induced by water loss, and LOX may be a key enzyme in some conditions.

1340-1440

S13-P-17

#### THE INFLUENCE OF DRY MATTER PRODUCTION IN NURSERY STOCK OF COLUMNAR-TYPE AND NORMAL-TYPE APPLE TREES GRAFTED ON THE NEW DWARFING ROOTSTOCK JM7

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Dry matter production in 3-year nursery stock grafted on the new dwarfing rootstock JM7 was studied by using columnar-type apple trees, which have characteristics such as only a few lateral branches and short internodes, and normal-type cultivars 'McIntosh' and 'Fuji'. Comparing the tree growth characteristics, the tree height, tree width, total shoot length and shoot numbers of columnar-type trees were fewer than those of normal-type trees. Total integrated solar radiation per leaf of columnar-type trees was lower than that of normal-type trees because columnar-type trees had short internode and wide leaf area per branch. Dry matter production per tree of 'McIntosh' and 'Fuji' were 526 g and 785 g respectively, and that of 'Wijcik', '8H-9-1' and '8S-60-74' were 203 g, 355 g and 223 g, respectively. So, dry matter production per columnar-type tree was definitely lower than that of normal type trees. In regard to the organic assimilate partitioning rate, it was lower for branches and higher for leaves and root (<2 mm) of columnar-type trees than for normal-type trees. It was considered that light interception per leaf and dry matter production in nursery stock of columnar-type trees grafted on JM7 rootstock was lower than that of normal-type trees grafted on the same rootstock.

1340-1440

S13-P-18

#### EFFECTS OF ROOT PRUNING AND SUPPLEMENTAL IRRIGATION ON NET CARBON EXCHANGE, TRANSPIRATION AND WATER RELATIONS OF PEACH

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Field studies were conducted at the Horticulture Research Center in Carbondale, IL in 1998, 1999 and 2000 to evaluate the effects of root pruning and supplemental irrigation on net carbon exchange (NCE), transpiration (E) and leaf water potential (j) of mature 'Loring'/Lovell peach trees. Trees were root pruned parallel to the row, 60 cm from the center of the trunk on both sides to a depth of 30 cm at petal fall (PF), 3 weeks after petal fall (PF+3 wk), 6 weeks after petal (PF+6 wk) or not root pruned. Half of the trees were provided with supplemental irrigation at the beginning of stage III of fruit growth. NCE and E were measured twice: 1) beginning of stage III of fruit growth, and 2) after fruits were removed from the trees. Leaf water potential (j) was measured once a season during stage III of fruit growth (1997, 1999) and after harvest (1998), in two instances during the course of the day (pre-dawn and mid-day). Root pruning time and supplemental irrigation interaction did not show a trend response for NCE when measured at stage III or after harvest in 1998, 1999 or 2000. Date of root pruning or supplemental irrigation did not affect NCE at stage III or after harvest in any of the years. In 1999, E during stage III of fruit growth increased by 100%, 120% and 110% for PF, PF+3wk and PF+6wk root pruning treatments, respectively. After harvest in 1998, E increased by 91% for PF root pruning treatment and was reduced by 10% and 7% by the PF+3 wk and PF+6 wk root pruning treatments, respectively. In 1997, jpre-dawn fit a linear trend response to the interaction between the date of root pruning and supplemental irrigation ( $P < 0.0532$ ), and the date root pruning increased the jpre-dawn. In 1997, supplemental irrigation increased jmid-day. In 1998, jpre-dawn fit a quadratic trend response to the timing of root pruning ( $P < 0.0948$ ). In 1999, supplemental irrigation decreased jpre-dawn ( $P < 0.0576$ ).

1340-1440

S13-P-19

#### EFFECTS OF IRRIGATION METHODS ON APRICOT GROWTH AND FRUITING

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Drip irrigation is an approach to watering that is growing in popularity. There are many advantages inherent in a drip irrigation system, including the reduction of water usage by almost 50%. Dobrogea is a very dry area, localised in south-east of Romania where orchards need irrigation. This study was carried out to obtain more information regarding the behaviour of apricot in response to localised irrigation. The biological material used was three cultivars from the new Romanian selections (Tudor, N.J.A.42 and Traian). Drip and microsprinkler irrigation regimes were evaluated between 1999-2001, soil samples were taken from the soil profile irrigated during different periods to determine the soil humidity. Vegetative growth and quality production of apricot, by physical and chemical analyses was also determined. The production of fruits and total growth has been significantly increased by irrigated variants, with the biggest production in the V2 dripper irrigation and the V3 microsprinkler irrigation.

1340-1440

S13-P-20

#### USE OF SOIL MICROORGANISMS AND DIFFERENT FERTILISATION TIMING AS NEW TOOLS TO REDUCE CHEMICAL INPUTS INTO PEACH ORCHARDS

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Peach orchard integrated production requires a reduction in the inputs of fertilisers. Exploitation of soil microorganisms or modification of fertilisation timing can facilitate the achievement of this objective. A mixture of mycorrhizal fungi and rhizosphere bacteria (500 g/tree, MMB) and a split distribution of N (24 g N/tree, spring and post-harvest) were tested in comparison to spring N distribution on a nectarine orchard. Rate of root mycorrhization was assessed in two periods, (June and October). Leaf photosynthetic rate was recorded using a CIRAS auto IRGA, measuring a/q curves on different leaves. Leaf N mineral content was determined by the Kjeldahl method. Fruit were harvested twice, according to commercial picking standards. Fruit mass and firmness, total soluble solids content

and acidity were determined on a 30-fruit sample. All determinations were recorded for two years. Percentage of root colonization by mycorrhizal fungi was comparable among all the treatments in early summer, whilst it increased in MMB samples at the end of the vegetative season. Leaf N content was lower in the MMB treatment. Photosynthetic maximum rate was higher in sun leaves from MMB treated trees. No differences were observed concerning tree growth, yield and average fruit weight. Comparable fruit quality parameters were measured among all treatments. In our conditions, both the timing of N availability and the treatment with MMB did not affect plant growth or fruit mass and quality. We hypothesise that in the case of MMB the amount of nitrogen required by trees was provided by enhanced microbial activity. These preliminary results show that split N distribution could be used as a tool in the management of nitrogen fertilization, for the reduction of N-leaching. The possibility of reduction of the chemical input in the peach orchard by using soil micro-organisms seems promising and could open new perspectives for cultivation in integrated orchards.

1340-1440

S13-P-21

#### THE IMPACT OF SUMMER PRUNING ON FLOWER BUDS METABOLISM IN THE DORMANT PERIOD

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The high commercial value of apricot fruits has proved to be a strong stimulus for research and development on the cultivation and profitable production of the crop. The climatic conditions in Romania are favourable for apricot culture and the country has areas with differences in climatic conditions. One of the factors restricting apricot culture is the short biological rest period which is completed in late November or early December. This situation stimulated the start of vegetative growth as well as early flowering. The aim of summer pruning at different stages of the vegetative period has been to induce delayed flowering. The biological material used was 'Selena', 'Sirena' and 'Mamaia' grafted on *Armeniaca vulgaris*, the trees being trained as bush-vases at planting distances of 4 x 3 m. The summer pruning was applied at three different timings during the vegetative season, corresponding to incipient growth (V1-15.05), intense growth (V2-30.05) and slower growth (V3-21.06) of annual shoots and consisted of cutting back to 5-7 leaves from the base of all the annual shoots. The pruning in control trees was applied after harvesting (2.08). In autumn, the axillary growths below pruning cuts were marked on each tree and bloom was determined. Axillary growths and buds were analysed for: -respiration intensity; -peroxidase and catalase activity; -the dynamics of starch; -the vitality of buds; and -morpho-anatomical aspects of flower buds. Buds in the control had a high vitality and intense metabolic activity resulting from an advanced degree of differentiation. Weak metabolic activity was observed in V3 and V2, correlated with a late differentiation of flower buds.

1340-1440

S13-P-22

#### HYDRAULIC CONDUCTIVITY OF PEACH CULTIVARS AS AFFECTED BY NANKING CHERRY (*PRUNUS TOMENTOSA*) ROOTSTOCK

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Dwarf peach trees grafted on Nanking cherry produce fruit with better size and quality, but they sometimes show serious incompatibility. Growth of 4 peach cultivars, 'Beni-shimizu', 'Hakuho', 'Shimizu-hakuto' and 'Hakuto' grafted on 'Ohatsu' seedling, a wild strain of peach and on 8 clones of Nanking cherry propagated by cutting was investigated in 1998. For the scions, the stem growth of 'Hakuho' and 'Shimizu-hakuto' exceeded that of 'Hakuto'. For the rootstocks, 'Ohatsu' showed the largest growth, followed by clones '5-6' and '15-8' (*P. tomentosa*); '5-10' showed the smallest growth with fissure symptoms where grafted. Hydraulic conductivity expressed as resistant rate of sap flow (sec/mL/cm<sup>2</sup>) was measured by the pressure chamber method. The 5 mm-long segments, including a part of the grafts, were set in a chamber, and the basal parts were immersed in a dye solution. The apical part was connected to a graduated pipette, which protruded outside the chamber. Then, the flow rate was counted under continuous pressure of 0.2 MPa after flushing to exclude emboli. The resistant rate of flow greatly differed, as much as 100 times among the different segments. A negative correlation of  $r = -0.819$  ( $n = 23$ ) was observed between the mean stem

length and their resistant rate of flow. One-year shoot growth was measured in 2000 using another 226 trees of compatible 'Hakuho' and 'Beni-shimizu', less compatible 'Tennyu', and incompatible 'Shuho' grafted on 3 clones of Nanking cherry. Some of these same combinations were replanted in clay pots. The sap flow rates during water stress and its recovery after watering were measured by the heat balance method and the resistant rates of their stem segments were also measured. The trees with better growth showed higher rates of sap flow at midday and after re-watering. There were significant correlations of  $r = 0.784$  ( $n = 14$ ) and  $r = -0.780$  between the mean shoot length and the recovery rate of sap flow just before and 3 hours after re-watering, and the hydraulic conductivity of the stem segment, respectively.

1340-1440

S13-P-23

#### FEATHERING INDUCTION IN SWEET CHERRY (*PRUNUS AVIUM* L.) BY LEAF DEFOLIATION AND CYTOKININ FOLIAR APPLICATION IN THE NURSERY

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The growth of axillary meristems into sylleptic shoots is supposed to be controlled by the apical meristem. Nevertheless, cherry shoot pinching allows the release of an inconstant number of laterals with different behavior in relation to main shoot growth rate, dimension of the pinched portion, seasonal climate conditions, and variety to rootstock interaction. As a result, scion quality is negatively affected by shoot pinching because of the absence of a well shaped central leader, and by the irregular growth of laterals which may be low in number and grow too upright and vigorous; thus with low suitability for high density planting systems. Growth regulators seem to have an even lower reliability for use in the cherry nursery. In the present work, apical leaflet removal was utilized to avoid apical pinching, together with apical foliar application of cytokinins. The following cherry varieties: 'Kordia', 'Celeste', 'Summit' and 'Sunburst', budded onto Gisela 5, Colt, and Mazzard rootstocks, were treated during the first growing season after budding in the nursery. The very positive results indicate that lateral feathering may be highly improved in cherry, using apical leaflet removal and low doses of cytokinins. Lateral shoots, with low vigor and wide branching angles, were formed in numbers of 3 to 6 per plant, consistently. This very powerful technique allows nurserymen to control scion quality in the nursery and to produce 1-year-old well-feathered plants for spindle training in high density cherry orchards.

1340-1440

S13-P-24

#### CHANGES OF NITROGEN ACCUMULATION AND NITRATE REDUCTASE ACTIVITIES UNDER PROLONGED DARKNESS IN THE SEEDLING OF JAPANESE PEAR

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Japanese pear (*Pyrus pyrifolia* Nakai) is very sensitive to nitrogen, thus a little too high amount of nitrogen can induce various physiological disorders. In order to understand the nitrogen metabolism in Japanese pear, we investigated the nitrate reductase activities (NRA) in seedlings of pear under prolonged darkness with the addition of soluble carbohydrates to the nitrate reductase assay medium. In leaves, total nitrogen content and reduced nitrogen were slightly changed with different periods of darkness. In contrast, nitrate content increased up to 36 hr and decreased thereafter. A similar pattern appeared in stems as well as in roots. In darkness, a change of chlorophyll content coincided with a change of nitrate concentration in leaves. It suggests that the nitrates could accumulate in the leaves in Japanese pear without light and photosynthesis assimilates. However, in leaves at 24 hr darkness NRA decreased to one-fifth of that at 0 hr of darkness, in stem at 12 hr to one third, but in root the reduction in NRA was slower than in other tissues. It suggests that light and the assimilates of photosynthesis are required for NRA in Japanese pear. Therefore, the NRA proportionally increased with increasing concentration of soluble carbohydrates added. It appears that there are other possible factors than NRA responsible for the nitrate increase under prolonged darkness in Japanese pear.

1340-1440

S13-P-25

**CHARACTERIZATION OF GRAFT UNION DEVELOPMENT IN SWEET CHERRIES (*PRUNUS AVIUM* L.) ON DWARFING ROOTSTOCKS**Mercy Olmstead\*<sup>1</sup>, N. Suzanne Lang<sup>1</sup>, Gregory Lang<sup>1</sup>, Shirley Owens<sup>2</sup>, Frank Ewers<sup>3</sup><sup>1</sup>Dept. of Horticulture Michigan State Univ. East Lansing, MI 48824; <sup>2</sup>Center for Advanced Microscopy Michigan State Univ. East Lansing, MI 48824; <sup>3</sup>Dept. of Plant Biology Michigan State Univ. East Lansing, MI 48824-1312

Interspecific hybrid rootstocks for sweet cherries (*Prunus avium* L.) have been introduced to reduce plant height and increase productivity. Mechanisms of dwarfing in sweet cherry are not well understood, thus best management practices are difficult to delineate for all rootstock/scion combinations. Historical work on apples (*Malus* spp.), citrus (*Citrus* spp.), and some *Prunus* species, indicate possible mechanisms: graft incompatibility; presence of virus; incomplete formation of vascular elements during healing of graft wounds; and hormonal or phenolic interactions between scion and rootstock. Thirty-six trees were bud-grafted using 'Rainier' (scion) on Gisela 5 (dwarfing), Gisela 6 (semi-dwarfing), and Colt (non-dwarfing) rootstocks in late August 2001. Heterografts were prepared in three combinations: 'Rainier' x 'Colt', 'Rainier' x 'Gi 6', and 'Rainier' x 'Gi 5'. Homografts (rootstock bud-grafted on rootstock) were also used to include variation due to wounding effects of grafting. These were: 'Colt' x 'Colt', 'Gi 6' x 'Gi 6', and 'Gi 5' x 'Gi 5'. Six of each combination (hetero- and homograft) were double-budded to ensure success. Graft unions were harvested monthly beginning one month after bud-grafting to investigate vascular connections and surface features within the graft union. Graft unions were sectioned into 20 mm sections with a sliding microtome and stained with three stains (safranin, fast green and aniline blue). A laser confocal microscope (Zeiss 210) and scanning electron microscope were used to characterize tissue details, including calcium oxalate formation in the functioning phloem. Callus formation around the wounding site was visible two weeks after bud-grafting. Safranin and fast green stains allowed visualization of xylem elements, whereas aniline blue allowed visualization of callose plugs in sieve tube cells indicating non-functioning phloem. Tissue details of graft union sections will be detailed in the presentation.

1340-1440

S13-P-26

**OSCILLATORY BUD DORMANCY AND SHOOT GROWTH DYNAMICS IN PEACH**

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Shoot growth dynamics varies with species and climates, under the influence of dormancy and positional hierarchies. The inhibition of cell elongation of the primary meristem, under favorable conditions, is considered an index that represents well dormancy and its intensity. The analysis of such a dormancy shows its own dynamics, decreasing with time and along the shoot axis with a minimum in the apex. It also shows the existence of oscillations in time along the axes, an event that may interact with cold in changing spring growth.

1340-1440

S13-P-27

**GUM INDUCTION BY METHYL JASMONATE IN FRUITS, STEMS AND PETIOLES OF *PRUNUS DOMESTICA* L.**M. Saniewski\*<sup>1</sup>, J. Ueda<sup>2</sup>, K. Miyamoto<sup>2</sup>Research Institute of Pomology and Floriculture, 96-100 Skierniewice, Poland<sup>1</sup>;<sup>2</sup>College of Integrated Arts and Sciences, Osaka Prefecture Univ., 1-1 Gakuencho, Sakai, Osaka 599-8531, Japan

Ethylene or ethylene-releasing compounds (i.e. ethephon) applied exogenously also stimulate gum formation in stone-fruit trees and their fruits (members of the Rosaceae), including *Prunus domestica* L. We investigated the effect of methyl jasmonate (JA-Me) on gummosis in *Prunus domestica* L. In our studies made in Japan it was found that methyl jasmonate (JA-Me) applied exogenously at concentrations of 0.5 and 1.0% in lanolin paste induced gummosis in green fruits at different stages of ripening, in current growing and older stems, petioles and the main midrib of *P. domestica*. JA-Me applied simultaneously with ethephon syn-

ergistically induced gummosis in stem, petioles and main midrib. Experiments using different inhibitors of jasmonic acid simultaneously with ethephon, and ethylene biosynthesis inhibitors simultaneously with JA-Me, and those examining the chemical composition of polysaccharides (after hydrolysis) in gums of *P. domestica* induced by JA-Me compared with those induced by ethephon and their mixtures, and naturally occurring ones will be also presented.

1340-1440

S13-P-28

**LATE SEASON LEAF GAS EXCHANGES OF THREE YOUNG CHERRY CULTIVARS GROWING ON FIVE ROOTSTOCKS**Alberto Santos\*<sup>1</sup>, Moutinho-Pereira<sup>2</sup><sup>1</sup>Agronomy Dept. Univ. of Trás-os-Montes e Alto Douro Ap. 202, 5001-911 Vila Real, Portugal; <sup>2</sup>Biological and Environmental Eng. Dept. Univ. of Trás-os-Montes e Alto Douro Ap. 202, 5000-911 Vila Real, Portugal

Two three-year old cherry trees of each of the cultivars 'Burlat' (Bu), 'Van' (Va) and 'Summit' (Su) on each of the rootstocks 'Edabriz'(Edb), 'Gisela 5' (Gsl) 'Maxma 14' (Mx), 'Cab 11E' (Cab) and *Prunus avium* (Pav) were selected to establish a randomized complete bloc design. The objective was to evaluate the rootstock and cultivar effects on plant leaf gas exchanges near the end of the growing season (September 4th), on a sunny day. Measurements were carried out using an IRGA, type LCA-3, ADC. The inter-row distance in the trial is 5 m apart and in-row spacings vary according to the relative vigour of the rootstock. The plants of each rootstock/cultivar combination were measured 14 times during the diurnal period, and the data were submitted to a two-way analysis of variance, and the contribution of each factor to the global variation calculated. 'Summit' cultivar was the most active relatively to net CO<sub>2</sub> assimilation, stomatal conductance and transpiration rate, but its intrinsic water use efficiency was lower than that of the others. Concerning the rootstocks, two groups could be identified as different (Pav-Mx-Cab and Gsl-Edb), the first one being the most active. The interactions Bu\*Pav and Su\*Pav were the most active on the first week of September, and the lowest CO<sub>2</sub> assimilation rates were observed on Van cultivar when growing on the dwarfing rootstocks, Gisela 5 and Edabriz.

1340-1440

S13-P-29

**EFFECT OF NURSERY TREATMENTS ON APPLE TREE GROWTH, YIELD AND PRUNING COSTS**Alberto Santos\*<sup>1</sup>, Filipa Queirós<sup>3</sup>, Rogério de Castro<sup>3</sup><sup>1</sup>Agronomy Dept. Univ. of Trás-os-Montes e Alto Douro Ap. 202, 5001-911 Vila Real, Portugal; <sup>2</sup>Crop Science Dept. Escola Superior Agrária - Instit.Polit. Bragança 5301-855 Bragança, Portugal; <sup>3</sup>Animal and Crop Science Dept. ISA - Univ. Técnica de Lisboa 1349-017 Lisboa Portugal

This study covers the period from nursery to late production phase of the apple cultivars Golden Delicious and Granny Smith on MM.106 and M.9 rootstocks. Cultivars were budded at three heights from ground level on intact liners or headed-back more or less severely at nursery planting, resulting in a budding-point either on one-year ('old') or on current-year ('new') tissue. 'Golden Delicious' grew more vigorously than 'Granny Smith', and also required more time for pruning, whether on M.9 or on MM.106, but it bore less fruit on M.9. On this rootstock a strong direct relationship was noticed between budding height and a reduction in yield and trunk diameter, as well as the time required to prune each tree, particularly with 'Granny Smith'. However, this relationship was not observed in MM.106, on which rootstock the high-budded trees grew and yielded a higher total crop, and also took longer to prune. Tissue age at budding point also had a lasting and definite influence on the behaviour of both cultivars on MM.106, with budding on 'old' tissue causing reduced growth, production and pruning time. On M.9, the least growth was observed when budding high with 'Golden Delicious' on 'old' tissues and with 'Granny Smith' on 'new' tissues.

1340-1440

S13-P-30

**THE RESPONSE OF APPLE ROOTSTOCKS P 22, M.9 AND M.26, AND APPLE TREE VARIETIES 'JONAGOLD' AND 'GALA', TO SOIL ACIDIFICATION**Lidia Sas Paszt\*<sup>1</sup>, Stanisław Mercik<sup>2</sup><sup>1</sup>Research Institute of Pomology and Floriculture Pomologiczna 18 96-100

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Acidification of Polish soils is a progressive process, both in terms of decreasing pH values and the size of areas covered by soils recognized as acidic and very acidic (more than 60% of soils under cultivation). Considering very unfavourable effects of strong acidification on soil and plants, these studies were aimed at determining the level of tolerance of apple rootstocks and apple tree varieties to soil acidification. Soil acidification to pH 3.6 strongly reduced growth of apple rootstocks in comparison to pH 4.6 and 6.0. Among the examined apple rootstocks, P 22 was the most tolerant to strong soil acidification. Lower level of tolerance was shown by M.9 and the lowest by M.26. The sensitive M.26 rootstock contained high concentrations of Al, Fe and Zn in the roots whereas the shoots contained high concentrations of Mn and low concentrations of macroelements. The leaves of apple rootstocks grown on the most acidic soil contained the highest concentrations of Al, Mn and Zn and low levels of Ca and P. However, the reverse was obtained on soils having pH 6.0. In the trees of both apple cultivars, the number of lateral shoots, the sum of shoot length as well as the height and diameter of leaders increased with an increase in pH from 3.7 to 5.0. Further increase to pH 6.4 did not affect the above-mentioned growth parameters of the trees. Both 'Jonagold' and 'Gala' budded on P 22 rootstock had the highest number of flowers and fruitlets, less on M.9 and the lowest on M.26.

**1340-1440**

**S13-P-31**

**STRUCTURAL DEVELOPMENT OF BRANCHES OF "ROYAL GALA" APPLE GRAFTED ON DIFFERENT ROOTSTOCK/INTERSTOCK COMBINATIONS**

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The architecture of 3-year-old branches of 'Royal Gala' apple grafted on different rootstock/interstock combinations of M9 and M106 and grown with minimal pruning was studied. Structure of the branches was described in terms of annual shoots (A1, A2, A3) consisting of growth units (GU). Three types of GU were distinguished: vegetative unit with internode extension (U), vegetative spur with minimal internode extension and fruiting spur or bourse. A1 annual shoots in all treatments were monopodial and mostly comprised two extension units. Number of extension units per annual shoot A had dramatically decreased over subsequent years while number of fruiting and vegetative spurs per A had increased. Rootstock/interstock combinations did not affect this composition of annual shoots changing over the years. Total number of annual shoots (A2 and A3) per branch markedly decreased with decreasing vigour of the rootstock/interstock combination (M106/M106>M106/M9>M9/M106>M9/M9). Number of nodes per U was similar in all treatments during the first year of development. In subsequent years this number had decreased and was affected by the vigour of the rootstock/interstock combination. Finally, the composition of annual shoots was not affected by the rootstock/interstock combinations, while the number of shoots per branch and the number of nodes per U in years 2 and 3 decreased with decreasing vigour of the rootstock/interstock combination.

**1340-1440**

**S13-P-32**

**SIZE-CONTROLLING APPLE ROOTSTOCKS FOR FINLAND**

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The rootstocks used for apple production in Finland are the clonal rootstocks YP and A2, and Antonovka seedlings, which all are vigorous. The dwarfing rootstocks tested until now have not been sufficiently winter-hardy. M.26 is used to some extent in the southernmost apple production area, but the hardness is inadequate for widespread cultivation. The cultivation trial consisted of 52 breeding selections and two cultivars. Amongst these rootstocks 25 selections were progenies from the cross YP x M.26, and 27 from the cross YP x M.27. There were three replications, and the total number of trees was 412, from which 234 with 'Lobo' and 178 with 'Samo'. Cv. Lobo was planted in 1985 and Samo one year later. Three size-controlling rootstocks were released in 1997. The rootstocks originate from crosses between hardy and vigorous YP (*Malus baccata* (L.) Borgh. op.) and M.26 and M.27. The size of Lobo trees on MTT1 has been 40 % of YP or seedling rootstocks. MTT2 and MTT3 grow more vigorously and the tree size has been 50-55 %. The cropping capacity of the rootstocks has been good. The rootstocks anchor well, and the trees do not require support. The winter-hardiness is good. The size-controlling effects of the rootstocks appeared more clearly, when the trees growing on them reached the cropping age, about 3-4 years after the planting. In the first years, the young trees on different rootstocks grew very similarly, and there were no remarkable differences in the annual shoot growth, or in the trunk growth between rootstock clones. The rootstocks are now virus free and micropropagated. The named rootstocks and some other size-controlling breeding selections are in further trials in commercial orchards.

**1340-1440**

**S13-P-33**

**CHARACTERISTICS OF THE RESPIRATION CHAIN IN RELATION TO FLOODING TOLERANCE IN PEAR ROOTSTOCKS**

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To estimate flooding tolerance of several pear rootstocks, shoot and fruit growth, leaf water potential and root activity were measured under experimental flooding conditions. Two strains of *Pyrus calleryana* (P. c), No. 6 and No. 8, were most tolerant to flooding, followed by *P. betulaeifolia*, strains U and N, and P. c, No. 4, No. 7 and No. 10. *P. dimorphophylla*, *P. pyrifolia* (P. p), *P. pyrifolia* x *betulaeifolia* (P. p x b) and *P. pyrifolia* x *calleryana* were not tolerant to flooding. The effects of flooding on ethanol production and cyanide-insensitive respiration of the pear rootstocks were studied. Ethanol content increased in the roots with no significant difference among the rootstocks during flooding treatment, whereas ADH activity in P. c, No. 6 and No. 8 was three times higher than that in P. p x b and P. p. Roots of P. c, No. 6 and No. 8 seemed to secrete ethanol into the soil. The level of cyanide-insensitive respiration of the roots was increased by flooding in P. c, No. 6 and No. 8, but not in P. p x b and P. p. When HCN evolution from the root of the pear rootstocks was determined by treating them with N2 gas and NaN3 solution, roots of the plants evolved the same level of HCN. Change in the density of mitochondrial particles in the pear roots was measured before and after flooding treatment. No apparent change was detected in the density of mitochondrial particles (Fraction I) in roots of P. p x b and P. p by the flooding treatment. Conversely, the heavier mitochondrial particles (Fraction II) appeared in the roots of P. c, No. 6 and No. 8 by flooding. Fractions I prepared from P. c, No. 6 and No. 8 were less sensitive to cyanide than were those from P. p x b and P. p. Fraction II, induced in the roots of P. c No. 6 and No. 8 by flooding, was markedly insensitive to cyanide. From these results, we discussed the relationship between the changes in respiration chain and flooding tolerance in pear rootstocks.

**1340-1440**

**S13-P-34**

**CHILLING AND HEAT REQUIREMENT IN APRICOT AND PEACH VARIETIES**

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The aim of this research was to evaluate and to compare the applicability of different models to the environmental conditions of Northwest Italy, in order to characterize the phenological behaviour of 5 peach and 5 apricot cultivars and to quantify their chilling and heat requirement. Climatic data were recorded during three seasons by meteorological stations installed in the experimental orchards. Hourly temperature data were measured from the end of summer till

full-bloom. Phenological data were determined weekly in the orchard, following Fleckinger stages. The Utah model was used to determine the starting date of chilling units accumulation. To calculate chilling units requirement (WCR), several methods were compared (Hutchins, Weinberger-Eggert, Utah, North Carolina). To determine the real moment when the chilling requirement was satisfied, in order to assume it as the starting point for accumulation of the heat requirement, ten twigs of each variety were collected weekly from November to February and put under controlled conditions. Dormancy was considered broken when 70% of the twigs and 50% of the flower buds on each twig began to flower (Stage F). To assess growing degree hours accumulation (GDH), and growing degree days accumulation (GDD) several base temperatures were tested and compared. The choice of the base temperature was based on the lower variability calculated during three years. Results show different amounts of chilling units and growing degrees for apricot and peach cultivars. The comparison of the four methods to calculate WCR showed a large range of variation. The date of dormancy breaking presented wide variations among varieties: from the end of December to the beginning of February in apricot and from the end of December to middle January in peach. GDH and GDD both seemed to be reliable methods for calculating heat requirements; the best base temperature to estimate GDH and GDD is equal to 4.4 °C.

1340-1440

S13-P-35

#### DYNAMICS OF ENDOGENOUS IAA AND CYTOKININS IN COLUMNAR TYPE APPLE TREES AND RESPONSE TO APPLICATION OF GROWTH REGULATORS

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We examined the relationship between the growth habits and the dynamics of endogenous hormones (IAA, Cytokinins) in columnar type apple trees to establish a cultivation system using this type of tree in Japan. In addition, the effects of applying a plant growth regulator on shoot growth and flower bud differentiation of columnar type trees were investigated. The levels of endogenous IAA and cytokinins in shoots of 'Maypole' and 'Tuscan' (both cultivars are columnar type), and 'McIntosh' (normal type) in June and July were quantified by GC+MS. The IAA level in shoots was higher in the columnar than in the normal type. Cytokinin levels varied for each cytokinin, and the ZR level was higher than that of other cytokinins. There were no significant differences in the total cytokinin level in each tree type. The IAA/total cytokinin ratio tended to be higher in the columnar than in the normal type. Two-year-old trees 'Trajan' (columnar type) and adult trees 'Fuji' (normal type) were sprayed with naphthaleneacetic acid (NAA), maleic hydrazide (MH), benzylaminopurine (BA) alone, BA+MH, and BA+ gibberellic acid (GA<sub>3</sub>). In both types, the total growth of shoots was greater in the treatment with BA than with NAA. The BA spray increased the length of lateral shoots on the main stem in 'Trajan' and two-year-old branches in 'Fuji'. On the other hand, the number of lateral shoots was notably increased by the BA spray in 'Trajan', but only slightly increased in 'Fuji'. Although the response of 'Trajan' to BA alone was greater at 600ppm than at 300ppm, there was little difference in the response between 300 and 600ppm in 'Fuji'. The effects of applying BA plus MH or GA<sub>3</sub> had interactive effects in 'Trajan' compared to 'Fuji'. These results indicate that the IAA/cytokinin ratio may be related to the growth habits of the columnar type.

1340-1440

S13-P-36

#### GAS EXCHANGE IN SWEET CHERRY CANOPIES: CONTRIBUTIONS FROM DIFFERENT LEAF TYPES

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We examined the efficiency of, and capacity for, net CO<sub>2</sub> exchange (NCE) and transpiration (E) of 4 sweet cherry leaf types: a) shoot leaves (SH), b) 1-year-old non-fruiting spur leaves (1YR), c) 2-year-old fruiting spur leaves (2YR), and d) 3-year-old and older fruiting spur leaves (3+YR). For each leaf type, leaf area (LA) was measured and light-saturated gas exchange was determined within

1 h of solar noon at weekly intervals between full bloom and harvest. Spur LA expanded rapidly, becoming fully established 35-40 days after full bloom (DAFB), irrespective of spur age. Shoot LA reached maximum shortly after terminal bud set (80-90 DAFB). A positive correlation ( $r^2 = 0.73$ ) was found between shoot length and shoot LA. At full expansion, SH leaves were larger (45 cm<sup>2</sup>/leaf) than spur leaves. Among spur leaf types, 3+YR and 2YR were similar (33 cm<sup>2</sup>/leaf) and 1YR were the smallest (22 cm<sup>2</sup>/leaf). Mean no. of leaves per spur were 8.5, 7.6, and 6.7 for 3+YR, 2YR, and 1YR, respectively, giving mean LA/spur of 281, 251, and 147 cm<sup>2</sup>. For each leaf type, light saturated leaf NCE increased from initial expansion until 65-70 DAFB (ca. 1 week before harvest), and declined thereafter. Leaf E peaked between 75-80 DAFB. Mean NCE rates between leaf unfolding and harvest were highest in SH and similar among spur types, 12.7, 10.9, 11.6, and 11.0 μmol·m<sup>-2</sup>·s<sup>-1</sup> for SH, 1YR, 2YR, and 3+YR, respectively. Nighttime respiration rates were ca. 10-16% of maximum daily NCE, irrespective of leaf type. Between leaf unfolding and harvest, mean E was approximately 3.0, 2.5, 2.6, and 2.5 mmol·m<sup>-2</sup>·s<sup>-1</sup> for SH, 1YR, 2YR, and 3+YR, respectively. Chlorophyll and leaf N content of each leaf type will also be presented. Results will be discussed in relation to measurements of whole-canopy gas exchange and the temporal and spatial variability in carbon supply within sweet cherry canopies.

1340-1440

S13-P-37

#### INVESTIGATING THE INFLUENCES OF SCION BUDS ON IN SITU WALNUT GRAFTING BY FEEDING 32P

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'Shan-1', a cultivar of Walnut, was used to study the effects of scion buds on the uniting process of walnut (*Juglans regia* L.) in situ grafting by an isotopic tracing technique. 32P was fed to the root systems of rootstocks. The grafting method used was whip and tongue, one of the methods of apical graftage. There were four scion bud treatments: two-bud scions, upper-bud scions (single scion bud about 10cm above the grafting union), lower-bud scions (single scion bud about 2 cm above the grafting union) and no-bud scions. The dynamic curves of 32P movement in the new shoots indicated that scion buds affected the healing process of the graft unions significantly. The number of buds on a scion and the distance of scion bud from the graft union had great influences on the early uniting and scion bud sprouting. Comparing the four treatments, 32P was detected earliest in the two-bud scions, and then the upper-bud scions and finally lower-bud scions. No 32P was detected in the no-bud scions although they were able to form graft unions. The results indicated that the earliest rootstock-scion communication occurred in the treatment involving two-bud scions. It was earlier than that in the single-bud scions. The distance of the scion bud from the grafting union influences rootstock-scion communication and new shoot growth. The closer the scion bud was to the graft union, the slower the communication between the rootstock and scion, and the slower the sprouting of the new shoot, although the speed of the communication and the new shoot growth became faster later. The two new shoots sprouting on the two-bud scion showed different growth dynamics. The upper shoot would keep growing faster than the lower one up to 80 days after sprouting. After 80 days, however, the growth of the lower shoot would gradually speed up, become stronger, and take over dominance eventually. Although there were differences between two-bud scions and single-bud scions, the survival rate of grafting was not influenced, indicating that single-bud scions could be used in walnut in situ grafting. For single-bud scions, bud proximity to the graft union should not influence grafting success, although the speed of union might vary. The practical significance of single-bud scion grafting is discussed with respect to the serious problem of short supply of scions in walnut propagation.

1340-1440

S13-P-38

#### STUDIES ON SINGLE-BUD SCION GRAFTING OF WALNUT (*JUGLANS REGIA* L.)

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Walnut (*Juglans regia* L.) has low branching ability, which results in a shortage of scions for propagating good cultivars and, therefore, slows down their distribution. In order to solve this problem and make full use of the scions, single-bud scion grafting experiments were conducted on the cultivar 'Lipin-1' by using the whip and tongue graft method in Beijing, China. Scions were divided into four treatments: upper-bud scions (scion bud is about 10 cm above the graft union), lower-bud scions (scion bud is about 3 cm above the graft union), no-bud scions (scion with internode only) and disbudded scions (lower-bud scions with buds removed). Influences of grafting time, scion bud position, temperatures, humidity, and light-reflecting film on the healing of graft unions and grafting success were studied. Optical microscopic sections were also made for examinations of the healing process of graft unions. The results were as follows: (1) Survival rate of grafting was not influenced by scion bud positions. However, differences were noticed in the speed of graft union formation. (2) The effective time of single-bud scion graftage of walnut in Beijing was from March 20th to April 10th. It could be extended to May 10th if light-reflecting films were used to maintain the humidity and lower the temperatures. (3) The optimum temperatures for single-bud scion grafting were 20–240 °C. The survival rate decreased sharply at 280 °C. (4) The optimum humidity for high survival rates of single-bud scion grafting was 40% when using the soil-sawdust mixtures as grafting media. (5) The anatomical study showed that scion buds and their position had no influence on callusing, formation of an isolation layer, and early differentiation of cambium; scion buds closer to the graft union promoted the formation of callus bridges; and the differentiation of xylem vessels was relatively slow in lower-bud scions, while it occurred almost at the same time in the other treatments. (6) The survival rate of this single-bud scion grafting technique is up to 85%, which, at least doubled the scion usage of the traditional spring grafting method. The practical use of single-bud scion grafting is discussed. A grafting system of single-bud scion was established for effective propagation of walnut trees in Beijing area.

**1340–1440**

**S13–P–39**

**EFFECTS OF PRUNING TECHNIQUES ON CANOPY VOLUME, SHOOT GROWTH AND INFLORESCENCE BUD ABSCISSION FOR BEARING PISTACHIO TREES**

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This study was carried out between 1993–1998 to determine the best pruning techniques for trees of the 'Uzun' variety of pistachio grown in Gaziantep. In addition to traditional pruning methods, light and heavy pruning were applied to one-year-old shoots in order to evaluate the response of pistachio nuts. 25 cm and more length growing shoots were cut above 2–3 vegetative bud every years. This treatment has shown the best result. The shoot lengths were 14 cm on the heavily pruned, 12 cm on the lightly pruned and 10 cm on the traditionally pruned trees. On the heavily pruned trees less canopy volume (25 %) was produced than on the lightly pruned trees. Inflorescence bud abscission in the lightly and heavily pruned trees was less than about 12–17% from traditional pruning method.

**1340–1440**

**S13–P–40**

**GROWTH AND FLOWERING RESPONSES OF SWEET CHERRY CULTIVARS TO PROHEXADIONE-CALCIUM AND ETHEPHON**

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Young sweet cherry trees on seedling rootstocks are excessively vigorous and slow to flower and fruit. Many such trees have been planted in Washington State orchards in the past few years. Prohexadione-Calcium (P-Ca) and ethephon (ETH) can control vigor and stimulate precocious flowering and fruiting in such trees. Single or double applications of P-Ca (125–250 mg a.i./liter) or ETH (150–200 mg a.i./liter) in spring reduced vigorous shoot growth in young 'Bing' / Mazzard and 'Tieton' / Mahaleb sweet cherry trees without inducing a second growth flush. Similar applications in 'Lapins' / Mazzard slowed, but did not reduce, shoot growth. When the first application was a tank mix of P-Ca+ETH, shoot elongation slowed or stopped for up to 6 weeks in all 3 cultivars, after which a strong second shoot growth flush began in July. A second flush was observed regardless of the composition of a second spray application, if used. A similar tank-mix applied in

June as a single treatment or as a follow-up after either P-Ca or ETH alone or the tank mix, stopped shoot growth or reduced the vigor of a second growth flush. Fourth-leaf trees of 'Attika', 'Bing' and 'Regina' on Mazzard rootstock in the same orchard were treated twice over a 3-week interval with P-Ca, ETH or the tank mix. P-Ca alone slowed shoot growth in 'Attika' and 'Bing' for several weeks after treatment but did not reduce overall growth. ETH alone reduced both shoot growth rate and total shoot growth. In both cultivars, the tank mix produced a strong, synergistic reduction in shoot growth. In contrast, 'Regina' shoot growth was reduced only by ETH regardless of the presence or absence of P-Ca. P-Ca treatments alone did not increase flowering the next year. ETH applications improved flowering, but the P-Ca+ETH tank mix increased flower bud density the next spring up to 3-fold on both previous season's shoots and on spurs on 2- and 3-year-old wood. Yields were similarly increased where flowering was greater.

**1340–1440**

**S13–P–41**

**INTEGRATED CROP MANAGEMENT (ICM) IMPLICATIONS FOLLOWING THE USE OF (PROHEXADIONE-CA) APOGEE ON APPLES (*MALUS X DOMESTICA* BORKH.)**

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Apogee® can dramatically reduce the shoot growth of apple trees. This can influence both pruning costs and fruit quality. Two large studies were conducted on 'York Imperial' apples to study the impact of Apogee® and pruning on ICM factors. In 2000, the effects of these treatments and fruit thinning were evaluated in 3 commercial orchards. Three-tree plots were used in three blocks per orchard. Four sprays of Apogee® successfully reduced shoot growth. Winter pruning resulted in the most vigor. The number of aphid colonies was significantly reduced in Apogee® treatments. No effect of Apogee® was observed on the severity of the internal larval complex (ILC) (Oriental fruit moth/codling moth/lesser appleworm) or oblique-banded leafroller fruit infestation, however the highest percentage of fruit without insect injuries was collected from trees treated with Apogee® alone. Apogee® treated fruit had the lowest mean fruit weight but this may have been due to an increase in fruit load. In 2001, a large-scale experiment was conducted in 2 commercial orchards. In each orchard a pruned and a non-pruned block was selected of similar age. In order to reduce the ingress of insects into the data plots their size was increased in 2001. Within each block a uniform area of 9 rows by about 50 trees was treated with Apogee®. Rates were 0.84, 0.62 and 0.38 kg/ha and 1.1, 0.84 and 0.56 kg/ha in the non-pruned and pruned orchards, respectively applied at 1 cm of growth and a 2-week intervals. Two insect data sampling areas were selected that were at least 24 meters from non-treated trees. Apogee® reduced shoot length while pruning increased shoot length. The number of aphid colonies was significantly reduced in Apogee® treatments. It appears that the number of oblique-banded leafroller infested terminals in the pruned orchards was reduced by Apogee®.

**1340–1440**

**S13–P–42**

**FIRE BLIGHT AND VEGETATIVE GROWTH CONTROL RESPONSES OF SEVERAL MALUS ROOTSTOCKS AND CULTIVARS TREATED WITH PROHEXADIONE CALCIUM (APOGEE)**

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Fire blight (FB), a serious bacterial disease of apple pear, leads to loss of bearing surface and often tree death. Research on the GA-synthesis inhibitor, prohexadione calcium (PC), indicates it is an effective compound for minimizing FB infections as well as for regulating tree growth. The commercial interest in PC is its ability to reduce secondary FB infections as well as reduce the need for dormant and/or summer pruning. Previous studies on PC, however, are not reflective of the growing conditions experienced and apple cultivars used in northern growing regions of North America. Two experiments were conducted to determine: (1) the benefits of PC for controlling secondary FB in several Malus

rootstocks, and; (2) the efficacy of PC on regulating the shoot growth of six commercial apple cultivars. In the first experiment, potted M.9, M.26, Bud. 9, M.7, V.1, and V.3 apple rootstocks, grown in a greenhouse, were sprayed with each of five PC treatments (water only, 1 spray of 250 mg/L, 2 sprays of 125 mg/L, 3 sprays of 83.3 mg/L, 4 sprays of 63.5 mg/L). Repeat applications will be made every 7d. Two weeks after the first PC spray, shoot tips were inoculated with a virulent strain of *E. amylovora*. Five weeks after inoculation, the number of shoots infected, length of infected shoot, and total shoot length were measured. There was a significant ( $P < 0.001$ ) rootstock effect on FB infection. PC treated plants had less FB infection, however there was significant rootstock and PC interaction. In the second orchard experiment, 'Empire', 'Delicious', 'Crispin', 'Vista Bella', 'Northern Spy' and 'Golden Delicious' trees were sprayed with each of 3 PC rates (water only, 2 sprays of 125 mg/L, 4 sprays of 125 mg/L). Repeat applications will be made every 14d. The length of 7 tagged extension shoots/tree were measured to determine the seasonal rate of shoot growth and effectiveness of PC in reducing shoot growth. Percentage shoot reduction ranged from 15 to 50 % in comparison with control treatments, and this response was consistent among the cultivars receiving similar treatments. There was no significant cultivar x PC interaction. These data indicate that careful rootstock selection and the use of PC for FB control is warranted when growing FB sensitive cultivars. Furthermore, cultivars respond similarly to PC in northern climates in terms of the percentage reductions in shoot growth achieved. Therefore, applying higher rates to more vigorous cultivars appears necessary to achieve greater absolute growth reduction.

**1340-1440**

**S13-P-43**

**SOIL INTEGRATED MANAGEMENT IN POMICULTURE AT SCPP BANEASA**

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Taking account of ecological peculiarities, specific to tree plantations (orchards), and economic considerations linked to investments in the orchard, more detailed knowledge of soil management factors, as they affect tree maintenance and the permanent improvement of soil fertility, as well as avoiding pollution of the environment, constitute a priority area of study in modern pomology. From the agrochemical standpoint, soil management in an integrated cropping system refers to types of agricultural measures that lead to avoidance of soil degradation, by optimizing their agrochemical properties and maintaining and increasing their nutrition capacity, by way of development of technologies for balanced application of fertilizers (organic and mineral), which depend upon soil and climatic conditions and start with the establishment of the orchard. Following the agrochemical study performed in the SCPP Baneasa area of Romania regarding the status of soil fertility, problems with the soils were noted. These were, low pH in some plots, low to medium nitrogen availability, and low rates of mobile phosphorus in some half of the area studied. This showed the need for developing a technological sequence, which would lead to the improvement of the productive capacity of these soils. This sequence involved: a) performing periodical checks on the state of fertility in the research plantations; b) development and extension work, that includes performing the usual soil analyses, practiced in laboratories of agrochemistry, which allows us to appreciate the status of soil in terms of its supply of the nutritive elements necessary for the development of fruit trees; c) establishing foliar diagnoses by analyses of plant samples at the main stages of their development, which allows us to correct the nutritional needs of the plants. In soils where the pH reaches the limits to which trees will tolerate it is recommended to perform amendments of these with the aim of eliminating the problem, which can damage certain fruit tree species such as apricot, peach, nectarine, cherry, sour-cherry and apple. Also, the improvement of physical, chemical and biological features of the soil, during the vegetation period and the use of cultivars resistant to diseases obtained from the mother plantations free of virus diseases is very important for obtaining stable yields. The paper contains also, proposals concerning some possibilities for fertilization using only organic and foliar fertilizers (excluding chemical fertilizers). Taking account of the diminishing supplies of organic fertilizers (especially manure) in the last ten years in Romania because of reductions in animal livestock, the paper will present some possibilities

ties for replacing these types of fertilizers.

**1340-1440**

**S13-P-44**

**COMPARISON OF SELF-ROOTED AND TIP-GRAFTED SEEDLINGS OF (*PRUNUS CERASUS* X *P. FRUTICOSA*) HYBRIDS AND *AMELANCHIER ALNIFOLIA***

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This study was initiated to reduce acreage and time for tree fruit breeding at the Univ. of Saskatchewan. Seedlings of sour cherry hybrids and saskatoons were chip-bud grafted onto the top branches of mature, bearing trees. After two growing seasons, seedlings on their own roots were compared to the same genotypes that had been tip grafted. For both crops in the study, vegetative growth of tip grafted seedlings was similar to that of the trees onto which they were grafted and significantly different from self-rooted seedlings. Tip grafting promoted cold acclimatization and hardiness of cherries but had little or no effect on hardiness of saskatoons. Sour cherries that were tip grafted had decreased leaf number by 64%, shoot length by 84%, and shoot diameter by 76%. None of the tip grafted branches showed winter damage but 40 of the 52 rooted seedlings had winter dieback. By August 12, terminal growth of tip grafted branches had ceased but seedlings were still actively growing. After two growing seasons, tip-grafted saskatoons had 93% more leaves, shoots were 257% longer and shoot diameter increased by 42%. Time of cessation of vegetative growth was similar for rooted seedlings and tip-grafted branches.

**1340-1440**

**S13-P-45**

**THE INFLUENCE OF SCION-ROOTSTOCK COMPATIBILITY ON PEAR PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERISTICS**

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The tested objects were leaves, shoots, and fruits from fifteen-year-old pear-trees of three varieties: 'Yablunivska' and 'Parisianka' grafted on the Quince A rootstock as well 'Bosc' grafted on the same rootstock with the 'Cure' interstock. Annual and biennial seedlings of the pear varieties 'Vyzhnitsia', 'Malevchanka', also 'Bosc' grafted on the Quince BA-29 as well as three-year-old saplings of 'Vyzhnitsia' and 'Zolotovoritska' grafted on either the mountain-ash and on the June-berry were all investigated. The above-mentioned varieties grafted on the wild pear or on their ownroots were used as a control. The investigations showed that in spite of a retarding influence of the quince rootstocks upon the scion growth, the varietal differences both in growth dynamics and in leaf pigment content remained the same. At the same time, the level of scion-rootstock compatibility has a strong influence on the formation of assimilates and their transport, as well on the biomass distribution between over- and underground plant parts. It was shown that 'Vyzhnitsia' is more compatible with Quince BA-29 than 'Malevchanka'; 'Yablunivska' is more compatible with Quince A than 'Parisianka'; 'Bosc' has a very low level of compatibility with quince but using 'Cure' as interstocks may considerably improve the situation. 'Vyzhnitsia' is more compatible with mountain-ash and June-berry than is 'Zolotovoritska'. The latter has extremely high incompatibility with June-berry. Our investigations showed that the total dry mass/starch content ratio in leaves and shoots decreases in line with increasing levels of scion-rootstock incompatibility. Therefore, it may be useful as one of the stable indicators for evaluating this incompatibility level.

**1340-1440**

**S13-P-46**

**'ANNURCA' AND 'FUJI' APPLE CULTIVARS: BIO-AGRONOMIC PERFORMANCE AND FRUIT QUALITY IN A SICILY INLAND AREA**

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In addition to the cultivar 'Annurca' which traditionally represents one of the most important cultivars grown in Southern Italy, today there is an increasing demand for crisp, flavoursome cultivars such as 'Fuji'. The aim of this study is to test the performance of three rootstocks (M.9, M.26, MM.106) and their influence on yield and quality (chemical-physical characteristics and volatile compounds) of both 'Annurca' and 'Fuji'. Qualitative and quantitative analyses of the volatile fractions were carried out with SPME-GC/MS. The research took place in an area representative of central Sicily (800 m a.s.l.). Our results showed some interesting differences among the rootstocks tested. Specifically, plants grown on the rootstock MM.106 gave the best fruit quality. In both cultivars, fruit firmness, soluble solids concentration and acidity were significantly affected by the rootstock used. Also, volatile fractions differed with respect to the cultivar and the tissue within the fruit. Specifically, in the epicarp we detected more than 35 volatiles involved in the aroma composition of both cultivars. In the mesocarp, 'Fuji' exhibited a broader range of volatile compounds (9 compounds), and consequently had a richer aroma than 'Annurca' (4 compounds). Quantification of individual compounds was also performed. Some of the volatile compounds examined in this study could be used as markers for identification of specific cultivars.

**1340-1440**

**S13-P-47**

**BRASSINOSTEROID BIOSYNTHESIS INHIBITION AS A SIDE EFFECT OF THE COMMONLY USED IMIDAZOLE FUNGICIDE IMAZALIL**

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In the medium of dark germinating *Arabidopsis thaliana*, 0, 0.16, 0.625, 2.5 or 10 µM imazalil (IMA) was combined with 0, 0.063, 0.25 or 1.0 µM epibrassinolide (EBR). In the presence of a minimum of 2.5 µM of the imidazole fungicide imazalil, dark germinating *Arabidopsis thaliana* seedlings showed a clearly de-etiolated phenotype. The hypocotyl length was reduced and the cotyledons had opened. A major part of the hypocotyl length reduction could be restored by 0.0625 µM EBR. Full restoration was not possible by raising the concentration of EBR. An additional experiment revealed that the combination EBR and GA<sub>3</sub> was necessary for a complete restoration of the hypocotyl length. The dose dependent root length reduction by IMA could not be overcome by adding EBR. This could be expected because it is well known that exogenous applied EBR inhibits the root length. Intriguingly, IMA could partially counteract this effect of EBR. Possible target enzymes of IMA are reviewed. These are cytochrome P450 enzymes, not only present in the pathway of brassinosteroids, but are also active in gibberellin biosynthesis and abscisic acid metabolism. The consequences for horticulture of the side effects of this commonly used fungicide are discussed.

**1440-1500**

**S13-O-48**

**FUTURE ROLE OF PLANT BIOREGULATORS IN FRUIT PRODUCTION**

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Over the last few decades plant bioregulators (PBRs) have emerged to become integral parts of many horticultural production systems. At least for the time being, it is difficult to imagine having acceptable alternatives, for instance, for steering fruit formation in pineapples, optimizing fruit production in apples, pears, citrus and grapes, and for controlling shoot height in ornamentals. Competition with plant breeding for many of these uses exists and will continue to exist. However, even despite the possibilities that genetic engineering offers, it is still expected that PBRs will continue to offer faster solutions to many problems. PBRs enable plant growth and development to be actively regulated, thereby adjusting a given genotype to its particular growing conditions. Hence, PBRs can be used in a highly flexible manner for the "fine-tuning" of plants, which grow at a given site under largely uncontrollable and unpredictable environmental conditions. It is unlikely that this will ever be achieved by any kind of breeding. Worldwide, PBRs account for only 3 to 4 % of the total sales of plant protection agents. Relative to other types of plant protection compounds, the discovery, development, use, and commercialization of new PBRs are more complex and, typically, require a higher degree of experience, skill, and financial input. In recent years, many companies in the agrochemical industry have withdrawn from

PBR research, disillusioned about the prospects of this field. Conversely, other companies have found their way to enter the market, maintain or even expand their PBR business. It is worth noting that at least five new active ingredients have been introduced into horticultural practice over the last ten years. Furthermore, registration for minor uses is publicly supported in most countries. Against this background, it is predicted that PBRs will maintain to play a significant role in fruit production.

**1500-1520**

**S13-O-49**

**EFFECTS OF UREA AND THE DEFOLIANT-CUEDTA IN A SINGLE OR A COMBINED APPLICATION IN THE FALL ON N RESERVES AND GROWTH PERFORMANCE OF YOUNG FUJI/M26 APPLE TREES**

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One-year-old potted Fuji/M26 apple trees were grown outside during the growing season. Uniform trees were selected and divided into four groups, and sprayed, respectively, with water (control), 0.5% CuEDTA, 3% urea and a mixture of 0.5% CuEDTA and 3% urea (CuEDTA+urea) on Oct. 5. Leaf defoliation was recorded after the treatment. All trees were harvested in late December, and half of the trees from each treatment were destructively sampled for N analysis and the other half, kept in a 2 °C cold storage, were repotted into nitrogen free medium (vermiculite : perlite = 1:1) in early April for regrowth evaluation. Both CuEDTA and CuEDTA+urea treatments promoted leaf defoliation, but CuEDTA slightly reduced whereas CuEDTA+urea significantly increased nitrogen reserve levels of the trees compared with the control. The regrowth performance in the following season was positively related to nitrogen levels, and the new growth biomass, leaf N and leaf color (SPAD readings) were all increased with the increase of reserve N after two-month's growth.

**1520-1540**

**S13-O-50**

**THE CONCEPT OF CENTRIFUGAL TRAINING IN APPLE AIMED AT OPTIMIZING RELATIONSHIP BETWEEN GROWTH AND FRUITING**

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Manipulation of vegetative growth-fruiting relationships to ensure high quality fruits and regular cropping is the objective of all apple production systems. For some decades, the use of intensive orchards has been proposed to improve yield, notably early cropping, and profitability. The example of developments toward the solaxe system in France shows that training concepts have evolved from a two-step vision—first, the establishment of a solid framework leading to non-bearing years and, second, maintenance pruning to ensure cropping—to a more integrated vision of fruit tree management with lighter tree structure and greater importance given to the control of fruiting as part of training procedures. Based on deeper knowledge of tree biology and genetic variation, the main objective is nowadays to orientate overall tree vigor toward fruiting laterals to improve fruit quality and return bloom, rather than to influence vegetative vigor by means of dwarfing rootstocks or pruning. This concept implies fitting three components at planting in the orchard, rootstock/cultivar combination—planting distances—desired tree height. On the bearing tree, crop regulation is ensured by artificial extinction, i.e. the complete and definitive removal of fruiting spurs, with chemicals and hand thinning of remaining fruit buds if necessary. We recommend artificial extinction more specifically in the center of the tree and underneath branches, first to remove potentially poor quality fruits and second to improve light distribution within the tree. These training procedures favoring the peripheral layer of the tree canopy are included in an overall concept, the centrifugal training (conduite centrifuge). For 3 years, experiments have been carried out in experimental and commercial orchards to assess the effects of these training concepts on fruit quality attributes and regular

cropping. The benefits for sustainable fruit production are discussed.

**1540-1600**

**S13-0-51**

**GAS EXCHANGE AND WATER RELATIONS IN 'FUJI' APPLE TREES GROWN UNDER DEFICIT IRRIGATION**

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A multi-year study was established in a commercial orchard near Quincy, WA during summer 2001 to investigate the effects of partial rootzone drying (PRD) and season-long deficit irrigation (DI) on growth and productivity of apple trees. Control trees were irrigated to keep soil moisture close to field capacity. Both PRD and DI received 50% of the irrigation volume applied to the control but differed in irrigation placement. With PRD, water was applied to only half the trees' rootzones while the DI regime had the same wetted surface area as the control. Differences in soil water content among treatments became significant in mid summer. By the season's end, differences between the control and the deficits were close to 0.10 m<sup>3</sup>.m<sup>-3</sup>. Whole-canopy net carbon exchange (NCER) was monitored three times throughout the season using custom-made inflatable Mylar<sup>®</sup> cuvettes. Single-leaf net gas exchange, predawn ( $\psi_p$ ) and midday leaf water potential ( $\psi_M$ ) data were collected every 2-3 weeks.  $\psi_p$  in PRD was significantly lower than in the control on three sampling dates out of the seven performed. In DI,  $\psi_p$  was lower than control only in September. Significant differences in  $\psi_M$  appeared on July 25 and continued throughout the season.  $\psi_M$  in PRD was always 0.3-0.4 MPa lower than in control trees. Leaf net gas exchange in PRD was lower than in control on July 13 and in August. In July, mean NCER in control was 6.3  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ , which was significantly higher than in PRD and DI (5.1 and 4.7  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ). In September, NCER in control was again higher than in the two deficit irrigation treatments (3.7, 2.3 and 2.8  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  in control, PRD, and DI, respectively). However, fruit diameter measurements throughout the season showed no negative effect of PRD or DI on fruit growth.

**1600-1620**

**S13-0-52**

**KEY PROCESSES IN LEAF SENESCENCE**

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The aim of the work was to assess the key processes of leaf senescence and possible restricting factors, which influence photosynthesis and mobilisation of both nitrogen and carbohydrates in the autumn. Apple was chosen as the model crop and harvested either at the commercial harvest date (mid October), or with a delay of six weeks, to evaluate the source-sink relationship and abiotic effects on leaf senescence. 1) The photosynthetic potential of the senescing apple leaves remained large at 8-14  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  CO<sub>2</sub> after the commercial harvest date. Trees were saturated with respect to light ( $\text{PAR} > 800 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ ) and not limited by leaf chlorophyll content or stomatal function. 2) The presence of fruit on the apple trees with delayed harvest enhanced leaf photosynthesis due to larger in vivo RUBISCO activity in comparison with trees harvested at the commercial harvest date. 3) Maximum photochemical efficiency (Fv/Fm), measured as PS II chlorophyll a fluorescence, of senescing apple leaves also remained large for three weeks after the commercial harvest date. The subsequent decrease in the photochemical efficiency was delayed in trees harvested six weeks later. 4) Chlorophyll degradation and anthocyanin synthesis, both used as measures of senescence, were delayed in apple leaves of trees harvested later. 5) Nitrogen content declined more rapidly, by 30% in 4 weeks, in the leaves of apple trees harvested at the commercial date, an indication of more rapid translocation to the woody, perennial parts of the tree. 6) Four weeks after the commercial harvest date, a frost further enhanced the decreases in photosynthesis and photochemical efficiency as well as chlorophyll degradation, thereby accelerating senescence. In conclusion, the time of fruit removal determined the beginning of leaf senescence, defined by chlorophyll breakdown and anthocyanin synthesis, and by nitrogen translocation. This sequence in senescence and translocation was delayed by 1-2 weeks in leaves of trees harvested at the later date.

**1620-1640**

**S13-0-52-A**

**TO BE ANNOUNCED**

**1640-1700**

**S13-0-52-B**

**TO BE ANNOUNCED**

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**Tuesday · August 13**

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**1100-1140**

**S13-0-53**

**MECHANISMS FOR CONTROLLING FRUIT SET AND ABSCISSION INVITED PRESENTATION**

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Fruit set and abscission are opposing mechanisms but are finally regulated by the same process, the hormonal regulation of the abscission zone (AZ). Auxins (IAA) and ethylene are the hormones mainly involved in this process. The mechanisms controlling IAA- and ethylene concentrations at the AZ are, however, only partly understood. At anthesis and during flowering growth of the ovary ceases (cell division and extension) and the level of hormones, except ABA and ethylene, are rather low. Immediately following pollination/fertilisation there is a sharp drop in ABA followed by ethylene. Almost simultaneously the concentration of cytokinins (CKs) increases. Because CKs are known to reduce ABA concentrations it seems plausible that fertilisation, by increasing the concentration of CKs, again initiates the cell division process by removing the ABA/ethylene cell division block. This, together with the subsequent increase in GAs and IAA, leads to a rapid increase in cell extension, ovary growth and sink activity. The interactions between hormonal concentrations, tissue sensitivity, sink activity and assimilate allocation, although extensively studied, is presently not well understood and progress in their horticultural manipulation by, e.g. altering hormone concentrations, are still at an initial stage. In addition to the described internal regulation of fruit growth and abscission, dominance phenomena in between fruits and fruits and active vegetative sinks are strong determinants of fruit growth/abscission. Here the relative polar transport rate of IAA between these sink organs seems to be the main signal determining the degree of dominance and the abscission potential of a particular fruit. This rate of IAA transport, however, is correlatively regulated in a rather complex manner, so that attempts at reliable treatments to increase natural or parthenocarpic fruit set or thinning are extremely difficult to achieve. Hormonal regulatory processes, horticultural manipulations, and various tree factors that interact with each other when influencing fruit set and abscission will be discussed by demonstrating results from some experiments. In the long term it is hoped that these investigations may provide possibilities of developing treatments aimed at interfering in a more reliable way with fruit set and abscission than is presently possible.

**1140-1200**

**S13-0-54**

**CARBOHYDRATE ALLOCATION IN APPLE STEMS CAN BE ALTERED BY FRUIT LOAD**

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Carbohydrate allocation is a key process in deciduous fruit trees. In this study, our aim was to determine whether reserve accumulation in one-year-old apple stems is controlled by carbohydrate availability and, therefore, able to be altered by sudden changes in fruit load, or responding to seasonal environmental signals (day-length, temperature etc.). We attempted to alter the accumulation of starch into one-year-old stems during fruit development by altering fruit load on girdled branches. One-year-old branches with fruit were girdled

early in the season and the fruit load adjusted to high (6 fruit), low (2 fruit) and zero (no fruit). This fruit load was then altered at different stages throughout the season. Changing fruit load throughout the season caused starch amounts to increase when fruit loads were reduced. This increase corresponded to the reduction in sink strength. Starch levels increased more rapidly and to a higher amount when all the fruit was removed compared to a low level of fruit being left on the branch. Interestingly, by the end of the season, twelve weeks after harvest, all treatments had the same level of starch, regardless of their treatment and levels throughout the growing season, suggesting a limited pool size for starch accumulation. This requires further investigation, particularly relating to ungirdled branches. Soluble sugars showed much smaller changes. Sucrose and glucose amounts remained unchanged despite manipulation of fruit loads. Sorbitol was a major component of the total carbohydrates, but in spite of this, did not respond to fruit load changes. The results suggest that starch can be forced into storage out of season, and that its accumulation is dependent on carbohydrate availability. Storage is a low priority sink, and starch is only stored when other higher priority sinks are removed.

**1200–1220**

**S13–0–55**

**GROWTH REDUCTION AND FLOWERBUDQUALITY ON PEAR TREES**

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The removal of chlormequatchloride (CCC) in European pear production has resulted in an excessive vegetative growth pattern on pear trees and in a strong reduction in the overall production level. This growth reaction was very strong on the main Belgian pear cultivars Conference and Doyenné du Comice. In some orchards, very strong measures such as root pruning or stem incision with a chain saw were taken with the aim of reducing the vegetative shoot growth and to improve the processes of flower bud formation. These measures were often combined with a total ban of nitrogen fertilisation which brought the trees even more out of balance, due to a lack of fertility. Also, there is an intensive search for alternative molecules for chemical growth regulation. After trials with Paclobutrazol and Flurprimidol, in the past, interesting results were obtained recently with Prohexadione Calcium during the last few years. The growth reduction response is different for each pear cultivar and late regrowth problems could be a problem on young pear trees of the cultivar Conference. The effects of the different growth controlling strategies on the vegetative behaviour of the pear trees will be discussed in this paper. Also the effect of growth controlling measures on fruit quality and on flowerbud formation will be included.

**1220–1240**

**S13–0–56**

**RESPONSE OF CHEMICAL BLOSSOM THINNING OF 'OPAL' AND 'VICTORIA' PLUMS**

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In order to achieve annual yields of high quality fruits, commercial practise in Norway is to blossom thin 'Opal' and 'Victoria' plums with a chemical agent and make further crop adjustments by hand post-bloom. During the period 1998-2000, thinning trials were conducted at Ullensvang Research Centre and at growers sites in western Norway using bloom thinners on mature European plums trees. In 1998, unsprayed control and handthinned 'Victoria' trees were compared with trees treated full bloom with a single application of 1 % Armothin and 1.5 % ammoniumthiosulphat (ATS) and a post-bloom application one month after full bloom with the mixture 10 ppm 1-naphthylacetic acid (NAA) and 75 ppm ethephon. The same program was conducted in the following two years and included a single full bloom treatment with 250 ppm ethephon as well. At growers sites three trials were conducted during the 2000 season testing 1-1.5 % ATS and 5-7 % lime sulfur compared to handthinned fruits 5 cm apart and unthinned. All thinning treatments reduced significantly the crop load and enhanced the fruit quality (fruit size, soluble solid contents, fruit firmness and ground and surface colour). Fruit sets were reduced to about the half and the percentage of class 1 fruits was doubled compared to the control trees. All thinning compounds caused some minor leaf injuries, but not on the fruits. No differences in the amount of gummosis (internal disorder of the fruits) were observed between the different treatments.

**1340–1440**

**S13–P–57**

**INFLUENCE OF FERTIGATION WITH NITROGEN ON THE GROWTH AND CROPPING OF JONAGOLD APPLE TREES**

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The trial was conducted in a 'Jonagold'/M9 orchard (2500 trees/ha) and the experiment was designed as split-block comprising five treatments (fertigation with 45 kg N/ha, 60 kg N/ha, 120 kg N/ha, irrigation without fertilisers, and control—without irrigation and without fertilisers), two timing variants (treatments during vegetation period from 1 May–20 June – variant A, and treatments from 1 May to 1 August – variant B), and three replications, where each replication comprised five trees. The treatments lasted seven years beginning in the second year after planting (1992-1998). During the cropping years (1993-1998) there were no consistent treatment effects on the cumulative yield and yield efficiency, however, treatments had a significant influence on regularity of bearing. The lowest alternate bearing was exhibited by the control 'Jonagold' trees, while in the variant with irrigation without fertilisers a very high percentage of bienniality was evident.

**1340–1440**

**S13–P–58**

**AN OVERVIEW OF AND STATUS OF BLOSSOM THINNING IN POME AND STONE FRUIT**

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Early thinning of apples is important because of its impact on fruit size and next season's flower bud initiation. An overview and current status of blossom thinning in pome and stone fruit will be presented. Specific data with several blossom thinners on pome and stone fruit conducted by the author during the last 15 years and results of other researchers will be presented. Full-bloom sprays of sulcarbamide (Wilthin), pelargonic acid (Thinex), endothalic acid (Endothal), and ammonium thiosulfate (ATS) have been used for blossom thinning of apples and stone fruit. In 1986, the author, while studying dormancy of low chill peaches, found that that late (at bloom time) application of hydrogen cyanamide (Dormex) will reduce number of blossoms, and thus used this chemical as a blossom thinner. Effects of various rates and/or timings of Dormex, ATS, and/or Wilthin on blossom thinning (fruit set), fruit quality, and yield of 'Fuji', 'Delicious', and 'Rome' apples, peaches and plums were studied. All of these chemicals reduced the blossoms and fruit set, and higher concentrations were more effective. Double application of these chemicals often resulted in more blossom thinning than a single application. Double application of ATS at a rate of 5.68 liters per 378.5 liters or a single application of this chemical at a rate of 9.46 liters in 378.5 liters resulted in satisfactory levels of thinning in 'Fuji' apple. Double application of ATS at a rate of 9.46 liters in 378.5 liters resulted in excess thinning and is not recommended for apples. A single application of Dormex at 1.182 liters in 378.5 liters significantly reduced the fruit set in 'Fuji' and 'Rome'. Fruit size was increased when effective blossom thinning occurred. Wilthin at high concentrations caused fruit marking. The efficiency of blossom thinners on peaches, plums and apples depended on stages of blooms, concentrations, and frequency of applications.

**1340–1440**

**S13–P–59**

**PRIMARY AND SECONDARY ATTRACTANTS OF FLOWERS IN PEAR *PYRUS BETULIFOLIA***

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The primary insect attractants of pear flowers are nectar and pollen; secondary attractants include odour and visual factors, such as colour and size of flower. *Pyrus betulifolia*, a drought-resistant pear was studied in a Hungarian pear collection between 1998-2000. The diameter of flowers varied between 29.1-31.4 mm, whereas the number of dark purple anthers was in the range 19.8-21.3. The number of the green stigmata was 2 or 3. Flowers isolated for 12 hours produced very small amounts of nectar (0.6-4.8 µL/flower), with relatively high refraction

values (9-18%). Hourly studies of nectar secretion dynamics showed that the taxon usually produced a little nectar in the morning, but no nectar secretion took place in the afternoon. The most intensive anther dehiscence could be observed at noon in 1999, it coincided, however, with the peak of nectar secretion in 2000. Flowers were homogamous, since both stigma receptivity and anther dehiscence began in the balloon stage, and continued synchronously afterwards. Pear nectar usually contains only glucose and fructose, representing the hexose-dominant type secretory product. The nectar of *P. betulifolia*, however, contains sucrose too, belonging to the hexose-rich type. The structural basis of floral nectar production in pear is the receptaculo-ovarial nectary. In *P. betulifolia* it is automorphic both at the apical and the basal part of the gland, stretching also along the style. The nectary epidermal cells are palisad-like, with meso- or xeromorphic stomata among them. The thick glandular tissue, which can be well distinguished from the parenchymatous tissue, consists of 3-8 cell rows. The percentage of viable pollen grains was above 50% each year, which should be sufficient for successful pollination. *P. betulifolia* proved to be highly attractive for bees, due mainly to its ample pollen offer and sucrose-containing nectar, and was accordingly visited by a large number of bees each year.

**1340-1440**

**S13-P-60**

**HISTOLOGICAL STUDIES ON PISTACHIO VEGETATIVE ORGANS AS RELATED TO FRUCTIFICATION**

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Effects of fruiting on histological structure and histochemical characteristics of shoots and leaves of pistachio (*Pistacia vera* L.) were microscopically examined on tissues sampled from trees with different crop-loads and carbohydrate reserves availability (bearing, non-bearing and trees subjected to inflorescence-bud removal during winter dormancy for five consecutive years). Differences in cambium activity and xylem and phloem structure in several developmental stages are reported. Starch content was higher in "debudbed" than in non-bearing and bearing trees.

**1340-1440**

**S13-P-61**

**FRUITLET THINNING OF THE PEAR CULTIVAR 'ABBÉ FETEL' WITH NAPHTHALENEACETIC ACID**

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Fruitlets of 'Abbé Fetel' (*Pyrus communis* L.) need to be thinned to reach high commercial quality at harvest. Naphthaleneacetic acid (NAA) was evaluated as fruitlet thinner at two application dates on 8-year-old pear trees trained to palmette leaders. The study was conducted at the Comahue National Univ. (lat. 38°56' 67°59'W). Treatments were 1) control, 2) NAA (10 mg L<sup>-1</sup>), applied on 13 Oct. 2000, at 17 days after full bloom (DAFB) and 3) NAA (10 mg L<sup>-1</sup>), applied on 23 Oct. 2000, at 27 DAFB. Fruit diameter (FD) was recorded twice weekly (n=20 per date and treatment). At 138 DAFB (initial commercial harvest), crop load and fruit weight were determined. Fruits were then graded into size categories. From 138 to 166 DAFB, the maturity indices were measured at weekly intervals. Analysis of variance was used and mean separations were computed with Student's t-test. Treatments 2 and 3 resulted in 47.1% and 52.6% of the fruit >70mm, respectively, compared with 22.2 % from the untreated controls. Fruit yield, as expressed by kg of fruit >70mm tree<sup>-1</sup>, was 6.43, 21.13 and 31.19 for treatments 1, 2 and 3, respectively. FD was not significantly altered by NAA sprays; the following logistic model best fitted the fruit growth vs. time curve on non-thinned trees:  $FD=81.83/1+e^{2.34-0.03DAFB}$  ( $R^2=0.97$ ,  $P<0.001$ ). At 138 DAFB, there were no statistical differences among treatments in fruit firmness (range 55.5-59.4 N), starch index (range 2.2-2.5), or soluble solids concentration (range 12.2-12.9 Brix). Consequently, our data indicate that NAA applied at 27 DAFB was most effective for thinning 'Abbé Fetel' pears, and for enhancing fruit size at ripening, with no effect on the maturity indices. More research is needed to determine the optimum NAA rate and timing under alternative environmental and management conditions.

**1340-1440**

**S13-P-62**

**BLOSSOM THINNING AS A STRATEGY IN CHEMICAL THINNING OF APPLES IN NEW ENGLAND**

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Experiments were initiated to evaluate the effectiveness of several compounds as blossom thinning chemicals on 'Delicious' apples. In one experiment Within at 0.25 L/100 L water was compared with endothall at 0.125 to 0.25 L/100L and pelargonic acid at 0.25 L/100 L. Pelargonic acid and Within at all concentrations thinned appropriately and comparably. Endothall was a more potent thinner and overthinned at 0.25 L/100 L rate. Within and pelargonic acid thinned comparably to the standard postbloom thinning treatment of naphthaleneacetic acid (NAA) at 6 mg·L<sup>-1</sup> plus carbaryl. All blossom thinning treatments increased fruit size at harvest, whereas standard postbloom thinning with NAA plus carbaryl did not. Only NAA plus carbaryl caused pygmy fruit formation. In another experiment on 'Stardrimson Delicious', thinning with endothall at 0.094, .125, and 0.188 L/100L was compared at timings of 80-100% bloom or at 30-40% and 80-100% bloom. Endothall at 0.188 L/100 L thinned more than endothall at 0.094 L/100 L. Regardless of the concentration, two applications of endothall thinned more than one. One application of endothall thinned at 0.188L/100 L thinned comparably to the standard postbloom thinning treatment of 6 mg·L<sup>-1</sup> plus carbaryl. The usefulness of blossom thinning will be discussed as it fits into overall thinning programs.

**1340-1440**

**S13-P-63**

**EFFICIENCY OF TEMPERATURE AND RATE OF VEGETATIVE BUD BREAK IN PEACH, CV. RIOGRANDENSE**

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The chilling hours requirements are the most important factor in determining the adaptation of temperate fruit crops, to South Brazil. A experiment was carried out, in Pelotas, RS, Brazil at Embrapa Clima Temperado. Twenty five 2-year-old 'Riograndense' peach trees planted in 20 L pots were placed in a controlled environment chambers from April 2000. The chambers were set at constant air temperatures of 3 °C, 6 °C, 9 °C, 12 °C and ambient. After 100, 200, 300, 400 and 500 hours chilling hour treatments at each temperature, the plants were forced in a growth chamber at 25 °C. The flowering and leafing out of the buds were observed three times a week. The endodormancy was regarded as completion when the final percentage of flowering and leafing out was 50%. The chilling hour requirements for 'Riograndense' were defined as 500 hours and the most efficient temperature to release the endodormancy is 6 °C, evaluated using the rate of vegetative bud break (RVBD) and regression analysis.

**1340-1440**

**S13-P-64**

**SELF-INCOMPATIBILITY IN JAPANESE PEARS: PECULIAR INHIBITORY ACTION OF S-RNASE ON SELF POLLEN-TUBE GROWTH IN VITRO**

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In Japanese pears (*Pyrus pyrifolia* Nakai), purified S-RNase (RNase associated with self-incompatibility allele) from the styles can cause selective inhibition on the growth of self pollen-tubes in vitro, and its RNase activity is essential for the inhibitory action. However, stylar proteins of the pear (proteins removed S-RNase by cation exchange chromatography), which possessed three times higher RNase activity than S-RNase, did not show any inhibitory action. When the biological function of several RNases, S-RNase, RNase T1, RNase T2 and RNase A, was compared in vitro, S-RNase against the self pollen showed the strongest inhibition, followed by RNase T1, RNase T2 and RNase A. S-

RNase action on cross pollen was the weakest. These results suggest that S-RNase recognizes self pollen-tubes in vitro and degrades RNAs in the tube, resulting in a cessation of pollen-tube elongation.

**1340-1440**

**S13-P-65**

**INDIVIDUAL VARIABILITY OF NECTAR SECRETION IN THE FLOWERS OF PLUM CV. REINE-CLAUDE D'ALTHANN**

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Floral nectar production (microliter), refraction (%) and anther dehiscence were studied hourly from 8 to 18 o'clock in the flowers of 'Reine-Claude d'Althann' in a Hungarian cultivar collection in 2000. The aim of this study was to determine the insect attraction capacity of flowers in different ontogenetic stages and to describe if there is any individual variance from the point of view of pollination strategy in this self-sterile plum cultivar. The pollination biological type of this cv. is homogamy beginning with protogyny, however exposed stigma position was not detected. Young flowers preceding pollen shedding were protogynous, because only stigma secretion was observed. Later, in the anther dehiscence phase, flowers became homogamous. Flowers attracted bees both with their nectar and the pollen on offer. Nectar was secreted at 9-10 and 18 o'clock, its amount varied between 0.1 and 12 microliters, the refraction values were between 3-23%. As it is well known from the literature, six hours after the secretory peak at 9.30 there should have been another maximum, at 15.30. The lack of the afternoon secretory peak may be due to the dry, warm and windy weather. Anther dehiscence was continuous the whole day, except for young flowers, which began pollen shedding only in the afternoon. The majority of flowers secreted nectar uniformly, significant differences were not observed, except for a few flowers. The amount of secretory product was variable.

**1340-1440**

**S13-P-66**

**EFFECT OF SHADING TREATMENT ON SUGAR METABOLISM DURING FLOWER BUD FORMATION IN JAPANESE PEAR [*PYRUS PYRIFOLIA* (BURM.) NAK.] 'KOUSUI'**

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In this study, we examined the effect of shading, a treatment to reduce flower bud formation, on sugar concentrations and its metabolism in buds of Japanese pear. Spurs of 23-year-old trees of 'Kousui' Japanese pear were shaded with double-layered cheese cloth for approximately every three weeks between May 24 and Sept. 12, 2000, then terminal buds were sampled after the every shading treatment. Increases in the activities of NAD dependent sorbitol dehydrogenase (NAD-SDH), NADP dependent SDH (NADP-SDH), acid invertase (AI), sucrose synthase (SS) and sucrose-6-phosphate synthase (SPS) were observed in shaded buds compared to the non-treated controls. On the other hand, concentrations of fructose, glucose and sorbitol in buds were reduced by the shading treatment, and these sugars were positively correlated with the relative growth rate of bud. Additionally, sorbitol concentration was negatively correlated with activities of SDH (total) and soluble AI, and glucose with NADP-SDH. These results may suggest that sugar concentration should be the limiting factor of bud growth. It could be possible that the reduction of sugar concentration by the shading may increase the requirement for sugars in buds, thus causing the increases in activities of sugar metabolizing enzymes.

**1340-1440**

**S13-P-67**

**EFFECTS OF PH AND TEMPERATURES ON POLLEN GERMINATION AND POLLEN TUBE GROWTH OF PEAR (*PYRUS PYRIFOLIA* NAKAI) IN VITRO**

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Because of low temperatures during the blooming period, fruit set was significantly decreased in pear in terms of poor pollination and fertilization. This

study was carried out to determine if pollen germination and pollen tube growth could be affected by temperature and pH. Dehydrated pollen of 'Chuhwang' pear were cultured for 2 hours in various temperatures (15, 20, 25 and 300 °C) and pH (3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0 and 6.5). Pollen germination and pollen tube growth, which was investigated using an Image analyzer, were the highest at 250C and pH 6.0 in vitro. However, pollen germination and pollen tube growth gradually decreased at lower pH values. Pollen cultured at 150 °C had lower germination rates than those of the others. When cultured at 300 °C the pollen tubes were abnormally thin and curved. Therefore, the optimum conditions should be maintained during blooming and pollinating in pears, because pollen germination and pollen tube growth are very sensitive to low and/or high temperatures.

**1340-1440**

**S13-P-68**

**POLLEN PRODUCTION FROM FLOWERS FORCED INTO EARLY GROWTH FROM SHOOTS CUT AND PLACED IN SOLUTIONS OF HYDROXYQUINOLINE AND PLANT GROWTH REGULATORS**

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Most of *Pyrus pyrifolia* trees have the characters of gametophytic self-incompatibility, therefore must be pollinated by bees and/or hand for fruit production. In terms of hand pollination in commercial pear orchards much pollen has to be prepared before blooming time in the spring season. The procedures of collecting pollen are not easy because pears have short flowering periods. To develop an efficient method of pollen collection this research was carried out, which involves cutting shoots and placing them in water in a growth chamber (250 °C) before the time of natural blooming. The bundles of 20 shoots, each of which has 6 to 8 floral buds on 30 cm of shoot length, were cut and placed into plastic containers (20 L) containing 50, 100, 200, 300 and 400 ppm hydroxyquinone (HQ) solution, respectively. Also other shoots were cut into mixed solutions of either HQ + gibberellic acid (GA) or HQ + benzyladenine (BA) for 7 to 8 days after receiving their chilling requirement. Pollen of pear obtained from anthers was collected prior to dehiscence and allowed to air-dry for 12 hours. Bud break, flowering and pollen production on shoots were improved by the shoot forcing treatments in 100 and 200 ppm HQ solution. It was assumed that the HQ in the cutting solution improved the water absorption and its movement to the buds of the twigs. Flowering rate and collected pollen amount were higher in 20 ppm GA than in that of controls. Also, 50ppm BA treatment showed more pollen amount although no significant differences of flowering rates between treatments. The higher the total carbohydrate contents in the barks of the shoots as storage nutrients, the more amounts of pollens collected.

**1340-1440**

**S13-P-69**

**EFFECTS OF FOLIAR APPLICATIONS OF BORON AND CALCIUM JUST AFTER HARVEST ON POLLEN GERMINATION AND POLLEN TUBE GROWTH DURING THE SUBSEQUENT SPRING**

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Most commercial pear (*Pyrus pyrifolia*) orchards in Korea have carried out hand-pollination so as to increase fruit set and harvest good shaped fruits. This study was carried out to increase pollen viability by postharvest sprays with boron, calcium and urea solution. In an orchard experiment, the solutions of 100 ppm boric acid, 300 ppm organic calcium, which was extracted from oyster shells, 1.0% urea, 50 ppm benzyl adenine (BA) and 300 ppm Ca(NO<sub>3</sub>)<sub>2</sub> were sprayed on the leaves 3 times at 7 day-intervals just after harvest on 5 October 2000. Next spring, pear flowers were sampled and pollen germinated in vitro. We investigated pollen germination and pollen tube growth by using an image analyzer. As a result, boric acid treatment showed significantly higher pollen germination, also pollen tube length was extended vigorously by the B treatment, but repressed by foliar applied urea in comparison to controls. Also, organic Ca and Ca(NO<sub>3</sub>)<sub>2</sub> treatments increased pollen germination and pollen tube growth following the boric acid treatment Development of floral organs and fruit characteristics are discussed in relation to the treatment

1340-1440

S13-P-70

**EFFECTS OF NUTRIENTS ON POLLEN GERMINATION AND POLLEN TUBE GROWTH OF PEAR (*PYRUS PYRIFOLIA*)**

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This study was carried out to determine the responses of pollen to mineral nutrients as essential elements for plant growth and development. Desiccated pollen of *Pyrus pyrifolia* was cultured for two hours in agar media with the addition of various concentrations of  $MgSO_4$  (25, 50, 100, 200 and 400 ppm),  $H_3BO_3$  (25, 50, 100, 250 and 500 ppm),  $Ca(NO_3)_2$  (10, 25, 50, 100, 250 and 500 ppm) and  $KNO_3$  (50, 100 and 200 ppm). Pollen germination and pollen tube growth, which were investigated by an Image analyzer, were significantly increased in 100 ppm boric acid compared with the other treatments. However, too high a Ca concentration (more than 200 ppm Ca) induced cell ?? and denatured the pollen. The higher Mg concentrations showed the lower pollen germination and pollen tube growth. It was assumed that the boron concentration could increase the potentials of flower, fertilization and fruit set.

1340-1440

S13-P-71

**CORRELATIONS BETWEEN FRUITING BRANCH SIZE AND OPTIMUM NUMBERS OF FRUITS ON THE FRUITING BRANCH IN 'FUJI' APPLE TREES**Jong-Hyun Ryu<sup>1</sup>, Yong-Koo Kim\*<sup>2</sup>

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To determine optimum numbers of fruits on the fruiting branches, the sizes of fruiting branches on 13-, 20- and 25-year-old Fuji apple trees on MM.106/seedlings were graded with basal diameters of 8.1-10mm, 10.1-12mm, 12.1-14mm, 14.1-16mm, 16.1-18mm. In the Korean apple market the bigger the size of an apple, the higher the price of the fruit. For the 'Fuji' cultivar, an apple of over 300g, which is equivalent to an apple with a diameter of over 90mm, would belong to the category of high priced apples in the market. Based on the demand of the Korean apple market, basal diameter of a fruiting branch was related to the number of fruits on it to establish a basic rule for thinning apple fruit buds on fruiting branches. With trials on 3 apple orchards over 13 years old, it was considered appropriate to leave one apple to each fruiting branch of 8.1-12 mm, 2 apples to fruiting branches of 10.1-12 mm, 4 apples to fruiting branches of 12.1-14 mm, 5 apples to fruiting branches of 14.1-16 mm and 6 apples to fruiting branches of 16.1-18 mm diameter, with the objective of producing apples between 85 to 90mm diameters. It was anticipated that the findings would be used as a standard for judging the number of fruiting buds to leave on a fruiting branch in winter pruning.

1340-1440

S13-P-72

**A POLLINATION EXPERIMENT WITH THE PEAR CULTIVAR 'CLARA FRIJS'**

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A pollination experiment was carried out to study the effects of self and cross-pollination of the cultivar 'Clara Frijs'. Flowers were emasculated at the balloon stage and hand-pollinated two times at the beginning of flowering and one time at full bloom. as the pollinators used were 'Clara Frijs', 'Anna' 'Premiere', 'Sierra', 'Fritjof' and 'Ingeborg'. In one replication, flowers were not pollinated but still emasculated and bagged. Initial and final fruitset was determined. Fruit size was measured and the number of viable seeds counted. In open pollinated fruits, where seed distribution was investigated, the most prevalent number of seeds was found to be 4. Less than half of the pollinated flowers resulted in harvested fruits after no- and self-pollination; but the cultivar 'Ingeborg' also seemed to be a poor pollen donor. Fruit lengths and widths were lower when flowers had not been pollinated or after self-pollination and nearly no seeds were found in these fruits. When the cultivar 'Ingeborg' was

used as pollen donor it resulted in a poor fruit size and a low number of viable seeds. It seemed that most of the cross-pollinators tested succeeded in pollinating and fertilising 'Clara Frijs' producing good fruit and seed development. In the combinations with 'Sierra' and 'Fritjof' as pollinators the average numbers of viable seeds were higher than 5.

1340-1440

S13-P-73

**STUDIES ON THE REPRODUCTIVE BIOLOGY OF ALMOND**

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The main almond production area in China is in South Xinjiang, where 10,000 hectares of almond trees are planted. The characteristics of the reproductive biology of almond including flower bud differentiation, pollination, fertilization, and fruit-set of four cultivars were studied. The period of floral physiological differentiation ended in late May. Spraying the tree with GA3 or picking off leaves prevented the bud from forming flowers in this critical period. The floral morphological differentiation began after this critical period. From June to October, the microscopic floral parts developed along the flanks of the growing point. The whole stage of floral differentiation lasted about 110-125d. After fruit ripening, flower buds developed faster than previously. The pollen mother cells developed during the dormancy in winter. Bicellular pollen grains formed before the buds sprouted. The female archesporium formed when the buds sprouted. The development of the embryo sac conforms to the polygonum type. The shape of pollen grains is ellipsoid with three germinating pores. The almond pollen, with striate pits on its ectexine decoration belongs to N3P4C5 type. The size of pollen grains differ significantly between the cultivars. The flowering of 'Shuang Guo', 'Zhi Pi' and 'Ying Zui' occurred at almost the same time. These cultivars produced a large quantity of pollen of high quality and were self suited for pollinating each other. 'Ying Zui' is self-compatible. By fluorescent microscopy, the pollen was shown to germinate in about 2 hrs after deposition on the stigma. Afterwards, it took as long as approximately 6 days for the pollen tube to grow through the style and one more day to grow into the ovary and two more days to reach the nucellus. Paraffin microtome sections revealed that the pollen tube arrived at the embryo sac and completed double fertilization about 9 to 10 days after pollination.

1340-1440

S13-P-74

**EFFICACY OF CHEMICAL THINNERS AS AFFECTED BY CLIMATE AND LOCATION**Guglielmo Costa\*<sup>1</sup>, Fabrizio Bucchi<sup>1</sup>, Joan Bonany<sup>2</sup>, J Carbo<sup>2</sup>, I. Iglesias<sup>3</sup>, A. Dorigoni<sup>4</sup>, J. Vigil<sup>5</sup>, H.J. Weber<sup>6</sup>, M. Stopar<sup>7</sup>

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Regulation of fruit crop load by means of chemical thinning is deemed necessary for sustained economic apple production. Bioregulators available with thinning activity are limited and there is a clear tendency to a further reduction in availability, especially in areas with strong regulatory controls. This is the case of Carbaryl, an insecticide with strong thinning effects, that most probably will not be available in the near future in most European countries. On the other hand, certain new apple cultivars being introduced in most areas of South Europe, like 'Fuji' and 'Gala' strains, have special thinning requirements. 'Fuji' is classified as a difficult to thin cultivar whereas 'Gala', although quite responsive to chemical thinners, is characterized as having the tendency to produce small fruit diameters and requires a quite strong thinning program to reach marketable size fruits. Therefore, there is a need for new chemical thinners with high efficacy and that are environmentally safe. The evaluation of new chemical thinners and the development of new strategies with existing and long available products are the objectives of the Eufirin working group on chemical thin-



ning. The goal of this working group of European scientists has been to conduct field trials using common methodologies. Recently, the group's activities have focused on Benzyladenine and new application strategies with Ethephon. Results on the effects of Benzyladenine and early applications of Ethephon on 'Fuji' and 'Gala' will be presented and discussed. Comparisons of the efficacy and robustness of the results of BA and Ethephon and its relationship with location and weather conditions will be considered.

**1340-1440**

**S13-P-75**

**PRELIMINARY STUDY ON PHYSIOLOGICAL REASONS OF ALMOND FRUIT DROP**

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Almond is one of the most important horticultural products and the majority of suitable Iranian areas are cultivated under irrigation systems or are rain-fed systems. Shahr-e-kord city is one of the areas of production where the causes of fruit drop, which is one of the limiting factors for development and cultivation of almond, is a problem. Studies to examine these issues, including almond kernels damaged by a kernel feeder bee, are going on now. Research is in progress in Charmahal Va Bakhtiari 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, then the texture of the fruit becomes soft and shrinks, respectively. Afterwards the fruits will fall by slight shaking of the branches. There are gums formed inside some fruits. It seems that difficulties in pollination and fertility are not the factors for this problem, because all the fallen fruit have embryos and kernels. The rate of falling fruit is severe in Shahr-e-kord city in early June and in some of the orchards can be up to 70%. The rate of falling fruit is much lower in the Koh-e-Sorkh Kashmar; estimated below 5%. According to this investigation, carried out between these two areas, the climatic conditions are one of the most important factors for the cause. The research concentrates on investigating the physiological mechanisms of the abscission, and focuses on the climatic conditions, management, and the effect of different genotypes, etc.

**1340-1440**

**S13-P-76**

**ORGANIC BLOSSOM THINNING OF APPLE**

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A study was conducted in eastern New York to evaluate organically acceptable blossom thinners for increasing fruit size, fruit quality and return bloom of apple. Mature 'Gala'/M. 9 trees in the Hudson Valley were thinned with NC 99, a calcium/magnesium brine solution (Genesis Agri Products, Inc., Union Gap, WA); Fish oil (Crocker's Fish Oil, Quincy, WA) tank mixed with liquid lime sulfur (FOLS); or Wilthin (AMADS, Entek Corp., Brea, CA), and were compared to an unthinned control. All thinners were applied as a single spray at 80% bloom. NC 99 and FOLS were also applied as a double application, with one spray at 20% bloom plus a second spray at 80% bloom. FOLS was also applied as a double application at petal fall and at petal fall plus seven days. NC 99 and FOLS caused petal browning and a marginal leaf burn, and double applications caused more severe injury than single applications. Both NC 99 and FOLS reduced fruit set, while Wilthin did not. FOLS resulted in the most thinning while NC 99 resulted in slightly less thinning. Post-bloom FOLS reduced fruit set more than all other treatments. NC 99 reduced yield by a third when applied twice during bloom. FOLS, whether applied once or twice during bloom, also reduced yield by a third, while the post-bloom applications of FOLS reduced yield by 58%. Both FOLS and NC 99 increased fruit size with larger fruit resulting from double applications than from a single spray at 80% bloom. The largest fruit resulted from the post-bloom FOLS treatment. None of the treatments affected seed number. Two sprays of FOLS during bloom slightly increased fruit russet. Both NC 99 and FOLS have potential as organic thinners for apple. The mode of action of these chemicals is not limited to desiccation of flower parts, as shown by the efficacy of the post-bloom treatment. Growers who use these chemicals as organic thinners will have to accept a noticeable amount of leaf burn that results from their use.

**1340-1440**

**S13-P-77**

**EFFECT OF ETHEPHON AND PACLOBUTRAZOL ON FRUIT THINNING OF JAPANESE PEAR**

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Field experiments were conducted to investigate the thinning effects of ethephon and paclobutrazol on Japanese pear 'Kosui' and 'Hosui' cultivars during the 2001 season. In 'Kosui', ethephon at concentrations of 100, 250 and 500-ppm was applied to flower clusters 9 days before full bloom (DBFB) and to fruit clusters 18 days after full bloom (DAFB) while, paclobutrazol at concentrations of 500 and 1000-ppm was applied to flower clusters at full bloom. In 'Hosui' ethephon at concentrations of 100 and 250-ppm was applied to flower clusters 6 DBFB and to fruit clusters 15 DAFB. In 'Kosui' ethephon induced fruit abscission and showed a thinning effect. The thinning effect was significant when applied at 500-ppm concentration, 9 DBFB to flower clusters and at 18 DAFB to fruit clusters. It was also observed that with the ethephon treatment of 500-ppm concentration, when applied 9 DBFB, the proportion of clusters that had four or less fruits was 60% compared to the controls with 16%. Fruit weight at harvest time was not affected by ethephon when applied to flower clusters 9 DBFB, but it was decreased by ethephon when applied to fruit clusters 18 DAFB. Paclobutrazol also induced fruit abscission and showed a thinning effect. With the paclobutrazol treatment of 500-ppm concentration, the proportion of clusters that had four or less fruits was 63% compared to controls with 3%. However, paclobutrazol significantly decreased fruit weight at harvest time. In 'Hosui' ethephon treatments induced fruit abscission and showed thinning effects except when applied at 100-ppm concentration 6 DBFB. It was observed that with the ethephon treatment of 250-ppm concentration, when applied to fruit clusters 6 DBFB, the proportion of clusters that had three or less fruits was 85% compared to controls with 24%. The proportion of clusters that had no fruit was high (about 40%) when ethephon was applied at 250-ppm concentration to flower clusters 6 DBFB. The fruit weight at harvest time was not affected by ethephon treatments.

**1340-1440**

**S13-P-78**

**INVESTIGATION ON THE ADAPTATION OF SOME LOW-CHILL APRICOT CULTIVARS TO KIRIKHAN (TURKEY) ECOLOGICAL CONDITIONS**

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This research was carried out between 1996 and 2001 at the experimental apricot orchard of the Horticulture Dept., Agriculture Faculty, Mustafa Kemal Univ., Hatay, Kirikhan/Turkey. In the experiment, 5 low chill cultivars of the apricot ('Priana', 'Feriana', 'Canino', 'Precoce de Colomer', 'Precoce de Tyrinthe') were used as materials. In these cultivars, some phenological and pomological characteristics such as flowering period, average fruit weight, fruit dimensions, flesh/seed ratio, acidity and TSS were examined. In addition, the vegetative growth of the cultivars was evaluated by measuring the trunk diameters and lengths of annual shoots. According to the average value of six years, the highest average fruit weight was obtained from 'Precoce de Tyrinthe' (31.92 g), whereas the weight of the 'Precoce de Colomer's' fruits was the lowest (20.52 g). The flesh/seed ratio was the highest in the 'Precoce de Tyrinthe'. 'Priana' had the highest TSS content with 15.10%, whereas 'Precoce de Tyrinthe' had the lowest TSS value with 10.33%. In terms of ripening, 'Priana' was the earliest cv (20 May) and 'Precoce de Colomer' was the latest cv (3-5 June).

**1340-1440**

**S13-P-79**

**GIBBERELLINS AND CYTOKININS RELATED TO FRUIT BUD INITIATION IN APPLE**

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The possible involvement of cytokinins and gibberellins in flower bud for-

mation of apple has been studied. Endogenous cytokinins were detected in immature seeds which presumably are produced in these tissues since no cytokinin activity was found in xylem sap at the time when seeds were analyzed. The application of exogenous cytokinins to spurs at the time of flower initiation increased the amount of return bloom, whereas radioactive cytokinin accumulated mainly in the bourse bud. Endogenous gibberellins from 'Golden Delicious' seeds were biologically estimated and detected by GC-MS. Apple seed gibberellin-like activity peaked about 10 weeks after full bloom. GC-MS analysis detected gibberellins A4, A7, A9, A12 and A20 in 10 weeks old seeds. These results are discussed in relation to fruit bud initiation in apple.

**1340-1440**

**S13-P-80**

**HAZELNUT GROWTH AND YIELD EFFICIENCY IN NORTHERN PORTUGAL**

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Two trials involving nineteen hazelnut cultivars were established on neighbouring plots at Vila Real, Portugal, in 1984 and 1989, to evaluate their growth and yield performance. In the 1984 planting (trial 1) the trees are grown as multistemmed bushes. The cultivars involved are 'Butler' (B), 'Daviana' (D), 'Ennis' (E), 'Fertile de Coutard' (Fc), 'Grossal' (Gr), 'Gunslebert' (Gu), 'Longue d'Espagne' (Le), 'Merveille de Bollwiller' (Mb), 'Morell' (M), 'Ronde du Piemont' (Rp) and 'Segorbe' (S). In the 1989 planting (trial 2) the trees are grown as single trunk vases. Six of the previous cultivars are used (B, E, Fc, Le, M and S) together with eight others: 'Camponica' (Ca), 'Cosford' (Cf), 'Couplat' (Cp), 'Lansing' (L), 'Negret' (N), 'Pauetet' (Pt), 'S.M.Gesù' (Sj) and 'Tonda di Giffoni' (Tg). The canopy size of the cultivars common to both trials was larger on the multistemmed plants, but their yield efficiency was lower at the same age. Overall cumulative yield up to 2001 averaged 83 kg of nuts per bush in the 1984 trial and 30 kg per tree in the 1989 trial, productivities being very different among the cultivars in each trial. The most precocious and productive table cultivar was B grown as a bush form, whereas Fc was more productive than B on a single trunk. 'Ennis' produced less fruit than B in total, but showed higher yield efficiency in both trials. The best cultivars for industry were M, Tg and N. Nut characteristics are identical to those reported elsewhere for the same cultivars, but the frequency of blanks appears greater in Trás-os-Montes.

**1340-1440**

**S13-P-81**

**NECTAR ANALYSIS, POLLEN PRODUCTION AND ANTHOCYANIN MEASUREMENT, REVEALED DISTINCT VARIATIONS IN PEARS**

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The present investigation was undertaken to analyze and measure amino acids and sugars in nectars of different pear species and cultivars. The pear species included were *P. betulaefolia*, *P. longipes*, *P. koroshinsky*, *P. brestcherienideri*, *P. boissierana*, and *P. cossoni*. The pear cultivars were; 'Packham's Triumph', 'Josephine', 'Lemon Bergomot', 'Sensation' and 'Nijisseiki'. Pollen production per 50 flowers for each of these pears was measured. For nectar extraction, one hundred open flowers were picked. All the calyxes, which contained nectar, soaked in distilled water for 20 minutes. The mixture was filtered (Whitman paper No 42). 25 mL of this solution was freeze dried and 5 ml distilled water was added to the remaining solid. A HPLC analyser with an amino Quanta C18 column was used to analyze the samples. Sucrose, glucose and fructose were measured with an enzyme kit using the methods of Bohering Mannheim. The results showed that there was a high degree of variability within the free amino acids of pears. Asparagine was found to be present in the highest concentration followed by glutamine, aspartic acid, glutamic acid, serine, alanine, arginine and proline. The lowest total sugar was found for *P. boissierana* and the highest was found for *P. cossoni*. There was a different pattern for sucrose concentration among pears. Some pears such as 'Lemon Bergomot', 'Josephine', 'Nijisseiki', *P. longipes* and *P. koroshinsky* had no or low amounts of sucrose, while some pears such as 'Sensation', *P. betulaefolia* and 'Packham's Triumph' had relatively high amounts of sucrose (290 to 100 mg/L). A dramatic variation was observed in pollen production of these pears.

The highest amount was exhibited by 'Packham's Triumph' 74 mg/50 flower. Three groups of pears were distinguished, based on anthocyanin measurements.

**1340-1440**

**S13-P-82**

**ENVIRONMENTAL EFFECTS ON FRUIT SET IN AN AUTOGAMOUS ALMOND**

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Fruit set was studied during two years in 'Guara', an autogamous almond cultivar, following four different pollination treatments: open pollination, open pollination of a reduced number of flowers, self-pollination, and cross-pollination with a cross-compatible pollen. The treatments were applied to trees growing in the open air, to a tree inside an insect-proof cage, and to bagged branches. Fruit sets inside the cage were in general lower than at the open air, thus pointing to the possibility that a reduction of the light intensity inside the cage may reduce the level of fruit set. However, both artificial pollinations resulted in higher sets inside the cage in one of the years. Fruit sets on bagged branches were always lower than at the open air and inside the cage, showing that besides a light effect, as observed inside the cage, a bag effect is responsible for the reduction of sets, probably due to the branch manipulation and flower damage by the bag. The reduction of the number of flowers not always resulted in an increase in the set level of the remaining flowers. There were no consistent differences between the two types of pollination, showing that 'Guara' has a complete genetic self-compatibility. Year effects were observed, but not affecting all the treatments in the same direction nor at the same level, thus stressing the need for autogamy evaluation during more than one year, even if the lower sets assured the autogamy of 'Guara'.

**1340-1440**

**S13-P-83**

**CHEMICAL REST BREAKING AGENTS FOR THE SOUTH AFRICAN POME AND STONE FRUIT INDUSTRY**

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Most of South Africa's deciduous fruit is produced in areas which are climatically marginal. Delayed foliation of deciduous fruit trees, the result of not receiving sufficient chilling during the winter months, results in poor bud break, poor pollination and fruit set, low yield, uneven fruit size, poor tree architecture and makes other orchard managerial practices such as fruit thinning and harvesting more difficult. Rest breaking agents such as dinitro-ortho-cresol (DNOC) have been used on apples and pears in the past to ensure a greater uniformity in bud break and to alleviate these problems. DNOC, known to be extremely toxic to both the environment and mankind, was recently withdrawn from the market. Pressure from international markets for safer fruit has caused the fruit industry to pro-actively move toward more eco-friendly production of fruit. This paper deals with the testing of safer, cost effective alternatives, which must be available to the South African deciduous fruit industry in order to remain viable. Trees of different cultivars in commercial orchards in various areas were sprayed with a range of chemicals having potential as rest breaking agents and compared to the current industry standard treatments and unsprayed controls. Counts were taken at intervals of the number of vegetative and reproductive buds broken as a percentage of total buds on each shoot. Yield and fruit quality was also taken in certain trials. From the results of the various trials conducted over the past four seasons, rest breaking agents, hydrogen cyanamide (Dormex) at a low concentration (0,5% to 1%) in combination with a winter oil at 2 to 4% is now recommended commercially for apples and pears. However, experiments involving new chemicals such as "Lift" on apples, pears cherries and other stone fruit have given promising results.

**1340-1440**

**S13-P-84**

**CROP LOAD MANAGEMENT OF HIGH DENSITY APPLE TREES IN MICHIGAN**

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Excessive crop in the 3rd or 4th year can dramatically reduce crop in subsequent years, especially if they enter into an alternate bearing cycle. Also, it can permanently place trees in stress, which makes them sensitive to low temperatures. A field experiment was established in spring of 1998 to determine the optimum crop load for dwarf apple trees in the 2nd, 3rd and 4th year with four varieties ('Jonagold'/M9 NAKB, 'Pacific Gala' /M9 NAKB, 'Gingergold'/Bud 9 and 'Honeycrisp'/Pajam 1); 150 trees for each were planted at a spacing of 1.8m X 3.9m. Five crop loads were established the first year of production (0, 1, 2, 3, 4 for 'Gala' and 'Honeycrisp'; 0, 3, 6, 9, 12 for 'Jonagold' and 'Gingergold') and applied in a plot design of 30 trees each. To each plot from the previous year were applied other five crop load levels the second year of production (3, 6, 9, 12, 15 for 'Jonagold', 'Gingergold' and 'Gala'; 3, 4, 5, 6, 7 for 'Honeycrisp'; 0 was maintained as control), resulting in 6 trees for each crop level. The following years the same treatments above will be applied, in order to see if the tree is able to maintain the same level of cropping. Trunk sectional area, blossom density, production, average fruit weight and fruit quality (only for 'Jonagold' and 'Gingergold') were measured. The fruit were graded based on 6 weight classes in order to see how the crop level affected the fruit size. The five treatments of first year cropping maintained a uniform level of distribution for all the variety but did not affect the average fruit size. Crop load did depress TCAI expressed by a linear relationship with a regression correlation of 0.92 for 'Gala', 0.9 for 'Jonagold' and 'Gingergold' and 0.67 for 'Honeycrisp'. This trend was noticed for the other five cropping levels in the second year of production. The size of the fruit was affected from the crop load showing an inverse correlation between the two. During the first two years of production blossom density was not highly affected by the crop load level.

**1340-1440**

**S13-P-85**

**TEMPERATURE DEPENDENCE OF COMPLETION OF ENDODORMANCY IN FLOWER BUDS OF 'SATONISHIKI' SWEET CHERRY AND A MODEL TO SIMULATE THE ENDODORMANCY DEVELOPMENT**

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The endodormancy requirement is satisfied by chilling temperatures, but its completion is not visible. It is important to estimate the time of endodormancy completion by simulation, for deciding the heating time in forcing cultivation in plastic houses, for predicting the flowering time and for estimating the southern limit of cultivation. To investigate temperature dependences of endodormancy development in flower buds of 'Satonishiki' cherry (*Prunus avium* L.) trees, potted trees were placed in chambers adjusted to various temperatures for various hours. Chilling for 1100 hours at 0-6 °C was necessary to complete endodormancy. These temperatures were the most effective for endodormancy completion. Chilling for more hours was necessary at higher temperatures from 6 °C to 15 °C. The endodormancy was not completed over 15C and under -6 °C. Chilling at -3 °C was about 1/2 times as effective as 6 °C. A developmental rate (DVR) model describing the relation between endodormancy developmental rate and temperature was developed by using those results. Endodormancy completion dates in the open field were estimated by applying observed hourly temperatures to the model. The estimated dates agreed well with the observed dates in the open field determined by the forcing experiment.

**1340-1440**

**S13-P-86**

**FRUIT AND SHOOT GROWTH FOLLOWING COMBINED GIRDLING AND THINNING OF ROYAL GALA APPLE TREES**

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Fruit size of 'Royal Gala' apples is generally unsatisfactory in the Western Cape region of South Africa. Orchard practices aimed at increasing fruit size generally lower either the vegetative sink strength (e.g. girdling) or the total

reproductive sink strength (e.g. thinning), thereby stimulating individual fruit growth. The interactive effects of these practices on tree physiology are poorly studied. Full-bearing 'Royal Gala' apple trees growing in the Elgin district, South Africa, were girdled (2 and 5 weeks after full bloom) and subjected to various degrees of hand thinning (2-3 weeks a.f.b.) in a factorial randomised block experimental design. Fruit growth, shoot extension and diameter growth of one-year-old and bourse shoots, and branch circumference were measured throughout the season, and final fruit size and yield determined. Girdling decreased bourse and extension shoot growth, and consistently led to increased fruit growth rates. Moderate thinning (to one fruit per cluster) stimulated shoot growth, but strong thinning (to one fruit every second cluster) and complete fruit removal led to decreased shoot growth. Fruit size was significantly improved by thinning to one fruit per cluster or one fruit every second cluster. No interaction was found between girdling and thinning except for a particularly strong girdling-induced decrease in extension shoot growth in defruited trees. The best results were obtained for girdled trees thinned to one fruit every second cluster (169 g per fruit compared to 129 g for trees not girdled or thinned). Yield per tree and per centimeter trunk circumference did not differ between treatments, thus ensuring a higher revenue for the total crop.

**1340-1440**

**S13-P-87**

**EFFECTS OF CULTIVAR, SEASON, CROP LOAD AND CHEMICALS ON CONTROL OF FLOWERING IN APPLE**

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Flower bud formation in apple is a key process that determines potential orchard productivity within a year and consistency of production from one year to the next. We have described the variability in floral bud development among seasons for a single apple cultivar ('Royal Gala'), and among four apple cultivars ('Royal Gala', 'Braeburn', 'Pacific Rose', 'Fuji') within a single season. Both the formation of appendages and onset of floral bud differentiation were influenced by season and cultivar. The influence of whole-tree crop load and time of fruit removal on return bloom were investigated for a weakly ('Braeburn') and strongly ('Pacific Rose') biennial apple cultivar. Delaying the time of fruit removal from individual spurs of either cultivar reduced the probability of their flowering in the following season. However, whole tree crop load had a more dominant effect on return bloom than time of fruit removal on the strongly biennial cultivar 'Pacific Rose' compared to the less biennial cultivar 'Braeburn'. Application of chemical thinners in the "on" year or GA<sub>3</sub> in the "off" year of a biennial bearing cycle were studied for their ability to restore biennial bearing trees to regular cropping in studies over several seasons. Application of GA<sub>3</sub> (100-300 ppm) significantly reduced floral bud formation and resulted in an improved balance between floral and resting spurs in the year following treatment, and even two years after treatment in a study on the cultivar 'Braeburn'. Benzyladenine applied as a chemical thinner in the "on" year of a biennial bearing cycle tended to enhance return bloom of 'Pacific Rose', but this trend was not observed if flowering was excessive in the year of treatment (fewer than 20 percent of spurs were vegetative). These results demonstrate the complexity of some of the factors that control flowering in apple at the tree and spur level.

**1340-1440**

**S13-P-88**

**CHEMICAL THINNING OF APPLE WITH LIME SULPHUR**

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Lime sulphur (LS) was evaluated as a blossom thinner for Fuji and Gala apple. LS was applied at rates up to 4% a.i. at 85% full bloom of 7-year-old 'Fuji'/M9 and 'Gala'/M9 slender spindle apple trees. Half of the 'Fuji' trees received post-bloom thinning treatments of carbaryl (1000 ppm) or Accel (100 ppm) at 11 mm king fruit diameter. *Ammonium thiosulphate* (ATS) at 1.0% a.i. at 85% full bloom was included as an internal commercial control. For each cultivar, LS reduced crop load linearly with rate. For 'Fuji', 4% LS showed results similar to the ATS control for reducing overall fruit set, increasing the proportion of fruiting sites with a single fruit, and increasing mean fruit weight at harvest. For 'Gala', 3-4% LS also thinned satisfactorily but was somewhat

less effective than the ATS control. Leaf burning, even at the highest LS rates, was no worse than with ATS treatment. Fruit quality characteristics (fruit shape, percent block red color, firmness, russet incidence, soluble solids and juice acidity) were unaffected by LS treatment with both cultivars. Storage capability, determined after 3 months of air storage, was unaffected by any treatment. The follow up spray of carbaryl to 'Fuji' further reduced crop load with no interaction with LS. Accel caused no significant additional thinning. The effects of LS and ATS on return flowering are discussed in relation to the degree for crop load reduction.

**1340-1440**

**S13-P-89**

**EFFECT OF FERTILIZATION IN THE CONCENTRATION OF N, P, CA, MG, FE, MN, CU, ZN, AND PHENYLALANINE AMMONIA LYASE AND POLYPHENOLOXIDASE ACTIVITY IN FRUIT OF ZACATECAS-TYPE PEACH**

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Tree nutrition during fruit development is the most important factor that influences quality and postharvest behavior (Duarte, 1991). The purpose of this research was to evaluate the nutrimental state of the fruit based on N, P, K, Ca, Mg, Fe, Mn, Cu, Zn and B content and phenylalanine ammonia-lyase and polyphenoloxidase activity of local race Zacatecas- type peach. The research was done in a orchard with ten-years-old trees that had been managed under minimum tillage for the last five years. Two formulations of fertilizer were evaluated as foliar and soil treatments plus the control. The variables evaluated were N, P, K, Ca, Mg, Mn, Cu, Zn and B content and phenylalanine ammonia-lyase and polyphenoloxidase activity. The formula of fertilization affect the mineral concentration of N, P, K, Ca, Mg, Fe, Mn, Cu, Zn and B in the fruit and phenylalanine ammoniolyase and polyphenoloxidase activity. In general fruit from trees with soil fertilization plus foliar application of Ca, Mg, B and Mo diminished the activity of phenylalanine ammoniolyase and polyphenoloxidase, being these fruits the less susceptible to internal browning.

**1440-1500**

**S13-O-90**

**FOLIAR-APPLIED 6-BENZYLADENINE COMBINED WITH LOW-BIURET UREA REDUCED ALTERNATE BEARING AND INCREASED CUMULATIVE YIELD OF PISTACHIO**

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Alternate bearing in pistachio (*Pistacia vera* cv. Kerman) is due to excessive abscission of floral buds for the next year's crop during the 'on-year' when trees are carrying a heavy crop. Floral bud abscission begins at seed fill (June) and proceeds through July. During the period from June 6 to July 26, developing fruit released the hormone abscisic acid (ABA). Concurrently, floral buds on shoots bearing an 'on-crop' accumulated 25% more ABA while endogenous concentrations of the cytokinins zeatin riboside and isopentyladenosine each decreased 40% compared to buds on shoots bearing few fruit. Foliar applications of 22 g/ha 6-benzyladenine (Accel, Valent BioScience) combined with 7.0 kg N as low-biuret urea/ha in early June and again in early July in the 'on-year' increased bud retention up to 3-fold the following off-year compared to the untreated control trees. Applying this treatment every year for five years significantly increased cumulative yield compared to untreated control trees. The 4-year cumulative yield (years 2-5, excluding the on-year in which the experiment was initiated) was 45.5 kg dry mass split nuts/tree for control trees and 59.1 kg dry mass split nuts/tree for treated trees. The cumulative yield for the two 'off-year' crops was 3-fold greater for treated trees compared to untreated control trees, making it clear that the treatment had a positive effect in reducing alternate bearing. A further increase in yield in the 'off-crop' year might be achieved by treating trees only in the 'on-year'.

**1500-1520**

**S13-O-91**

**ROOTSTOCK GENOTYPE AFFECTS FLOWER BUD DISTRIBUTION AND FLORAL DENSITY OF 'HEDELFINGER' SWEET CHERRY AND 'MONTMORENCY' SOUR CHERRY**

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New precocious and highly productive cherry rootstocks have led to management challenges for balancing of crop levels with adequate leaf area to assure good fruit size and quality. To examine how different cropping potentials might be managed more strategically, the influence of individual rootstock genotypes on precocious flower bud distribution and density was characterized using 'Hedelfinger' sweet cherry (*Prunus avium* L.) grafted onto 18 rootstocks and 'Montmorency' tart cherry (*Prunus cerasus* L.) grafted onto 9 rootstocks. Both sweet and sour cherry flowering occurs in simple buds containing a multiple inflorescence. Flower bud formation occurs solitarily on one-year-old wood, or on spurs of two-year and older wood. In 2001 (trees planted spring 1998), the first- and second- year wood of branches was examined to determine rootstock effects on nodal position for number of buds per spur, number of flowers per bud, number of fruits per node, leaf area, and lateral shoot development. Both rootstock and position within the second-year-wood affected flower number per bud and lateral shoot formation. On the less vigorous rootstocks of sweet cherry, spurs and lateral shoots predominated in the medial and distal sections. In all sweet cherry rootstock treatments, number of flower buds per spur increased from proximal to distal, and on Gisela rootstocks, the number of flowers per bud was consistently higher than in the other treatments. For most rootstocks, flower number per bud decreased or remained the same from proximal to distal, except CT500 and Gi.7, which showed a slight increase in number of flowers per bud. In tart cherry, number of flowers within these shoots was related to the length of the shoot. The implications of these results for better cropping management precision of sweet and sour cherry trees on specific rootstocks will be discussed.

**1520-1540**

**S13-O-92**

**THE POSSIBLE MODE OF ACTION OF THE CHEMICAL APPLE FRUIT THINNER BENZYLADENINE**

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In a two year trial, 'Elstar', 'Jonagold' and 'Golden Delicious' trees were treated with BA (100 mg/L) to investigate its mode of action. The following investigations were conducted: 1. leaves or fruits were treated separately with BA to determine its site of action; 2. the effects of BA on the photosynthetic efficiency of leaves were evaluated measuring photosynthesis, chlorophyll content and leaf area/tree; 3. the effects of BA on shoot growth as well as interactions between shoot growth and fruit set were determined; 4. seeds of fruits were counted and weighed to evaluate the effects of BA on seed development and 5. the hormonal effects of BA were evaluated measuring ethylene evolution of fruits or leaves as well as auxin (IAA) export from fruits and bourse shoots of the same fruit cluster. BA was only effective when leaves were treated. BA had no negative effects on the photosynthetic efficiency of leaves. BA treatments increased shoot growth but only after June drop. Therefore, it seems likely that increased shoot growth after BA application is the result of the thinning effect and not its cause. This assumption is supported by the observation that shoot pinching did not increase fruit set on trees treated with BA. No relationship was found between the thinning effect of BA and its effects on seeds. Ethylene evolution was not excessively increased after BA application, and may have, therefore played a minor role inducing fruit abscission. One week before June drop IAA export of BA treated fruit was on average reduced by 61 % compared to untreated control fruit. This indicates that BA may thin fruit by reducing their IAA export. It is further assumed that this reduction is caused by an increased IAA synthesis in primary spur leaves and associated bourse shoots leading to an autoinhibition of the fruit IAA transport. A detailed description of this model will be presented.

**1540-1600****S13-0-93****EFFECT OF TIMING OF CHEMICAL FRUIT THINNING OF APPLE DURING COOL SPRINGS ON CROPLoad, FRUIT SIZE AND RETURN BLOOM**

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Field studies were conducted in 2000 and 2001 with 6 and 7-year old 'Gala', and 'McIntosh' trees on M.9 rootstock and 'Delicious' apple trees on M.26 rootstock, where single application sprays of a tank mix of 75 mg/L of 6-benzyladenine(BA) (formulation VBC-3001) plus 600 mg/L of Carbaryl (formulation Sevin XLR Plus), or 7.5 mg/L of Naphthaleneacetic Acid (NAA) (formulation Fruitone N) plus 600 mg/L of Carbaryl were applied at 3 or 4 day intervals beginning at petal fall until 28 days after petal fall. Trees were sprayed with an airblast sprayer at 935 L/ha using a 2X concentration of chemicals. Calculated tree row volume was 1,870 L/ha. In both years a prolonged cool post petal fall period resulted in slow fruit growth rate and poor thinning during the traditional thinning window. Thinning effectiveness was poor when fruits were smaller than 15 mm and improved when fruits were relatively large between 15 and 20 mm. In 2000, this later period coincided with a warm period but in 2001 this coincided with one of the coolest periods during the experiment. It appears that in cool years, the applications of fruit thinning chemicals should be delayed until fruits are relatively large. These results are in contrast to our longstanding theories about fruit thinning and temperature and our general recommendation that NAA or BA be applied between 7 and 12 mm king fruit size. A possible explanation is that in cool years when fruit growth after petal fall is slow, carbohydrate reserves used to supply fruit growth are not reduced to a low level where the mild stress from chemical thinners applied under cool conditions would cause some fruits to abscise. In such years a relatively large fruit size is required before reserves are at a low point where they are most susceptible to chemical thinners. These results indicate that in cool years it is better to wait for relatively large fruit sizes before fruit thinners are applied.

**1600-1620****S13-0-94****CHEMICAL AND ENVIRONMENTAL EFFECTS ON APPLE FRUIT ABSCISSION PATTERNS AND FRUIT GROWTH**

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The influence of light and thinning chemicals on fruit abscission patterns of 'Royal Gala' apples during the first 10 weeks after bloom, and subsequent fruit growth was investigated over two growing seasons in Hawkes Bay, New Zealand. Whole trees were thinned with flower (NAA, lime sulphur) and/or fruitlet thinners (carbaryl, Cylex, lime sulphur) applied either alone or preceded by a shade treatment (75%) either five (2000/2001 season) or three three (2001/02 season) days in duration. Additional trees received a shade only treatment at the same time. Shade and chemical thinning treatments induced a range of fruitlet abscission patterns with variable effects on fruit growth and fruit size potential. Fruit abscission tended to occur in two waves, the first wave peaking two weeks after full bloom (FB) and the second 8 weeks after FB. The first wave of fruit abscission was more intense following application of NAA at full bloom and resulted in faster rates of dry matter accumulation during the period from 30-70 days after full bloom (DAFB). Shading trees for five days from 35 DAFB resulted in an intense wave of fruit abscission 7 weeks after full bloom and reduced the rate of dry matter accumulation during the period from 30-50 DAFB compared to the control. However, fruit dry matter at harvest was not significantly different from the control. These responses will provide baseline data for incorporation into a prototype, orchard scale model for prediction of fruit growth and size distribution.

**1620-1640****S13-0-94-A****TO BE ANNOUNCED****1640-1700****S13-0-94-B****TO BE ANNOUNCED****1100-1140****S13-0-95****FRUIT DEVELOPMENT AS AFFECTED BY PHYSIOLOGICAL FACTORS AND ENVIRONMENTAL CONDITIONS**Luca Corelli-Grappadelli<sup>1</sup>, Alan N. Lakso<sup>2</sup><sup>1</sup>Dipartimento di Colture Arboree, Sciences, Univ. of Bologna, V.F. Re 640126 Bologna, Italy; <sup>2</sup>Dept. of Horticultural Sciences, Cornell Univ., NYS Agric. Exp. Station, Geneva, NY 14456, USA

This paper focuses on the processes occurring in the fruit between the stages of fertilization and harvest, with particular emphasis on some physiological, energetic and modelling aspects affecting the growth of this organ. As fruit transition from flower to actively growing fruitlets, cell division sets the bases for final fruit size, which is the result of the product cell number x cell volume. If cell volume is relatively constant, a fruit with more cells should be larger at harvest. The importance of the cell division phase has been confirmed in apples that show a correlation between fruit growth during this early stage and final fruit size. Fruit growth rates have in turn been correlated to daily temperature regimes: warmer temperatures can induce faster growth in the initial stages, and can thus result in larger fruit at harvest. Cell volumes may also vary in fruits adding variation to final size. The interplay of length of season and temperature regimes needs to be evaluated along with other factors that influence this process, such as the type of leaves that support fruit growth, the light microclimate, crop load, vegetative growth and changes in the fruit anatomy/physiology. Along with endogenous hormones and nutrients involved in the control of fruit growth, the plant carbon balance and water relations play a major role. The energy requirements for fruit growth indicate the cost of production of these organs, which is more or less constant per fruit during the growing season, despite the fact that, depending on the type of organ (i.e. stone vs. pome fruit), the specific cost of production of different tissue components (e.g. mesocarp vs. endocarp or seed proper) vary widely. The cost of production of organs is useful as it provides a uniform expression for comparison to photosynthetic energy production. In conclusion, there are many factors capable of influencing the growth of the fruit, and also the quality attributes that the fruit attain after harvest. Knowledge and integration of these factors is important if the goal is to produce large amounts of top quality fruit.

**1140-1200****S13-0-96****TEXTURE DEVELOPMENT IN APPLE FRUIT—A BIOPHYSICAL PERSPECTIVE**R.K. Volz<sup>1</sup>, F.R. Harker<sup>\*2</sup>, A. Lang<sup>3</sup>, I.C. Hallett<sup>4</sup><sup>1</sup>Horticulture and Food Research, Institute of New Zealand, Hawkes Bay Research Centre, Havelock North, Hawkes Bay, New Zealand; <sup>2</sup>Research Institute of New Zealand, Mt Albert Research Centre, Private Bag 92169, Auckland, New Zealand; <sup>3</sup>Research Institute of New Zealand, Palmerston North Research Centre, Private Bag 11030, Palmerston North, New Zealand; <sup>4</sup>Research Institute of New Zealand, Mt Albert Research Centre, Private Bag 92169, Auckland, New Zealand

Consumer preferences for apples are strongly influenced by fruit texture. Sensory perception of texture is related to attributes that are perceived during chewing such as hardness (–effort/force exerted), crispness (–sound generated), and juiciness. All of these attributes are determined by the structure of cells and tissues in the cortical zones of the flesh. Not surprisingly, considerable research effort has been devoted to understanding texture change in relation to concurrent changes in tissue structure and composition. However this work has mostly been concerned with ripening-mediated fruit softening, and often after harvest. Many of the properties of the individual cortical cell, its constituent parts and its relationship with its neighbours are determined well before ripening begins. Cortical tissue puncture force was measured throughout fruit growth with probes of different sizes and compression forces estimated. Puncture force at maturity was also compared for different sized fruit from the same tree, for fruit grown in warmer or cooler regions of New Zealand, and for fruit from trees with heavier or lighter crop loads. Tissue cell densities, cell volumes and cell packing arrangements were also measured. Using this and other data, we explore some of the relationships between instrumental/sensory measures of texture and the biophysical construc-

tion of the tissue. Regulation of cell division, cell expansion and cell packing should be thought of as having relevance not only to final fruit size but also to final texture and other fruit quality attributes.

**1200-1220**

**S13-0-97**

**EARLY APPLE FRUIT DEVELOPMENT AND SORBITOL DEHYDROGENASE**

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Accumulation of sorbitol by developing apple fruit is critical to achieving size and quality. The primary enzyme involved in sorbitol accumulation is NAD-dependent sorbitol dehydrogenase (SDH; EC 1.1.1.14), converting sorbitol to fructose. SDH activity varies seasonally but can be manipulated by altering sorbitol availability. Possible transcriptional and translational regulation of SDH activity are being studied. Using activity assays and an SDH-specific antibody, an analysis of seasonal variation has revealed SDH activity and protein immediately following bloom, during the critical fruit set period. This is in addition to previously reported SDH activity peaks at 6 to 8 weeks after bloom and at ripening. Does the presence of SDH at this early time, not previously reported, have significant implications with respect to fruit set in apple? Transcriptional and translational regulatory aspects of SDH activity at each peak period will be compared.

**1220-1240**

**S13-0-98**

**TEMPERATURE EFFECTS ON FRUIT GROWTH, SHOOT GROWTH AND GAS EXCHANGE IN THE APPLE**

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Temperature is a main environmental factor affecting the net carbon exchange, carbon balance and carbon partitioning in the apple tree. However, temperature effects on growth and productivity are extremely complex since almost all processes are affected. Although shoot and fruit growth and gas exchange have been correlated to temperatures in several studies, this research began to simultaneously document the effects of temperature on key growth and physiological processes at different stages of fruit development. Experiments on potted 'Royal Empire' apple trees were conducted in controlled-environment chambers to examine temperature effects on growth and gas exchange. Four day/night temperature regimes were used for several days about every 30-45 days along the fruit development period starting 17 days after full bloom (DAFB). The temperature regimes were 12/7, 19/14, 26/21 and 33/28 °C. Relative humidity and light were constant at 80% and 14-hour daily light of about 950  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$  PAR at the top of the trees, respectively. The results indicate that fruit growth is highly sensitive to temperature early in the season, but significantly less responsive later. The greatest fruit and shoot growth occurred in the regime of 19/14 °C, and the lowest growth rates were recorded with the highest temperature (33/28 °C). In early August and mid September (82 and 129 DAFB, respectively), fruit growth did not respond significantly to temperature. The highest leaf net photosynthesis was observed when the leaf temperature was 22-27 °C, and it was reduced with the lowest and highest temperature treatments. Fruit respiration increased in an exponential response to temperature. The results reveal a greater sensitivity of fruit growth to temperature during early development stages. It is not clear whether the impact of high air temperature on potted trees was related to temperature only, to temperature-induced water stress or high soil temperature.

**1340-1440**

**S13-P-99**

**APPLICATION OF POLYPLOIDY TO CRANBERRY BREEDING AND BIOTECHNOLOGY**

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The development of polyploid cranberry (*Vaccinium macrocarpon*) was pursued to exploit the potential for improved fruit size and flower bud set. In addition, polyploidy may provide a method to reproductively isolate transgenic cranberry. Colchicine-induced polyploids were produced in vitro using an inverted stem technique. With a 24-hour treatment of 0.1 to 1% colchicine, up to 100% of

treated microshoots yielded at least one recovered polyploid plant. Polyploid status of the resulting plants was verified by increased stem, leaf, flower and pollen tetrad size. Colchipooids of the prominent cultivar 'Stevens' lacked any useful fertility, but colchipooids of 'Pilgrim' and 'HyRed' (a recently released 'Stevens' x 'Ben Lear' selection) yielded some fertility. First and second generation inbred and outcrossed progeny of these are being evaluated both in the greenhouse and in the field. Initial greenhouse results indicate some individuals have high levels of self-fertility with large fruit size. A parallel cross between the 'HyRed' colchipooid and a colchipooid of a bar-transformed 'Pilgrim' (tolerant to glufosinate herbicides) has produced some self-fertile progeny. Greenhouse tests have found that some fruit and seeds can be produced when pollen from these plants was used to pollinate untransformed diploid plants. Even if herbicide-tolerant triploid plants are produced from diploid/tetraploid crosses, previous experience with triploids of cranberry has found no fertility when self-pollinated or pollinated with pollen from diploid plants. Verification of a lack of fertility in polyploid to diploid crosses would allow the planting of transgenic polyploid cranberry without the risk of transfer of introduced genes to either conventional cranberry crops or native cranberry populations.

**1340-1440**

**S13-P-100**

**EXAMINING THE INFLUENCE OF DIFFERENT LEAF POPULATIONS ON SWEET CHERRY FRUIT QUALITY**

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Sweet cherry (*Prunus avium* L.) fruit quality is highly dependent on carbohydrate (CHO) availability and translocation, which in turn are dependent on the number and strength of competing sinks as well as the proximity of source leaves. Understanding CHO partitioning and source-sink relationships might lead to better management strategies for sweet cherry fruit quality. In May 2001, on fruiting branches of 'Hedelfinger/Gisela 5' and 'Ulster/Gisela 6' sweet cherry trees, we established six limb treatments to isolate the various leaf populations that serve as CHO sources for developing fruit: C, untreated control; T1, branch girdled at its base (i.e., isolation from the rest of the tree); T2, branch girdled at both sides of the wood bearing newly-fruiting spurs (i.e., CHO source = fruiting spur leaves only); T3, branch girdled at its base and at the tip of previous season shoot growth (i.e., CHO source = fruiting and non-fruiting spur leaves); T4, branch girdled as in T3 plus removal of fruiting spur leaves (i.e., CHO source = non-fruiting spur leaves); T5, branch girdled as in T3 plus removal of non-fruiting spur leaves (CHO source = fruiting spur leaves). For both scion/rootstock combinations, fruits from T1 were larger and had higher soluble sugars (SS) than the other treatments. Conversely, fruits from T2 and T4 were significantly smaller and had decreased SS levels. The leaf populations on either fruiting spurs alone or non-fruiting spurs alone (T4) were insufficient sources of CHO for optimal fruit development. Neither population fully compensated for the lack of the other. Both fruiting and non-fruiting leaves were required for full fruit development. The implications of these results and the future possible approaches to further elucidate sink-source relationships and CHO partitioning in sweet cherry will be discussed.

**1340-1440**

**S13-P-101**

**EFFECT OF GIBBERELIC ACID DURING DEVELOPMENT OF SWEET CHERRY FRUIT: PHYSIOLOGICAL AND MOLECULAR CHANGES**

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Sweet cherry (*Prunus avium* L.) fruit respond to treatment with gibberellic acid by a delay in ripening date and increased firmness at maturity. In the Pacific Northwest of North America this effect is utilized commercially to enhance fruit quality for a significant quantity of production. The present study investigates the relationship between date of ripening and fruit softening and the differential effects of gibberellic acid treatment on early and late maturing cultivars. Four sweet cherry genotypes producing fruits characterized as early/soft ('Merpet'), early/firm ('Celeste'), late/soft ('13S-27-17') and late/firm (Lapins) were evaluated for differences in fruit growth, firmness, hydrolytic enzyme activity and gene expression with or without gibberellic acid treatment. The fruit developed in three distinct stages after fertilization corresponding to the stan-

ard Prunus profile (cell division, lag phase, cell enlargement). Fruits on early maturing genotypes had a shortened period in lag phase compared to the late maturing cultivars. Fruit firmness increased from the earliest green-coloured stage (about 5 mm in fruit diameter) until the middle of lag phase, then decreased rapidly and continuously from that stage throughout maturation. Application of 20 mg l<sup>-1</sup> GA<sub>3</sub> decreased the rate of fruit softening and delayed fruit maturity 5-8 days only for the two late-maturing genotypes, but had no significant effect on early maturing fruits. The activities of the enzymes; polygalacturonase, pectinmethylesterase, carboxymethylcellulase, β-galactosidase, and β-glucosidase were compared throughout fruit development. These results will be discussed with respect to phenological stages of fruit growth and duration of fruit development.

**1340-1440**

**S13-P-102**

**NPA, SEED SET AND XYLEM DEVELOPMENT IN APPLE STALKS**

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In apple, good calcium nutrition is essential to good storage quality. Calcium enters the fruit exclusively via the xylem and only during the first half of the season before growth-induced stretching within the flesh renders the xylem dysfunctional. It is a plausible hypothesis that the more xylem is differentiated, the greater will be its conductance and the more calcium will enter the fruit. In apple, the stalk lengthens rapidly over a 3-week period just before bloom. It reaches its final length by about 2 weeks after petal fall. The majority of xylem vessels in the stalk are laid down before bloom during the extension phase but these vessels are of small diameter (protoxylem). The larger vessels that are more important to xylem sap conductance are produced mainly after pedicel extension is complete and only during the first 3 or 4 weeks following bloom. From then on, very few more vessels are differentiated and the potential conducting capacity of the stalk xylem is substantially complete. Studies of xylem development were made as a function of seed set. These show that the final conducting capacity of the stalk xylem is related to seed weight—higher seed weight is reflected in the development of more and larger vessels. An auxin transport inhibitor, NPA, was applied to stalks of Granny Smith apples 3 days after petal fall. Analysis of the stalks using a video light-microscope technique revealed that NPA suppressed the differentiation of the larger vessels, especially downstream of the point of application. We reasonably infer that the stimulus for vessel differentiation in the stalk is the basipetal diffusion of a natural auxin. Also that, very early on, this auxin is produced (at least in part) by the developing seeds. The familiar relation between seed set and fruit storage quality in apple is thus partially explained.

**1340-1440**

**S13-P-103**

**EFFECTS OF HARVEST TIME ON QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF PISTACHIO NUT**

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Harvesting time is one of the important factors that affects the quantitative and qualitative characteristic of pistachio nuts. This time can be varied by cultivar, rootstock, soil structure, nutrition, irrigation and weather conditions. Usually, pistachio harvesting begins from August 5 to October 20 in Iran. Harvesting of nuts before or after maturity causes the development of, shrunken and low weight kernels or coloured shells, respectively. In this study the effects of different harvesting times from August 5 to October 20 with 15 days duration and delays in processing of 0, 2, 12, 24 and 48 hours were evaluated on Ohadi pistachio cultivar grown in Kerman conditions. A randomised complete-block design (split plot) was used and means compared by Duncan's test. Results showed that delaying the nut harvest causes beneficial increases in size, splitting, sugar and fat content percentages of the kernels, but deleterious increases in over-maturity, colored shells and tatter hull percentage. By delaying processing, sugar rate decreased and colored nuts increased, but fat, ounce (nut size) and splitting percentages were constant.

**1340-1440**

**S13-P-104**

**THE POSITIVE INFLUENCE OF YEAR-ROUND REFLECTIVE MULCH ON APPLE YIELD AND QUALITY IN COMMERCIAL ORCHARDS**

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In N. America reflective mulches are used, over short preharvest periods, to enhance quality of apples and peaches particularly with regard to anthocyanin-based colouring. In a European system for apples, similar mulches typically are left on the orchard floor over several seasons and the present study has shown significant increases in fruit number and harvest weight resulting from this treatment. Influences on colouring were not always significant and may depend upon seasonal conditions. The harvest date was advanced and the number of times individual trees were picked reduced from 3 to 2 as a result of mulching. The spectral quality of incident and reflected radiation and its interaction with canopy architecture have been considered to derive an explanation for these benefits and for observed developmental changes in the trees and fruit. Revised management strategies for commercial orchards employing reflective mulches are also suggested.

**1340-1440**

**S13-P-105**

**CELLULOSE SYNTHESIS IN HARDENING ENDOCARP OF PEACH FRUIT**

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During peach fruit development, the endocarp becomes hard. The process may be followed by the secondary cell wall thickening and lignification, however, little is known about it. We isolated a clone putatively encoding cellulose synthase (PpCesA1) from peach fruit and investigated the relation to the endocarp hardening. PpCesA1 putatively encodes 1069 amino acids and estimated molecular weight is 120.9 kDa. The sequence is closely related to Arabidopsis cellulose synthase (AtCesA7) that is required to the secondary wall cellulose synthesis. Northern blot analysis showed that PpCesA1 mRNA was accumulated in endocarp during the hardening but not in mesocarp or pericarp, suggesting that PpCesA1 has a role in cellulose synthesis during endocarp hardening. The changes in cellulose content and lignin content of endocarp and other tissues of fruit during the endocarp hardening were also investigated.

**1340-1440**

**S13-P-106**

**EFFECT OF CLIMATIC AND SOIL CONDITIONS ON THE CONTENTS OF SUGARS AND ORGANIC ACIDS IN PEAR FRUITS (*PYRUS COMMUNIS* L.) OF THE CVS. 'WILLIAMS' AND 'CONFERENCE'**

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The research work reported here was carried out to investigate the effects of climatic and soil conditions on sugars (glucose, fructose, sucrose and sorbitol), soluble solids and organic acids (malic, citric, fumaric and shikimic) of the pear fruits (*Pyrus communis* L.) cvs. 'Williams' and 'Conference'. The contents of individual sugars and organic acids are very important indicators of internal fruit quality. We determined the contents of individual sugars and organic acids with HPLC (High Performance Liquid Chromatography) at harvest. The experiment comprised three growing regions in Slovenia: Kr\_ko (south-east of Slovenia), Bistrica ob Sotli (east of Slovenia) and Kamnik (north of Slovenia). The region (soil and climatic condition) had a statistically significant effect on the internal quality of the pear fruits cvs. 'Williams' and 'Conference'. The highest amounts of glucose, fructose, sorbitol and soluble solids and also the lowest contents of malic, citric, fumaric and shikimic acids were observed on cv. 'Williams' at Bistrica ob Sotli. The highest content of sucrose, malic, citric and shikimic acids and the lowest contents of sorbitol and soluble solids were observed at Kr\_ko. The content of glucose, fructose and sucrose were the lowest in Kamnik. On cv. 'Conference' the content of glucose, fructose, sucrose, malic, citric and shikimic acids were the highest at Kr\_ko. The lowest content of fructose, sucrose, sorbitol, soluble

solids, malic and shikimic acids were on cv. 'Conference' at Bistrica ob Sotli.

**1340-1440**

**S13-P-107**

**PROPERTIES OF VARIOUS FRUIT BAGS AND THE EFFECTS ON COLORATION AND QUALITY OF PEACH FRUITS IN RAIN-PROTECTIVE CULTURE**

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Properties of various fruit bags made of newspaper, white paper, yellow paper, coated yellow paper, gray paper, and black paper, and the effects on coloration and quality of 'Nagawawa Hakuto' peach fruits in rain-protected culture were studied. Light transmittance of new bags was in the order of white paper > yellow paper > coated yellow paper > newspaper > gray paper > black paper, and this trend was maintained till harvest time. The inner temperature of bags was in the order of white paper > gray paper > coated yellow paper > yellow paper > black paper > newspaper, and that of humidity was in the order of yellow paper > gray paper > black paper > white paper > coated yellow paper > newspaper. The kind of bags did not affect fruit weight. Fruit width was increased by black paper bags and fruit height was higher in the controls, while significant differences in the fruit shape index were not observed. Fruit firmness was higher (1.44 kg/5 mmf) in newspaper bagged fruit while that of white paper bag was low (1.01 kg/5 mmf). Soluble solids and titratable acidity were higher with respective black paper bag and gray paper bag, but sugar/acid ratio was higher with white paper bag. Fruit maturity was a little enhanced by the white paper bag (August 2), and the difference compared with the black paper bag that delayed maturity most was only 4 days. White paper bagged and unbagged control fruits showed low Hunter L\* values (43.62-44.27) and high Hunter a\* values, while yellow paper bag increased the Hunter b\* values. The percentage of damaged fruits in unbagged controls was 8-11% higher than that of bagged fruits regardless of the kind of bags.

**1340-1440**

**S13-P-108**

**FREE SUGARS OF PEACH FRUITS AS AFFECTED BY CROPPING SYSTEM**

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The composition and content of 'Baekmijosaeng', 'Kurakata Wase', 'Sunago Wase', and 'Yumyeong' peach fruits as affected by three cropping systems, such as heating (electric heating cable embedded in water-filled thermo-keeping PE film bag), nonheating (water-filled thermo-keeping PE film bag), both in two layer plastic house, and in the open control, were tracked bi-weekly from full bloom to harvest. Fruit fructose and glucose content decreased in various patterns as fruit developed. The content of fructose and glucose showed a gradual decrease in 'Baekmijosaeng'. The fructose content of heated and control 'Kurakata Wase' and 'Sunago Wase' peaches showed a gradual increase till 6 weeks after full bloom (WAFB) then decreased thereafter, while that of nonheated peaches increased again 8 WAFB. In 'Yumyeong', decreases in the contents of fructose and glucose continued till 6 WAFB (nonheating and control) or 10 WAFB (heating), and after showing a peak at 12 WAFB, decreased again thereafter. The glucose content of nonheated peaches exhibited an increase-decrease pattern. Sucrose content increased with fruit development and maturity regardless of cropping system and cultivar.

**1340-1440**

**S13-P-109**

**EFFECT OF FERTIGATION WITH CALCIUM SOLUTIONS ON THE SOIL PROPERTIES, TREE GROWTH AND FRUIT QUALITY IN APPLE**

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Several physiological disorders such as bitter pit and core breakdown of apple

fruits and preharvest drop are induced by Ca-deficiency, which also causes the decline of fruit qualities. This study was conducted to investigate the effect of calcium chemical compounds for preventing the Ca-deficiency symptoms that occur on acid apple orchard soils. 'Tsugaru' apple trees were treated by scattering calcium chloride (1.0 kg/tree), lime (2.0 kg/tree) and by fertigation of 5% CaCl<sub>2</sub> solution (19.44 KL/ha), organic calcium extracted from oyster shells (19.44 KL/ha) and Mulfure (N-P-K, 7:0:3 w/w/w, 9.5% soluble calcium, 3.0% soluble potassium) on 22 May, 21 June and 27 July 2001. The sample fruits were harvested on 26 August. For mineral analyses, the leaves were sampled from the middle parts of 30 to 40cm shoots. The fruit was divided into peel, flesh and core, and then measured for K, Ca and Mg contents. In addition, the cation exchange contents and pH of the soils was measured, as well as root activity and fruit characteristics. The soil analysis showed that the treatment involving scattering of CaCl<sub>2</sub> increased the Ca contents (4.12 me/100 g) compared with the untreated control (2.83 me/100 g) at 30 and 15?? soil depth. Also Ca contents in fruit and fruit firmness were higher in this treatment with CaCl<sub>2</sub>, while Mg and K contents were not influenced by the treatment. There was little effect on the Ca content in leaves compared to controls. Mg and K contents were higher in the Mulfure treatment than in the other treated groups. As a conclusion of the study, CaCl<sub>2</sub> scattered on the soil increased Ca contents in fruits and maintained the fruit firmness after harvesting, as well as giving higher fruit quality and lower preharvest drop.

**1340-1440**

**S13-P-110**

**BOURSE SHOOT INFLUENCE ON FRUIT GROWTH AND DEVELOPMENT, SUGARS, FIRMNESS AND CALCIUM IN APPLES**

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This study was conducted to investigate the effect of bourse shoots on the fruit growth and development, minerals and quality of apples. Three hundred bourse shoots bearing fruits were selected on 10 trees randomly in the experimental orchard of Chonnam National Univ., Naju, west southern Korea. Bourse shoot length and diameter were measured at two times on 20 July and 20 August. Harvested fruits were divided into 6 groups according to bourse shoot length; 0 cm, 1 to 10 cm, 11 to 20 cm, 21 to 30 cm, 31 to 40 cm, and longer than 41cm, respectively. The fruit characteristics, soluble solid content, flesh firmness and acidity, were measured just after harvest. The mineral contents of Ca, Mg and K were analyzed in fruit peel, flesh and core tissues. Most bourse shoots stopped growing in late June, while water-sprout shoots stopped in late July. Results showed that fruit L/D ratio were higher when bourse shoots were 30 to 40 cm in length. Soluble solid content and fruit firmness were higher in the fruits of 21 to 30 cm in bourse shoot length. Also calcium contents of the fruit were higher when the length of bourse shoots was 21 to 30 cm in flesh and skin tissues, although no significant differences in the other minerals were observed.

**1340-1440**

**S13-P-111**

**CHANGES OF JASMONIC ACID DURING RIPENING IN PEAR FRUIT AND INTERACTIONS BETWEEN JASMONIC ACID AND ABSCISIC ACID**

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Changes of jasmonic acid (JA) during ripening in 'La France' pear fruits (*Pyrus communis* L.), and interactions between JA and abscisic acid (ABA) were investigated. Endogenous JA and ABA were analyzed using gas chromatography-mass spectrometry (GC-MS). Interactions between JA and ABA were examined using fruit discs. Although JA increased rapidly after harvest [165 days after full bloom (DAFB)], it did not coincide with the changes of internal ethylene concentrations. Since ethylene production in the discs was not induced by the JA treatment, the increase of JA after harvest may have been caused by the environmental stress after harvest. The discs from pulp excised 160 DAFB (preclimacteric) and 174 DAFB (9 days in storage; climacteric) were collected and placed in petri dishes including a 0.4 M mannitol solution with a combination of JA, ABA and aminoethoxyvinylglycine (AVG). JA and ABA concentrations in the discs were measured at 0, 24, 48 and 72 hr after the initiation



of treatment. At the preclimacteric stage, JA treatment decreased endogenous ABA concentrations, but AVG had no effect. This result suggests that JA may influence endogenous ABA synthesis separately from ethylene. At the climacteric stage, the ABA treatment increased endogenous JA concentrations and decreased it when combined with AVG. This result also demonstrates that ABA may influence endogenous JA synthesis via ethylene.

**1340-1440**

**S13-P-112**

**MECHANICAL PROPERTIES OF APPLE ESSENTIAL IN RESPECT TO DAMAGE**

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Apple is produced in one of the largest volume of fruits in Hungary. The damage determined mechanical properties are situated in significant point amount all quality features. If we know them, we can design the different process (eg. transport, packing, post harvest technologies). The solving of impact problem (Boussinesq) with a good rheological model (Poynting-Thomson) is the base of our theoretical method. We expanded our results to investigation of transported apples (eg. in big box). The main results are: 1) The mechanical situation of apples can be characterized with a good described area. 2) The features of damage aren't like points, but like an area. 3) We have given the firmness of Hungarian varieties depending of this one on the place of fruit surface, changing of the firmness depending on growing and storage temperature. 4) We give a model for determining the bruise of apple transported in crate in different circumstances. Our method can be used with different fruits which are similar to apple.

**1340-1440**

**S13-P-113**

**STUDIES OF THE "TREE FACTOR" AND ITS ROLE IN THE MATURATION AND RIPENING OF 'FUJI' APPLES**

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Experiments were conducted to study the tree factor (TF), an unknown compound or compounds that is hypothesized to be synthesized in apple leaves and transported via the phloem to apple fruits. It is thought to inhibit ripening by suppressing ethylene biosynthesis or reducing the fruit tissue's sensitivity to ethylene. This research was designed as a two rootstock by four treatment factorial. Four limbs on each 'Fuji' apple tree (*Malus x domestica* Borkh), budded onto either M 7a or MM 111 rootstock were treated 140 days after bloom. Treatments included ringed+defoliated, ringed+urea spray, ringed+terbacil spray (a photosynthesis inhibitor), and an untreated control. In comparison with other treatments, the loss of starch and the change in red color of apples attached to ringed+defoliated limbs occurred earlier; however, fruits from this treatment had the lowest internal ethylene content (IEC) at 170 days after bloom. Ringing combined with either urea or terbacil spray enhanced apple growth. The weight, diameter, and soluble solids content of apples grown on M 7a rootstock were significantly higher than on MM 111. Nevertheless, attached apples from trees on both rootstocks had a similar IEC. Interestingly, the IEC of all samples doubled following the first frost at around 170 days after bloom. At that time, the IEC was still below 1 mL/L. In a simultaneous storage study, 25 percent of the apples ripened (IEC more than 15 mL/L) after storage at 20 °C for 10 days. Our results showed that ringing and defoliation reduced fruit growth, enhanced red color and stimulated starch degradation without a concomitant increase in IEC. Ongoing research in our lab relating ethylene biosynthesis and carbohydrate changes in 'Fuji' apples will also be presented.

**1340-1440**

**S13-P-114**

**ANALYSIS OF FRUIT SIZE CONTROL IN APPLE USING LARGE FRUITED MUTANTS**

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Achieving good fruit size is a primary objective of fruit growers the world over. Two large fruited mutants of 'Gala', 'Grand Gala' and 'Big Red Gala' were used as part of an on-going study to understand the mechanism of fruit growth in apple. Studies over the 2001 season showed that the diameter of 'Grand Gala' fruit was 7.5 mm larger than the 'Gala' fruit resulting in an increase in fruit volume by over 33%. The length to diameter ratio of the fruits was not affected indicating that the shape of the fruit was the same. Fruit weight at harvest was increased by almost 40%. All the increase in size was restricted to the fruit cortex with no effect on the core volume. Fruit development patterns of 'Grand Gala' showed that the difference in size was established as early as full bloom as the relative growth rate (RGR) patterns were not significantly different. In contrast, 'Big Red Gala' showed early significant differences (during the cell division phase) in RGR leading to a 22% increase in harvest fruit diameter. The sorbitol absorption rate of the fruit cortex tissue in 'Grand Gala' was 60% higher than that of 'Gala', indicating greater sink strength. The spur and bourse leaves of 'Grand Gala' also had higher specific leaf weights. A parallel detailed analysis of fruit development in 8 different apple varieties revealed a strong correlation between the pedicel size and the fruit diameter. This suggests a role for the pedicel in controlling fruit size. These large fruited mutants present a good model system and further studies may help better understand the basis of fruit size control in apple.

**1340-1440**

**S13-P-115**

**WHAT CAUSES THE VASCULAR NODULES IN SOME GALA X SPLENDOR APPLE FRUIT?**

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Vascular nodules are unsightly, dark-green growths, up to 10 mm in diameter, found in the cortex of fruit of the apple cultivar GS 2085. They are found on the core side of the five 'sepal' vascular bundles marking the core line (they are very rarely associated with the alternating five petal bundles). Vascular nodules first appear around six weeks after fruit set. Their frequency of occurrence is quite variable between fruit and between bundles within a fruit. We hypothesised that nodule development may require the presence of a microbe, in the same way as occurs with root nodules and plant galls. Nodule tissue was extracted from GS 2085 fruit and plated on a glycerol nutrient-agar culture medium under sterile conditions. A bacterial culture grew from approximately 10% of plated nodules. Colonies were slow growing, orange in colour and convex in form. In all cases the bacteria were flagellate rods, around 2-3 mm long. 'Biolog' identification and analysis of DNA extracted from nine representative cultures suggests that a range of bacteria colonise the nodules. The most common is a strain that has some affinity with *Pseudomonas syringae*. Other strains isolated were tentatively identified as *Curtobacterium* sp., *Sphingomonas* sp. and *Erwinia herbicola*. No cultures developed from non-nodular fruit tissue plated out according to the same procedure. Fruit of GS 2085 were inoculated ten weeks after bloom with the *Pseudomonas syringae*-like strain at a concentration of 10.08 cells per mL by direct injection into the fruit flesh at a depth of 10 mm. Fruit were harvested after 20 weeks and nodule frequency was recorded. No significant difference in nodule frequency was found between the injected fruit and controls taken from the same tree. The origin and significance of a bacterial presence in nodules has yet to be established.

**1340-1440**

**S13-P-116**

**FRUIT GROWTH AND DEVELOPMENT PATTERN OF SOME IRANIAN APRICOT GENOTYPES UNDER GHAZVIN PROVINCE ENVIRONMENTAL CONDITIONS**

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Ghazvin province is one of the most important fruit production areas of Iran. The diversity in, climates and good soils as well as the large areas suitable for fruit culture give this Province a high potential for fruit tree culture and production. There is a strong limitation on pome fruit culture in this region of Iran, due to the wide spread of fire blight (*Erwinia amylovora*) disease and the

susceptibility of pome fruit trees. This situation has led to increases in stone fruit culture, such as apricot, sweet cherry, sour cherry and peaches. In order to select the superior genotypes in the breeding programmes, as well as to manage stone fruit orchards efficiently, it is necessary to have information on the growth and development patterns of fruits such as apricot. With this aim, this study was conducted to explore and clarify fruit growth patterns of eleven local apricot genotypes, grown at the Esmailabad Orchard of Ghazvin Horticultural Research Center. To evaluate fruit growth patterns, four mature trees were selected for each genotype. On each tree, eight fruit from the middle canopy zone were randomly sampled at the 10-day intervals, from 30 days after full bloom until fruit harvest. Some fruit characteristics, such as diameter, volume, and fruit fresh weight were measured. Also, in order to monitor pit hardening and embryo development, diameter, volume, and fresh weight of the endocarps (stones) and seeds (kernel) were measured. Results indicated that there are some differences in measured characters in the whole fruit as well as in the stones and seeds of the studied genotypes. The pattern of fruit growth of all genotypes in terms of measured characters monitored and will be discussed.

**1340-1440**

**S13-P-117**

**DISTRIBUTION AND TRANSLOCATION FORMS OF PHOTOSYNTHATES IN 'HAYWARD' KIWIFRUIT**

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Distribution of photosynthates from leaves into stems and fruits was studied in current year fruiting shoots of 'Hayward' kiwifruit that were exposed to 14 CO<sub>2</sub> at different stages of fruit growth [approximately 30, 60 and 80 days after full bloom (DAFB)]. The stem, fruits and leaves were sampled 24 hours after 14 CO<sub>2</sub> feeding and the 14 °C activities in the ethanol soluble fraction (ESF) and the ethanol insoluble fraction (EIF) were measured. ESFs in stem, fruits and leaves were separated into individual compounds, and the 14°C activities were also measured. Distribution ratio of 14 °C in EIF in the fruiting shoot (stem+fruits+leaves) was about 20% at each growth stage. Distribution ratio of 14 °C in ESF in leaves was 99% at 30 DAFB, while in stem and fruits was 26% and 17% at 60 DAFB and 17% and 7% at 80 DAFB, respectively. In stem, fruits and leaves, the 14 °C included in the sugar fraction was mainly found in sucrose, glucose and fructose, and in the organic acid fraction was mainly citric acid and malic acid. However, the distribution ratio of 14 °C varied at different stages of fruit growth. Moreover, various 14 °C-compounds were used to clarify the form in which photosynthates were translocated from mesophyll to petiole at 144 DAFB. It was observed that one hour after the application of labeled sugars, organic acids and an amino acid to the mesophyll, translocation rates of sucrose and citric acid were fastest in sugars and organic acids. Fifty two % of sucrose, 22% of glucose, 3% of fructose, 84% of citric acid, 75% of malic acid and 96% of aspartic acid moved into the lateral vein without transformation, while 62% of glucose and 66% of fructose transformed into sucrose. These results suggest that the translocation of photosynthates from leaf to fruit in 'Hayward' kiwifruit mainly occurs in the form of sucrose, while it might be in the form of sugars, organic acids and amino acids.

**1340-1440**

**S13-P-118**

**QUALITY OF THE COMMERCIAL IRANIAN PISTACHIO NUTS AS AFFECTED BY TIME OF HARVEST**

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One of the most important factors affecting quality of pistachio nuts is time of harvest. Occurrence of early splitting in pistachio fruits is one of the considerable problems in orchards. These split fruits cause contamination of yield with the *Aspergillus* sp. fungus. The kind of cultivar and time of harvest are important factors determining early splitting and quality of yield. This study was carried out on four commercial Iranian pistachio nut cultivars. A factorial design was laid out at Rafsanjan/Iran in 2000 and the results for a period of 2 years from 2000 to 2001 are presented. Percentage of hulling, blank and immature fruits, early splitting, splitting, non-splitting, hull splitting, number of

nuts per 100 g dried nuts, kernel/nut ratio, kernel humidity, sucrose, oil and finally content of aflatoxin B1 and B2 were measured. Almost all the quality differences between cultivars were associated with time of harvest and their differences were significant. "Ahmad-Aghaei" was shown to be substantially better quality than the other cultivars. The end of September was determined as the best time of harvest.

**1340-1440**

**S13-P-119**

**EFFECT OF PARTICLE FILM ON FRUIT SUNBURN, MATURITY, AND QUALITY OF 'FUJI' AND 'HONEYCRISP' APPLES**

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Studies were initiated to evaluate the effects of a kaolin clay particle film product on fruit sunburn, size, color and maturity of 'Fuji' and 'Honeycrisp' apples and fruit mineral concentration of 'Fuji'. Trees in both studies were sprayed with kaolin clay (Surround, Engelhard Corp., Iselin, N.J.) at the rate of 56 kg/1870/L. In Idaho, six-year-old 'Fuji' apple trees on M.26 EMLA and B.118 rootstocks were sprayed with kaolin clay on 10, 17, and 24 July 2000. The experimental arrangement for each rootstock was a completely randomized design with 8 replications. In New York, six-year-old 'Honeycrisp'/M.26 EMLA apple trees were treated as follows: 1) untreated control; 2) kaolin particle film applied weekly from 15 May to 26 June; 3) kaolin particle film applied weekly from 6 July to 17 Aug. Treatments were arranged in a randomized complete block design with six replications. Kaolin particle film reduced fruit weight, red color, and the incidence of sunburn of 'Fuji' apples in Idaho. Sunburn did not occur on 'Honeycrisp' in the New York study. In that study, kaolin particle film had no effect on fruit weight or red fruit color when applied in May and June but reduced fruit weight and red color when applied later. Applications of kaolin particle film in July and August (New York) reduced both the proportion of the skin surface that was red, and also the red hue on the blushed portion of the skin. The reduction in red color development observed in 'Fuji' and 'Honeycrisp' was not related to a change in mineral nutrient concentration or to a delay in fruit maturity. Reductions in fruit color and size in our study are possibly due to an increase in the amount of reflected light, resulting in shading of the leaves and fruit. Based on our results, growers who choose to use kaolin particle film sprays to reduce sunburn should recognize that applications later than June may reduce red fruit color of apples and result in smaller fruit.

**1340-1440**

**S13-P-120**

**SYNTHETIC CYTOKININS INCREASES FRUIT SIZE OF 'ROYAL GALA' (*MALUS DOMESTICA*) APPLE IN ISREAL**

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The final fruit size of apple depends on the number of cells present at fruit set, the subsequent number of cell divisions and the extent to which these cells expand. However, cell division during the early stage of fruit development has a major influence on final fruit size. Studies with synthetic cytokinins CPPU and BA have shown promising results in controlling fruit growth of grape, kiwifruit, persimmon and pear, but in apple the fruit becomes malformed. In Israel, the summer is very hot and dry. Therefore, the duration of the cell division stage is short, and consequently we receive small fruits, especially in the 'Royal Gala' apple. During 3 consecutive years (1999-2001) we found that the application of CPPU, [derived from phenylurea] at concentrations of 10-20 ppm, or BA [derived from purine] at a concentration of 50 ppm, two weeks after full bloom, increased the rate of fruit growth. The yield of harvested fruit >75 mm increased considerably and significantly (72-175% after CPPU application, and 56-82% after BA application) with no effect on fruit drop, fruit shape and seed number. Our findings demonstrate the effectiveness of CPPU and BA on 'Royal Gala' apple and indicate that they have a significant potential to improve fruit size without any negative effects. Preliminary results on 'Red Delicious' apple show that these cytokinins may be used for other varieties as well.

**1340-1440**

**S13-P-121**

**EFFECT OF KAOLIN APPLICATIONS ON APPLE FRUIT QUALITY AND GAS EXCHANGE OF APPLE LEAVES**

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Sunburn is a major problem in the apple industry in South Africa, with damage amounting to as much as 50% of the crop culled in the orchard. During the first year M-97-009 (100% kaolin) was evaluated for its efficacy to control sunburn on 'Royal Gala', 'Fuji' and 'Granny Smith' apples. It reduced sunburn on all three cultivars, although not significantly on 'Granny Smith'. In addition, it reduced snout beetle damage. During the second year Surroundä WP (95% kaolin) was applied to 'Cripps' Pink', 'Royal Gala', 'Fuji', 'Granny Smith' and 'Golden Delicious' apple trees in the Western Cape and no significant reduction in sunburn was observed. This could be due to extremely high temperatures experienced during this particular season. The effect of these foliar applications on canopy light conditions, net CO<sub>2</sub>-assimilation rate (A), stomatal conductance and transpiration rate in 'Cripps' Pink' trees was also determined. In addition to these spot measurements, photosynthetic light response curves were performed. Measurements were taken on both the inner and outer canopies. The applications significantly reduced A in the inner canopy under both stressful and non-stressful atmospheric conditions, but reduced A in the outer canopy only under non-stressful conditions when stomatal conductance was high. Apparent quantum efficiency of leaves on the outer canopy of treated trees was reduced, possibly indicating that coated leaves reflect more light, and thus have less light available for photosynthesis than uncoated leaves under the same external light intensity. No significant effect on visible light transmission was found.

**1340-1440**

**S13-P-122**

**EFFECTS OF LEAF AREA REMOVAL ON SWEET CHERRY VEGETATIVE GROWTH AND FRUIT QUALITY**

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We examined the effect of altered source-sink relationships in three-year-old branches comprised of current season's terminal shoot growth (SH), 1-yr-old, non-fruiting spurs (1YR), and 2-yr-old fruiting spurs (2YR) on 7-year-old 'Bing'/'Gisela 5' sweet cherry trees. Treatments were imposed by manually removing dormant vegetative buds (5 March, 2001), and consisted of unmodified control (C), and removal of, terminal shoot bud(s) (-SH), vegetative buds on 1YR or 2YR (-1YR, and -2YR, respectively), and, both SH and 1YR buds (2YRonly). In addition, any lateral shoot growth was removed in all treatments. At harvest, fruit weight and soluble solids (%) were determined. Shoot length, shoot and spur (1YR and 2YR) leaf area (LA), and floral bud initiation were determined immediately following harvest, when present. In comparison to fruit from C, fruit from -SH and -1YR had similar soluble solids and 22% greater weight. Fruit from -2YR had similar weight and 16% greater soluble solids compared to fruit from C. Fruit quality from 2YRonly and C was similar. Shoot length was unaffected in -2YR, but 32% longer in -1YR, vs. C. There were no treatment effects on LA. Floral bud initiation was 13 and 5% greater on 1YR and 2YR, respectively in -SH, compared to C. Determination of single leaf light-saturated net CO<sub>2</sub> exchange rate showed slight (10-25%) photosynthetic compensation to reduced branch LA in 2YRonly and -SH. Results will be discussed in terms of branch source-sink relationships.

**1340-1440**

**S13-P-123**

**SUNBURN ON APPLES: INDUCING FACTORS, BIOCHEMICAL RESPONSES AND CONTROL METHODS**

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Between 1992-2000, different commercial orchards of cv. Fuji, Braeburn, and Gala in the South-Central Region of Chile (35 S; 71 W), were used to carry out studies related to sunburn in apples and possible control methods (chemical

protectors, overhead sprinkle irrigation (SI) and shade cloth). Chemicals such as SunShield™, Vitamin E and Vapogard™, did not consistently reduce sunburn under the high solar radiation and temperatures conditions in which fruit are grown in Chile. SI was the most effective method to reduce sunburn. However: water impurities, lack of knowledge on activation and inactivation temperatures and the high amount of water required, did not allow it to be operative. Shade cloth (18%) caused a significant sunburn reduction in the trees, although its effect was less than SI. Fruit position, plant age and row orientation within the orchard, had great influence on sunburn incidence. Additionally, several trials were carried out between 1996-2000, to study sunburn inducing agents (solar radiation, UV and temperature) and their physiological and biochemical effects on apples, as well as metabolites related to sunburn both in the field and in the laboratory. Results showed that, under Chilean conditions, temperature has greater influence on sunburn incidence than UV radiation. Increasing levels of some metabolites (phenols, anthocyanins), proteins and enzymes (polyphenol oxidase, superoxide dismutase) were observed on sun-damaged apple peels.

**1340-1440**

**S13-P-124**

**THE COEFFICIENT OF FRUITFULNESS OF SOME COMBINATIONS BETWEEN ROOTSTOCKS AND APPLE VARIETIES**

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During a six year period (1996-2001) in the agro ecological conditions of Gjilane (Object in Kravarica) we studied several parameters of apple cultivars. The studied parameters were: surface of cross section of the apple trunk in cm<sup>2</sup>, yield per m<sup>3</sup> of apple crown and yield per cm<sup>2</sup> of the trunk surface, and coefficient of yield in different combined apple cultivars 'Idared', 'Melrose' on rootstocks M. 26, 'Golden B on MM.106 and 'Granny Smith' on the rootstock M.9. The pruning system for all of the studied apple cultivars was a bush with distances of 4x1.7 and 4x1.9 m respectively

**1340-1440**

**S13-P-125**

**EFFECT OF PROMALIN AND MIXTALOL ON FRUIT GROWTH, YIELD EFFICIENCY AND QUALITY OF 'STARKING DELICIOUS' APPLE**

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Apple is the most widely grown fruit in the trans Himalayan region. Apple production is now being affected by the changing climate. Apples grown in the mid hills area become misshapen due to high post bloom temperatures which cause a reduction in yield and quality and consequently these fruits command low returns in the market. Promalin (GA + CK) and Mixtalol (bio-stimulant) were sprayed at 50% full king bloom and repeated at full bloom of the king petals in single and split doses to 'Starking Delicious' apple. Maximum fruit set and photosynthetic rates were obtained with 60 ppm Promalin applied in single doses. Mixtalol 10 ppm gave the highest yield when compared with control. Improvement of fruit shape in the form of L/D ratio, calyx length and prominence of calyx lobe formation was the most striking effect of Promalin and was significantly higher over the controls. Chemical constituents like TSS, total sugars, soluble proteins and anthocyanin contents were increased while acidity was decreased in fruits of Promalin and Mixtalol treated plants. Thus the investigations revealed that the Promalin and Mixtalol treatments in areas exposed to warm weather during flowering and development had improved the qualitative as well as quantitative parameters, which will be helpful to the farmers to achieve a good return.

**1340-1440**

**S13-P-126**

**'SURROUND' PARTICLE FILM APPLICATIONS-EFFECTS ON WHOLE CANOPY PHYSIOLOGY OF APPLE**

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A major problem in arid and semi arid regions is the excessive heating of the tree canopy and fruit, especially those exposed to direct solar radiation. Under such conditions, fruit and leaf surface temperatures may reach very high levels having undesirable effects on fruit skin properties (e.g. sunburn) and on carbon fixation and partitioning. The worldwide trend toward orchards with smaller trees having reduced vegetative vigour, exacerbates the situation. This paper evaluates the potential use of a chemically inert, reflective kaolin particle film on 5 year-old apple trees (*Malus x domestica* Borkh. cv. 'Braeburn' on M.9 rootstock) to reduce fruit sunburn damage and to examine its effect on net carbon exchange (NCE) rates. It is hypothesised that the particle film applications reduce surface temperature by increased light reflection, thus maintaining high stomatal conductance under excessive ambient heat stress conditions. At the leaf level, carbon assimilation rates over a wide range of incident light levels and temperatures were significantly lower on 'Surround'-treated trees than the control trees. However, neither leaf transpiration nor leaf stomatal conductance was affected by the particle film. Chlorophyll fluorescence measurements indicated greater quenching ability and lower photochemical yield of the 'white-washed' leaves, confirming the photosynthetic response. Differences in leaf gas exchange were due to the 'Surround' leaves absorbing 20% less light compared to the control leaves. Whole-canopy NCE, measured with an open-top cuvette system (Wünsche & Palmer, 1997, HortScience, 32:653-658), was not affected by 'Surround' applications despite cuvette temperatures of up to 40 °C. The different CO<sub>2</sub> exchange results between individual leaves and the whole-canopy may have been due to improved light distribution in the canopy due to enhanced leaf reflection. The particle film significantly reduced the number of fruit with visible sunburn damage, possibly due to 20% lower fruit skin temperatures when compared to the control trees. The beneficial temperature reduction by the 'Surround' cover and the ease of washing off the particles from the fruit, make it a promising treatment for alleviating excessive heat stress in apple trees grown in warm and dry locations.

**1340-1440**

**S13-P-127**

**KAOLIN TREATMENTS TO REDUCE SUNBURN IN POMEGRANATE**

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Surround WP, a processed kaolin (Engelhard Corporation, Iselin, NJ, USA) was reported to help reducing the use of fungicides and insecticides as well as the heat stress especially in fruits (Glenn et al. 2001). The goal of this research was to test the efficacy of this material to reduce, as much as possible, pomegranate damage due to sunburn, which may account for losses of up to 40% of the total harvest. The trial was conducted in a pomegranate orchard located in South-eastern Spain in Alicante province, where temperatures during summer may reach over 40 °C. The application schedule for Surround WP sprays over whole canopies and fruits was: 5% on June 18th, 2.5% on June 25th, 2.5% on July 16th and 2.5% on August 6th. A comparable non-sprayed control was marked for comparison. Fruit and leaf surface temperatures were measured using thermocouples. A significant temperature reduction was noted in the kaolin treated trees compared to the non-treated controls. While treated fruit showed temperatures at midday of 42.2 °C, the non-treated ones showed surface temperatures of 47.1 °C. Likewise the reduction by kaolin cover of leaf surface temperature reached 2.5 °C. Damage by sunburn was significantly reduced from 33.0% in the untreated controls to 13.1% in the kaolin-treated trees.

**1340-1440**

**S13-P-128**

**A STUDY ON THE DETERMINATION OF SOME MECHANICAL PROPERTIES OF SOME WALNUT VARIETIES**

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Walnut is an important protein source for human beings and can also be a

profitable fruit for agriculturalists. Before consuming the walnut, its shell has to be broken and the kernel extracted. The mechanical behaviour of the walnut is important for cracking. Improper or wrong cracking causes significant losses due to quality and kernel damage. Considering the mechanical behaviour of the walnut differs between varieties, physical and mechanical properties of each variety need to be determined. The objective of this study was to determine some of these mechanical properties; poisson's ratio and the modulus of elasticity of different walnut varieties from Aegean region of Turkey were studied. A compression test was applied on the walnut varieties using a load-displacement measurement device under laboratory conditions. From the measured vertical forces and deformation, cracking force, stress and energy, poisson's ratio and moduli of elasticity of walnuts were determined. The experiment was repeated immediately after harvest from different trees, so that the effect of variety and region on the mechanical properties of the walnut was examined.

**1340-1440**

**S13-P-129**

**FRUIT YIELD, TREE GROWTH AND CROP EVAPOTRANSPIRATION AS INFLUENCED BY VARIOUS IRRIGATION METHODS APPLIED TO THE GOLDEN DELICIOUS APPLE CULTIVAR PLANTED WITHIN THE HILLY REGION OF PITESTI-MARACINENI IN ROMANIA**

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The present paper investigates the effects of various irrigation methods on fruit yield and tree growth of the Golden Delicious apple cultivar grafted on MM.106 rootstock planted under the specific conditions of the hilly region of Pitesti-Maracineni, Southern Romania. The mean annual temperature was about 9.60 °C and rainfall 650 mm. Several irrigation methods were compared: sprinkler irrigation (SI), micro-sprinkler irrigation (MI), and drip irrigation (DI), as well as a control, non-irrigated treatment (NI). The experiment was conducted over a period of 7 years. Trees were planted at 3.6 m between rows and 1.5 m between trees in the row. Fruit yield and annual growth in tree trunk cross-sectional area (TTCSA) were measured every year within each of the treatments investigated. The experimental design was a randomised split-plot with three replicates for each treatment. Crop evapotranspiration was counteracted by rainfall, irrigation application, and soil moisture reserves and was calculated from field data based on the water balance equation. For the area studied, irrigation was needed especially during the July through September period, but crop evapotranspiration generally differed among the four irrigation treatments studied. MI and SI treatments showed the highest fruit yield values that were statistically different. Fruit yield correlated positively to both irrigation depth during the entire growing season and crop evapotranspiration both in individual irrigation treatments and when all the data were considered together. TTCSA was significantly different between the irrigation treatments in all years of the experiment. It was significantly and positively correlated to annual irrigation depth. Micro-sprinkler and drip irrigation induced a more efficient way of water application utilization in the 'Golden Delicious' apple orchard investigated. This was why these two treatments were the ones recommended to be extended into commercial orchard farming.

**1340-1440**

**S13-P-130**

**X-RAY MICROANALYSIS OF APPLES TREATED WITH KAOLIN INDICATES WAX-EMBEDDED PARTICULATES IN THE CUTICLE**

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'Gala' apples trees were treated with kaolin (Surround) in mid-July, and fruit were sampled 1 and 7 days after treatment. Apples were gently rinsed with cold deionized water to remove loose surface material. Peel tissue about 0.3 mm thick was excised with a razor and flash frozen on an aluminum block held at -190 °C, freeze-dried, and coated with a thin film of carbon. Samples were examined using an Oxford ISIS energy dispersive x-ray microanalysis system capable of light element detection. Qualitative secondary electron imaging combined with quantitative elemental compositional analyses indicated kaolin particles may become embedded in the cuticle between individual wax platelets. Effects on cuticle integrity will be discussed.

**1440-1500**

**S13-0-131**

**APPLE FRUIT GROWTH RESPONSES TO EARLY-SEASON SHADE AT VARYING DEVELOPMENTAL STAGES**

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Early-season fruit growth and abscission are affected by shade most at 15-25 days after bloom, while after 30-35 days, shade has much less effect on fruit abscission. This may be attributable to an improved carbohydrate balance. However, the apple fruit may become more resistant to limited carbohydrates after reaching a stage when it can accumulate starch as reserves. We propose that under carbon-limited conditions, the fruit uses its own reserves to maintain growth. To test this hypothesis, shade (20% of full light) was imposed over trees at three times during the early fruit development on the cv. 'Empire' grown in New York, and on the cv. 'McIntosh' grown in Massachusetts. Shade treatments lasted 6-10 days depending on the responses. Fruit diameter growth of 30 fruits on each tree were monitored every 2-3 days on control and shaded trees. Subsamples of monitored fruits were collected at each date for carbohydrate analyses. Initial crop loads were higher in 'McIntosh' than in 'Empire'. Results with 'Empire' indicated that at the 10 and 35 mm fruit diameter stages growth reductions due to shade took several days to develop; however, at 18 mm fruit growth response was more rapid. In McIntosh, it required about 4 days for fruit growth to slow substantially, regardless of time of shading. Between 4 and 8 days of shading of 18 mm fruit essentially stopped growth, whereas at 10 and 35 mm, fruit growth continued but at a reduced rate. The effects on fruit growth rates were generally earliest and strongest in heavier crop loads. Starch staining of fruits visible starch developed at about 20-25 mm diameter, and the staining intensity decreased with shading. Starch analyses of fruits from the different timings and treatments showed that starch was accumulating at 10 mm diameter, and increased with diameter. Although starch concentrations decreased somewhat with shade and reductions in fruit growth, the metabolism of fruit starch did not maintain fruit growth rates as hypothesized.

**1500-1520**

**S13-0-132**

**XYLEM DYSFUNCTION AND FRUIT MINERAL NUTRITION IN TIME AND SPACE**

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Quality in most fruit depends upon their calcium content and most suffer well-known physiological disorders associated with low fruit calcium status. Fruit generally contain less calcium than other organs (leaves, stem etc) because calcium is mobile only in the xylem whereas fruit are largely phloem fed. Studies have shown that fruit calcium accumulation shows interesting temporal and spatial patterns. In both apple and kiwifruit the rate of inflow declines during the season, falling virtually to nil by mid season. Moreover, the spatial pattern shows that some regions and some tissues within the fruit contain significantly less calcium than do others. We hypothesize that the patterns of temporal decline and also that of spatial inequality, are a result of temporal and spatial changes in xylem functionality. Also that these changes are caused by a stretching and breaking of fruit xylem as the surrounding flesh expands. A study of xylem functionality in both apple and kiwifruit employing a simple dye-infusion technique revealed a decline in functionality that matched the well-known seasonal decline in calcium accumulation. Moreover, the spatial pattern of dysfunction reflected the known spatial pattern of calcium distribution. Microscopy showed that the fruit xylem suffers multiple breakages. This suggests that the mode of xylem dysfunction is via a physical disruption of the bundles and this is consistent with their having been overly stretched by expansion growth of the flesh.

**1520-1540**

**S13-0-133**

**ETHYLENE INTENSIFIES BUT IS NOT A REQUIREMENT FOR METHYL JASMONATE-ENHANCED ANTHOCYANIN SYNTHESIS BY 'FUJI' APPLE FRUIT**

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Exogenous methyl jasmonate (MJ) stimulates anthocyanin accumulation in apple fruit peel. Anthocyanin synthesis in some apple cultivars reportedly is also stimulated by exogenous ethylene, however, the role of ethylene action in regulation of anthocyanin synthesis in apple fruit is unclear. MJ enhances ethylene sensitivity in various plants, therefore, studies were conducted to evaluate the role of ethylene and MJ in stimulation of anthocyanin synthesis in immature 'Fuji' apple fruit. Following ethylene and MJ treatments, fruit were exposed simultaneously to UV-B and visible light, then pigments were extracted and analyzed by reverse-phase high performance liquid chromatography. Treatment with MJ alone enhanced anthocyanin accumulation, including idaein, the major anthocyanin in apple fruit. Anthocyanin accumulation was further stimulated by treatment with MJ + ethylene. Treatment with the ethylene action inhibitor 1-MCP followed by MJ reduced red coloration slightly over MJ alone. Treatment with ethylene or 1-MCP alone, or ethylene+1-MCP had little effect on anthocyanin accumulation. Chlorogenic acid synthesis was also enhanced by treatment with MJ or ethylene, however, treatment with 1-MCP alone or with MJ decreased chlorogenic acid content. MJ enhanced production of hyperin, the major quercetin glycoside in peel tissue, while ethylene and 1-MCP had no effect on quercetin glycoside content when applied alone or in any combination.  $\beta$ -carotene synthesis was enhanced following MJ treatment, stimulated further by MJ plus ethylene, but was not enhanced by ethylene alone. The results indicate a synergistic response between ethylene and MJ for stimulation of anthocyanin synthesis. Treatments with ethylene alone or 1-MCP indicate a limited role for ethylene action in regulation of red color development by immature 'Fuji' apple fruit.

**1540-1600**

**S13-0-134**

**CELL DIVISION AND EXPANSION IN THE OLIVE FRUIT**

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We studied the cellular processes involved in mesocarp formation and the expansion patterns for mesocarp and endocarp tissues in fruits of eight olive cultivars with a wide range of fruit size: 'Arbequina', 'Frantoio', 'Gordal Sevillano', 'Hojiblanca', 'Leccino', 'Lechin de Sevilla', 'Manzanillo' and 'Picual'. Transverse equatorial sections were prepared from ovaries at bloom and fruits sampled throughout the growth season from mature, irrigated olive trees. Tissue areas, cell number and cell size were determined using computer image analysis connected to binocular and ocular microscopes. Mesocarp cell size, which increased to fifty times that at bloom, was similar for all varieties in value and rate of change. Mesocarp cell number was directly related to mesocarp area and final fruit size, with the larger fruits producing greater numbers of cells throughout development. Proportionate to final mesocarp cell number, however, all varieties showed the same cell division pattern. Endocarp expansion was completed by 8-12 wks after bloom, during which time mesocarp expansion was as great for large-fruited varieties, but only 60-80% of endocarp growth for small-fruited varieties. There was a clear interaction between the endocarp and mesocarp in determining final fruit size, with endocarp growth and sclerification influencing both mesocarp size and developmental timing. Mesocarp size differences among varieties depend on both cell number and endocarp size, with smaller fruits having lower cell numbers and smaller endocarps. On the other hand, there are consistent trends in the overall patterns of cell division and expansion, regardless of fruit size. These results for the olive fruit, a drupe originating from a bicarpelate ovary, may be indicative, as well, of the behavior of other stone fruits, and have important implications for cultural practices such as fruit thinning and deficit irrigation management.

**1600-1620****S13-O-135****MOLECULAR CHARACTERIZATION OF FRUIT RIPENING IN SOUR CHERRIES USING A HIGHTHROUGHPUT APPROACH**

Sang-Dong Yoo\*, Zhifang Gao, Wayne Loeschler, Steven Van Nocker  
 Laboratory of Pomology and Molecular Biology, Dept. of Horticulture, Michigan State Univ., East Lansing, MI 48842

Fruit ripening is a tightly controlled and highly programmed developmental event in higher plants. As in other plant developmental processes, a specific subset of genes has to be activated during fruit ripening to carry out complex biochemical changes such as tissue softening, flavor development, color development and sugar accumulation. To understand the fundamental molecular mechanism underlying fruit ripening physiology in sour cherry, a nonclimacteric fruit, we have examined expression profiles of genes that are induced during fruit ripening by using a highthroughput approach. A combined analysis of a small EST data set and differential screening for genes that are induced during fruit ripening by using high density cDNA arrays identified 54 cDNA clones in sour cherry. These genes were designated as ripening-associated gene regulons. Such regulons encoded putative proteins known to be involved in signaling pathways, metabolic pathways, cell wall modifications and stress/pathogen responses, which could represent major cellular activities during fruit ripening. RNA gel-blot analysis demonstrated that expression of these gene regulons was induced in a distinct temporal pattern. In addition, when sugar accumulation was suppressed during fruit development by limiting photosynthesis capacity, the induction of some regulon expression was abnormally delayed. An identified cis-acting domain conserved in sugar responsive genes in other plant species was also present in 5'-promoter regions of ripening-associated regulons (e.g. expansins). This observation strongly indicated that regulation of these genes might be under the control of sugar signaling and sensing during fruit ripening in sour cherry. Together with an emerging view of sugar as a signaling molecule in various plant developments, we suggest that sugars may have an important role in fruit ripening by controlling expression of ripening-associated gene regulons.

**1620-1640****S13-O-135-A****TO BE ANNOUNCED****1640-1700****S13-O-135-B****TO BE ANNOUNCED****Friday · August 16****0800-0900****S13-P-136****RESEARCH ON MULTIPLE ROW SYSTEMS IN APPLES**

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Modern apple growing necessitates high yield and high quality per unit area. This can only be achieved by using dwarfing apple rootstocks, such as M9. Previous results with a single row system using M9 at 3,5 m x 1,5 m distances, showed that the yield was 5-8 times to the yield from conventional system on seedling. This study aimed to increase the yields to much higher degrees, with Granny Smith and Gloster 69 apple cultivars on M 9. For this purpose, three systems namely single (143 tree/da), double (200 tree/da), and triple (230 tree/da) row systems were compared. The experiment was established in 1996 with 4 replicates at the Research Station Experimental Field in Yalova. The cumulative yields for the first 4 years were, in the single row system 5 205 kg/da, in the double row system 9 312 kg/da, and in the triple row system 8 542 kg/da for Granny Smith; the values for Gloster 69 were 7 085 kg/da, 9 874 kg/da and 9 673 kg/da respectively. In contrast, there was almost no yields on the conventional system during the first 4 year. As a result, and taking into consideration yields, as well as the other cultural practices, such as

pruning, spraying and harvesting, the double row system was strongly recommended for both cultivars.

**0800-0900****S13-P-137****METHODS FOR EARLY FORECASTING OF APPLE SIZE AT HARVEST**

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A growing interest exists in the early assessment of fruit growth and the forecast of fruit size at harvest. Real time monitoring of fruit development is thought to be an important component of modern fruit growing techniques, but its feasibility is still subject to questions. These are related to the lack of ready-to-use instrumentation or reference systems suitable for extended application in the orchard and also to whether such techniques are feasible, in terms of the grower's efforts needed to gather the data. Some reference tables exist, which aim to provide aid in irrigation scheduling, but their applicability is restricted to the sites for which they have been developed, and even then a sufficiently expanded database is necessary to ensure the validity of these reference values. Among the methods which do not necessarily require a reference, the one based on the early assessment of the slope of fruit growth, when it becomes linear, according to the exponential pattern of fruit growth, has been satisfactorily tested in a preliminary fashion. This approach appears to be capable of providing sufficient accuracy of forecast, and the accuracy can improve as time progresses toward harvest. Recently, a method based on degree-day accumulation has been proposed, which promises to provide a final size forecast as early as 50 days after full bloom (DAFB), thus greatly reducing the amount of data needed for the assessment. The present paper reports a comparison between the two methods of early prediction of apple size at harvest, for several cultivars (Gala, Golden Delicious, Jonagold, Fuji), during several years. The results will be discussed with emphasis on their accuracy, reliability, the amount of work required by the grower to provide the data.

**0800-0900****S13-P-138****A MULTI-SPONSOR, MULTI-PURPOSE WEATHER NETWORK TO ASSIST IN PEAR AND WINE GRAPE PRODUCTION ON THE NORTH COAST OF CALIFORNIA**

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The Lake County Pear and Grape PestCast Network was initiated with a grant from the UCIPM Project and the California Dept. of Pesticide Regulation through their PestCast disease forecasting project. The expandable radio telemetry network is unique in its multifunction purpose: pest management research, air dispersion, fire hazard, and agricultural/fruit frost data collection. Sensors are located in or above grape and/or pear canopies, depending on location. There are also several non-agricultural stations. Data varies by station and is summarized in 15-minute, hourly and daily increments and can be downloaded from the PestCast web site ([www.ipm.ucdavis.edu](http://www.ipm.ucdavis.edu)) for a variety of purposes. It is archived permanently so users may access current and historical information. The Lake County Weather Page ([www.wxnet.com/lakeco](http://www.wxnet.com/lakeco)) provides forecasts, real-time hourly data during frost season and data from the previous one, seven and 30 days. Users can obtain summarized data for each day of user-selected months and years. Data includes min/max temperatures, relative humidity, dewpoint, wind direction/speed, degree-hours over 65 °F (for fire blight), precipitation and ETo, chilling hours <45 °F, hours 32 °F or below/70-85 °F/>90 °F, leaf wetness hours (for pear scab and/or grape powdery mildew models), and growing degree days. Additional features include previous day and seven day observations, satellite and radar imagery, 24/48/72-hour weather charts, El Nino/La Nina statements, sunrise/sunset times, and Yakima, WA forecasts for the local pear industry. There are also links to UCIPM

and many other weather-related sites. Another feature is WINDS for the Web, an interactive program utilizing PestCast data. Output includes daily weather summaries, hourly weather observations, Zoller degree-hour and Cougarblight fire blight models, Mills Table apple scab infection model, degree-day models, UC grape powdery mildew infection model, and numerous daily and hourly meteorological graphs.

**0800-0900**

**S13-P-139**

**FORECASTING PHENOLOGICAL AND DISEASE DEVELOPMENT FOR AMELANCHIER ALNIFOLIA**

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Effective phenological and disease forecasting models are quickly becoming essential tools for precision farm management. Using a real-time weather monitoring system, accurate phenological and disease development models can be developed for high value crops. *Amelanchier alnifolia* (saskatoon or serviceberry) is an important native fruit crop found throughout the Prairies of Canada. Saskatoon production is often limited by a number of environmental factors including the devastating disease *Entomosporium* leaf and fruit spot (caused by the fungal pathogen *Entomosporium mespili*). Phenological and multidimensional disease forecast models are being developed to predict harvest, and to better control *E. mespili* in saskatoon orchards. Growing degree-day, and potato day equations showed greater accuracy than Julian days for predicting crop harvest. These same formulas were used to calculate vegetative development, which in turn was integrated with disease progress to create a more comprehensive disease forecast model. To develop a unique disease forecast model for *E. mespili*, host susceptibility at different phenological stages, inoculum levels, conidia release, and infection capacity of the pathogen in different environmental settings is being determined. To date, this study has shown that: a) as plant tissue ages it becomes less susceptible to plant disease; b) infected leaf area can be used to estimate inoculum levels; c) conidia release occurs in the first hour of precipitation events; and d) disease develops well in temperatures between 15 and 20 °C when leaf wetness durations are between 12 and 24 hours. A preliminary forecasting model has been developed on the basis of these data and equations.

**0800-0900**

**S13-P-140**

**EFFECT OF SPACING ON INDIVIDUAL TREE GROWTH, YIELD AND ORCHARD PRODUCTIVITY ON DIFFERENT ROOTSTOCKS**

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In our rootstock trial the individual tree growth is significantly influenced by spacing between the range of 741-1111 tree/ha on the following rootstocks: M.2, M.4, M.7 and MM.111. The trees on these rootstocks responded to the wider spacing with increased growth up to a maximum point. No effect of spacing was found on the rootstocks M.26 and MM.106, just a slight tendency was visible. However, although the wider space increased the individual growth, the calculated bearing surface of the orchard (TCSA cm<sup>2</sup>/ha, canopy volume m<sup>3</sup>/ha) responded differently. The bearing surface per area unit on M.26 and MM.106 showed a significantly decreasing trend due to the decreasing tree number. Slight decreasing tendency was found on M.7, MM.111, M.4 and MM.104 because of the compensating effect of increased individual growth. On M.2 there was a maximum point found at 926 tree/ha density. Highest cumulative yield efficiency of individual trees (kg/cm<sup>2</sup> TCSA) was found on MM.106 followed by M.2, M.26 and M.4. Yield efficiency was not influenced by the spacing of trees on M.26, MM.106, M.4 and MM.104, while the efficiency significantly decreased on M.7 at 741 tree/ha. On M.2 the 794 tree/ha produced significantly higher CYE, while at 1111 tree/ha density the trees

responded with significant lower CYE. Strong correlations were found between the bearing surface, calculated in canopy volume m<sup>3</sup>/area unit, and the yield/ha. Thus the highest cumulative yield per unit area was produced by 'Idared' apple on M.4 at 926 tree/ha, followed by M.26 at 1587 trees/ha, MM.106 at 1389 trees/ha and M.2 at 794 tree/ha, without no significant differences within the group. This performance of yield efficiency calculated on TCSA basis, which is widespread used for comparison of rootstock productivity, means that a correct comparison can be made only at optimum spacings for each rootstock and site. This is especially important for the comparison of rootstocks from different groups of growth vigour.

**0800-0900**

**S13-P-141**

**EFFECTS OF OVER-TREE SPRINKLING DURING HOT PERIODS ON TREE GROWTH AND FRUIT QUALITY OF 'WHASAN' PEARS**

Cheol-Ku Youn<sup>1</sup>, Seon-Kyu Kim<sup>\*2</sup>, Young-Ho Kim<sup>3</sup>, Sang-Cheol Lim<sup>3</sup>, Tae Youn<sup>3</sup>

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Effects of over-tree sprinkling during hot weather periods, when the temperature exceeds 30°C at intervals of 60 min or 30 min for 3 min on tree growth and fruit quality of 'Whasan' pears were studied. Chlorophyll content in SPAD values was increased to 10.3 and 8.6 by respectively 30 min- and 60 min-interval over-tree sprinkling compared to the 4.3 of non-sprinkled controls. Tree growth, measured as trunk diameter, shoot length, and shoot diameter was greater in the trees receiving the 60 min-interval sprinkling. Photosynthetic rate was in the order of 30 min-interval > 60 min-interval > control, though the differences were not significant. Stomatal conductance, intercellular CO<sub>2</sub> concentration, and transpiration rate tended to increase in the 30 min-interval sprinkling treatment. Thirty min-interval sprinkling significantly lowered the leaf temperature. Percentage fruits over 400g was significantly higher (41.1%) with 30 min-interval sprinkling than that of 60 min-interval (14.8%) or the controls (15.4%). Fruit weight and Hunter a\* values were increased by 30 min-interval sprinkling. Soluble solids and fruit firmness were not affected by over-tree sprinkling, but titratable acidity was increased.

**0800-0900**

**S13-P-142**

**GROWTH AND CROPPING EVALUATION OF SOME POPULAR TRAINING SYSTEMS FOR ORIENTAL PEAR, CV. 'NIITAKA' (PYRUS PYRIFOLIA)**

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Since the initiation of Y-trellis training trials in 1976 with the 'Danbae' cultivar in Korea, the Y-trellis has been adopted by growers and nowadays the majority of new pear orchards are planted using the Y-trellis system. However, standard Y-trellis systems, with a planting density of 6 m x 1 m, tend to fill up their allotted space by the 4th leaf and they require the removal of every other tree in the 5th leaf. To overcome this canopy overcrowding problem, a new training method called the Alternate Fan System was devised in 1996. The standard Y-trellis has also been modified by some growers based in their own ideas and experiences. This trial is focused on comparing various training systems devised since the inauguration of the Y-trellis in 1976 and to identify the best training system for the pear grower. Out of 5 training systems compared, 3 were Y-trellis and its modifications and 2 were Alternate Fan Systems and its modification. All the pear trees used in the comparisons were planted in 1996 and the major experimental results were as follows. In the 6th leaf, the standard Alternate Fan System showed the least water shoot emergence, but the largest free space between the alleyways with smaller pear size and relatively smaller amounts of crop compared with a modified Y-trellis, which avoided heading back pruning cuts as a modification of the standard Y-trellis system.

0800-0900

S13-P-143

**ESTIMATION OF APRICOT FRUIT VOLUME AND FRESH WEIGHT FROM FRUIT DIAMETER**

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Fruit growth is a function of volume (or weight) increase, and diameter by itself is generally a poor measure of fruit growth because it is not linearly related to volume or weight. In experimental work to evaluate changes in fruit growth and size, the transformation of non-destructive fruit diameter data to fruit volume estimates is desirable and has been investigated using mature trees of eleven Iranian apricot genotypes. Destructive fruit sampling produced a model to estimate apricot fruit volume and fresh weight from non-destructive fruit diameter data. There were 4 trees in each genotype. On each tree eight fruit from the middle canopy zone were randomly at 10-day intervals from 30 days after full bloom until fruit harvest. Fruit diameter, volume, and fresh weight were measured. Data was used to build up a model for estimating fruit volume and fruit fresh weight from non-destructive fruit diameter measurements. Strong relationships were observed between fruit diameter, fruit volume and fresh weight.

0800-0900

S13-P-144

**DEVELOPING APPLE YIELD MODELS: A STATISTICAL APPROACH**Faye M. Propsom<sup>1</sup>, Emily E. Hoover\*<sup>1</sup>, Frank Forcella<sup>2</sup>, Dennis Cook<sup>3</sup>

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Descriptive models have been useful for making predictions in horticultural production systems using parameters such as environmental conditions, cultivars, and growth measurements. The objective of this research is to model cumulative apple yields using data from the 1990 planting of the North Central Regional Research Project #140 (NC-140). 'Golden Delicious', 'Jonagold', 'Empire', and 'Rome' scions were grafted onto M9, B9, Mark, O3, and M26 rootstocks and were grown at twelve different locations over ten years from 1990 to 1999. Data collected yearly included trunk circumference, average fruit size, and yield, monthly maximum and minimum temperatures from October through April and monthly precipitation. Tree height and spread were also measured in 1994 and 1999. Six sites that represent a range of longitudes and latitudes across the U.S. were randomly selected to create the models. The other six locations were used to validate the models. Regressions were fitted using the measured tree growth parameters, temperature data, and yearly precipitation as predictors and the square root of cumulative yield as the dependent variable. Statistical techniques used to differentiate the rootstock/cultivar regressions within and among growing sites included multivariate regressions of the slopes and T-tests. Cumulative yields of apple can be modeled using regression analysis and some rootstocks will induce higher yields consistently, independent of cultivar.

0800-0900

S13-P-145

**HORTICULTURAL AND ECONOMIC PERFORMANCE OF HIGH DENSITY ORCHARD PLANTING SYSTEMS FOR PRODUCTION OF FRESH AND PROCESSED APPLES**Terence L. Robinson\*<sup>1</sup>, Stephen A. Hoying<sup>2</sup>, Alison M. DeMarree<sup>2</sup>

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Three replicated orchard planting systems field trials were planted in 1993, 1994 and 1995, respectively on growers farms in New York State. The first trial had 7 training systems each planted at 2 densities ranging from 1,098 to 5,980 trees/ha: 1) Vertical Axis/M.26 at 1,098 and 1,538 tree/ha, 2) Vertical Axis/M.9 at 1,495 and 2,242 trees/ha, 3) Slender Spindle/M.9 at 1,495 and 2,242 trees/ha, V-Slender Spindle/M.9, Y-trellis/M.9 at 1,495 and 2,242 trees/ha, V-trellis/M.9 at 2,242 and 4,485 trees/ha and Super Spindle/M.9 at 4,485 and 5,980 trees/ha. Varieties were 'Gala', 'Empire', 'Cortland' and 'Delicious'. The second and third trials had 4 training systems with densities ranging from 384 trees/ha to 1,655 trees/ha. These trials compared the traditional Central Leader/M.7 sys-

tem to higher density Vertical Axis systems on M.26 and M.9 to produce apples for the relatively low priced processing market. Varieties were 'NY674', 'Liberty', 'Fortune', 'Jonagold', 'Mutsu', 'Northern Spy' and 'Fuji'. With the first trial, cumulative yields were strongly related to tree density during the early years, but as the trees matured yields were largely a function of tree canopy volume/ha. After 9 years, cumulative yields were still related to tree density but with a curvilinear relationship. Profitability was also curvilinearly related to tree density with intermediate densities giving similar profitability to the highest densities. 'Gala' was the most productive and most profitable variety while 'Delicious' was the least productive and was not profitable with any system. With the last two trials, cumulative yields were also a function of density; however none of the systems or varieties were profitable with the low prices of the processing market. To be profitable new orchards intended for the processing market would require significantly higher prices than now received in that market. Among varieties 'Mutsu', 'NY674' and 'Fortune' were the most productive while 'Northern Spy' was the least productive.

0800-0900

S13-P-146

**EVALUATION OF VEGETATIVE AND PRODUCTIVE RESPONSES OF TWO PEACH TRAINING SYSTEMS (Y SYSTEM AND CENTRAL LEADER) IN AN ICM ORCHARD**Leo Rufato\*<sup>1</sup>, Andrea De Rossi<sup>1</sup>, Luciano Picoloto<sup>2</sup>, Evandro Parizoto<sup>2</sup>, Jose Carlos Fachinello<sup>2</sup>

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The Brazilian peach industry has increased over the last 3 years. A high-density system is the technique extensively utilized, but tree responses to this training management is unknown in Brazilian conditions. The objective of this study was to evaluate the vegetative and productive responses of 2 training systems in an ICM peach orchard. The study was carried out at the experimental farm of Univ. of Pelotas, Brazil, in a 4-year old peach orchard of cv. Maciel on Capdebosq, spaced at 1,5 x 5,0 m apart, in a complete randomized block design with three replications. The effect of Y and Central leader training systems on fruit yield, number of buds per branch, trunk diameter, foliage size and fruit quality (diameter, weight, flesh consistence and acidity) and damage percentage due to *Xanthomonas arboricola* pv Pruni, *Monilinia fruticola*, *Grapholita molesta*, *Anastrepha fraterculus* and birds was evaluated. The Y system showed the lower trunk diameter, fruit yield (2,61 ton/ha) and foliage size but the better quality of fruits in comparison with the Central leader system, that showed fruit yield of 8,55 ton/ha. We observed a higher percentage of damage caused by *M. fruticola* in the Central leader system. Project "Implementação da produção integrada de pessegos no Rio Grande do Sul" financiado pelo MAA/CNPq.-Brazil.

0800-0900

S13-P-147

**COMPARING HAND VS. MECHANICAL HARVESTING IN CLING PEACH: A LABOR REDUCTION TECHNOLOGY**S.M. Southwick\*<sup>1</sup>, K. Glozer<sup>1</sup>, J. Hasey<sup>2</sup>, R. Hansen<sup>3</sup>

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The supply of labor for cling peach growers is getting harder to locate and the costs of production are increasing. Mechanization of harvest, pruning and fruit thinning may be required in order for California cling peach growers to accomplish orchard work as well as compete throughout the world. We compared hand with mechanical harvesting for different growers and cultivars of cling peach in order to evaluate the efficiency of mechanical harvesting and the effects on saleable yield and fruit quality at the packing house and after storage in 2000 and 2001. At one location, fruit harvested mechanically were equivalent to hand-harvested fruit with regard to defects scored when fruit were 'handled' similarly i.e. height of drop, sorting in the bin. At a second location, with a different operator and machine, fruit defects compared from hand and machine harvests showed a



higher percentage with machine harvest. Incidence of red streaking tended to increase with cold storage over time in one trial. Fruit, tree, operator, or machine characteristics may have varied by site contributing to site to site differences. We have found that the incidence of defects is less affected by the manner of harvest than by the practices of the workers and their equipment when harvesting.

**0800-0900**

**S13-P-148**

**UNDERSTANDING AND PREDICTING APPLE FRUIT GROWTH: THE COMPLEXITY OF RESPECTIVE ROLES OF TEMPERATURE AND FRUIT COMPETITION**

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In contrast to the predictability of fruit development within controlled environment production of annual greenhouse crops, prediction of fruit growth and yield of apple has many challenges arising from our limited control of perennial plant development processes within dynamic variable environments. Many researchers have studied apple fruit growth, with some proposing models for the effect of temperature on fruit growth. Under conditions with no crop limitation (very low crop load), we can predict final fruit size at harvest with reasonable precision using early season temperatures. However, practical application of apple fruit size prediction requires understanding the complexity of environmental and crop competition factors as they apply across the phases of seasonal fruit development. We have used regional apple fruit growth studies and controlled environment studies to investigate the impacts of temperature and crop load on fruit growth. During the cell division phase (~ first 50 days after full bloom (DAFB)), temperature has a major impact on fruit growth. Crop load also has a major influence during this important phase. At 50 DAFB, fruit from unthinned trees were 32-45% smaller than fruit from trees thinned at 10 DAFB to a very low crop. Fruit from trees thinned at 10 DAFB to a high crop load were 23-31% smaller than fruit from low crop trees. Thinning all cropping treatments to the low crop level at ~55 DAFB, resulted in differences in fruit size at harvest attributable to competition effects during the cell division phase of fruit growth. We will also present results from controlled environment studies that indicate fruit growth occurring after cell division (i.e. from 60-110 DAFB) is crop load limited in a response that is also temperature mediated.

**0800-0900**

**S13-P-149**

**EFFECTS OF COMPOUND FERTILIZERS ON THE PHYSIOLOGY AND THE GROWTH OF THE FRUIT-TREE**

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In some areas of North China, the availabilities of the minor elements are too low to supply for the satisfactory growth of the fruit trees because of the high pH in the soil, which caused some serious disorders in fruit trees. The growers tried to solve these problems by soil fertilizing directly or fertilizing with the irrigation water. But these methods had little effect for the nutrient elements were quickly fixed by the soil after fertilizing. It took the author five years to compound the foliar fertilizers sprayed to the fruit trees in these areas. The compound fertilizers have the following advantages: Full nutrients—the fertilizers content minor elements, a few organic nutrients as well as major elements; Different formulas—the fertilizers have different formulas according to the habit of the different kinds of the fruit trees; Significant effects—the chlorophyll contents, the photosynthetic activity and the nitrate reductase activity in the leaves were significantly increased after 72hrs after the trees sprayed. The fertilizers can also improve the disease resistance and the fruit qualities of the sprayed trees, but have no effect on the vigorousness of the trees. The compound fertilizers are being applied for the patent in China.

**0800-0900**

**S13-P-150**

**GROWTH AND CROPPING OF THREE PEAR CULTIVARS GRAFTED ON FIVE ROOTSTOCKS**

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This study was conducted at the Research and Breeding Institute of Pomology in Holovousy in order to test some new pear rootstocks under the conditions of the Czech Republic. In a rootstock trial planted in the spring of 1996, five clonal rootstocks (OH x F 69, OH x F 87, OH x F 230, OH x F 333 and standard Quince BA-29) are being compared with 'Red Bartlett', 'Conference', and 'Lucas' as test cultivars. The cumulative yield per tree from 1996 to 2001 inclusive was in comparison with 'Red Bartlett' the highest on OH x F 69 and the lowest on OH x F 333. The yield efficiency (kg/cm<sup>2</sup>) was best on BA-29. The cultivar 'Conference' had the highest total yield and yield efficiency on OH x F 87. The lowest yield was on OH x F 333. The cultivar 'Lucas' was the most productive on OH x F 87. In the sixth year after planting no difference was observed in the growth vigour (indicated by trunk cross-sectional area) among OH x F clones with the cultivar 'Red Bartlett'. The trees on BA-29 grew less. Tree size of 'Conference' was largest for OH x F 230 and weakest for OH x F 333. The cultivar 'Lucas' grew strong on OH x F 69. Small trees were observed on the rootstock OH x F 87. The production of suckers proved to be small with all cultivars on all rootstocks. The anchorage of trees on all trees was adequate. No graft incompatibility has been detected yet.

**0800-0900**

**S13-P-151**

**ORCHARD SYSTEMS FOR PILLAR AND UPRIGHT PEACH PHENOTYPES**

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The pillar (brbr) and upright (Brbr) peach phenotypes are growth forms with a columnar or upright habit respectively. These genotypes exhibit compact canopies with vigorous vegetative growth, thus requiring management and training techniques different to standard (BrBr) peach trees. Advanced selections of a pillar ('KV91455') and an upright ('KV91278') phenotype were planted at 3 spacings together with 'Blazeprince', which has a normal growth habit. Tree spacings were 1.5, 2.0 and 4.0 m in-row and 6m between rows. Nine treatments that included growth habit (i.e., genotype), training system and tree spacing were planted in 4-tree plots with border trees and arranged in a randomized complete block design with 4 replications. Three training treatments were imposed: open center, perpendicular V, and central leader. Training system was matched to tree form and spacing to maximize fruit yield and quality, reduce labor costs, and increase orchard efficiency. After the third leaf, cumulative yields for treatments ranged from 14.2 to 33.0 metric tons/hectare. Yields per tree were highest for all treatments with 4.0 m spacing and at the 2.0 m spacing of the upright 'KV91278'. Pillar trees were significantly more productive on a per hectare basis at the 1.5 spacing; whereas upright trees produced more fruit per hectare at the 2.0 spacing. The standard, 'Blazeprince', had its highest yields at the 1.5m spacing when trained as a perpendicular V system. Yield efficiency based on trunk cross-sectional area was highest at the 2.0m spacing for both the pillar and upright trees. Light interception at solar noon was significantly higher in the pillar and upright training systems. Full bloom of the three phenotypes at the 4.0m spacing was 2-3 days earlier than at the two other spacings.

**0800-0900**

**S13-P-152**

**WILL HIGH DENSITY WORK FOR PROCESSING APPLES?**

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Similar to fresh market fruit, producers of fruit primarily destined for processing are interested in reducing costs and labor and increasing efficiency through the use of new pruning and training systems. This study looks at five different training systems established in two commercial orchards and examines the early yields, both on a weight per tree and \$USD per acre, and growth of the processing cultivar 'York Imperial'. The sites were established in 1997 on M.9 and in 1998 on B.9. Systems utilized at both sites are: Offset V Axe (V), Slender spindle (SS), Hytec (H), Vertical axe (A), and minimally pruned (UP). Trees in the V were planted at 0.9 m in the row while all other systems were planted at 1.8 m in the row. There were no differences in trunk cross sectional area (TCSA) through the third leaf at either site. TCSA, however, was smallest in the V system on M.9 and largest in

the A system at the end of the 4th leaf. Yields on a per tree or area basis were not influenced by training system in the third or 4th leaf on M.9. Yields per tree of 'York Imperial'/B.9 were also not influenced by training system but were different on an area basis in the 3rd leaf. Yield in \$USD per acre were determined for the systems based upon grading a subsample of fruit and applying the percentages to total number of fruit of harvested trees. Prices from a local processing firm were utilized to estimate the economic returns for each system.

**0800-0900**

**S13-P-153**

**PERFORMANCE OF "CONFERENCE" PEAR ON FIVE INTENSIVE TRAINING SYSTEMS IN THE NE OF SPAIN**

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Five training systems have been evaluated during three years after planting at two different growing areas at Catalonia (NE-Spain): Lleida and Girona, in order to ascertain the possibilities of improving the precocity and yield of 'Conference' (*Pyrus communis* L.) pear on Quince C (*Cydonia oblonga*) rootstock. In addition, the economic performance of the different treatments/locations has been evaluated. Trees were trained to a structured axis (control system), a vertical axis, and three Tatura type trellis systems, which differed in the number of branches per tree: Tatura 4 branches, Tatura 2 branches and Tatura 1 branch, using preformed trees, except for the structured axis. Density of planting ranged from 2133 to 5333 trees/ha, with spacing distances between trees from 0.5 to 1.25m x 3.75m between rows. In Lleida, in the second year after planting (2000), significant yields were obtained with all systems except for the structured axis. In the third year, very high yields were obtained with all the systems. Cumulative yields at the third leaf reached 62 tons/ha with the Tatura 2 and more than 50 tons/ha with the other systems, except for the structured axis with only 28 tons/ha. In Girona, yields were lower because it was using a replanted orchard site and specific soil characteristics were different from those of Lleida. Even so, in both sites the Tatura systems provided a higher efficiency than the control system. Fruit quality and size were similar for all the systems. Tree vigor was higher with the structured axis and yield efficiency was lower compared to that of Tatura systems. The highest planting cost was recorded for the Tatura systems reaching 27646 Euros/ha for Tatura 4, the most expensive one, and 6010 Euros/ha for the structured axis, the lowest.

**0800-0900**

**S13-P-154**

**THE EFFECTIVENESS OF DIFFERENT APPLICATION METHODS OF ZINC SULFATE ON NUTRITIONAL CONDITIONS OF APPLE IN CALCAREOUS SOILS OF IRAN**

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To evaluate the effectiveness of the different application methods of zinc sulfate in apples, an investigation was carried out in one of the orchards of West Azerbaijan province in 2000 growing season. The treatments with five replications were tested: T1; control, T2; balanced fertilization based on soil test except zinc application, T3; T1+trunk injection of zinc (1.0%), T4; T2+trunk injection of zinc, T5; T1+zinc broadcast, T6; T2+zinc broadcast, T7; T1+zinc spray (0.5 %), T8; T2+zinc spray, T9; T1+deep placement of zinc and T10; T2+deep placement of zinc. Analysis of soil tests from 0-30 cm and 31-60 cm depths indicated that the level of soil fertility was low, and the concentration of several nutrients were about or below the critical level. The zinc concentration from both soil layers were 0.2 mg/kg, indicating a severe deficiency of this element resulting from its continuous uptake without supplementing it. The analysis of the irrigation water showed high levels of bicarbonates. The results demonstrated that the greatest leaf area, chlorophyll index of leaves resulted from deep placement and spray treatments. Also the effect of zinc on the levels of the current year's growth of branches was significant and spray of zinc appeared to be the most effective method in this respect. The zinc concentration in the samples from the control plants were low (15mg/kg), and it was below the critical level so that trees showed severe deficiency symptoms. The foliar application of zinc sulfate resulted in high levels of zinc in the leaves, but a great percentage of this supplement remained in the leaf epidermis as well as in the

dead spaces between the leaf cells instead of being carried to other plant tissues. The concentration of P, Ca, were low in the samples from spray treatments, most probably due to antagonistic reactions between zinc and these elements. The effects of these fertilizer treatments on the concentration of N, K, Mg, Fe, Mn, Cu and B were statistically insignificant. The chemical analysis of the fruits showed high levels of N from spray treatments, which were correlated with high levels of zinc in the same samples due to direct spraying of fruits. The Ca levels of sprayed fruits were low. Other quality factors such as TSS, acidity level, sugar content and pH of the fruit juice were not affected by zinc sulfate. However, balanced fertilizer treatments especially deep placement along with spray application of zinc sulfate, resulted in improvements in apple quality indices. Considering soil condition (calcareous), and the obtained results, it appeared that the placement of zinc sulfate in the holes along with manure was the best method of zinc application in apple orchards.

**0900-0940**

**S13-O-155**

**FROM MOLECULAR TO TREE BIOLOGY AND PHYSIOLOGY: HOW TO INTEGRATE KNOWLEDGE IN FUTURE RESEARCH?**

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In the last decade, considering fruit production as part of the whole tree development became a new agronomic challenge, especially with the emergence of the Integrated Fruit Production concept. This necessitates that more account is taken of the complexity of fruit tree biology with respect to their perennality and the year on year increase of their structure. This was made possible, in particular thanks to the development of methods which allow the description and the analysis of entire tree structures. During the same period, physiological processes were investigated at much more detailed levels or scales, thanks to the progress of cellular and molecular biology. This led to the emergence of a new scientific question: how to integrate the knowledge obtained at these different scales or levels, from cellular or molecular scales to organs and tree scales? The present paper attempts to highlight possible points of view dealing with this new issue. Integration will be considered on an annual time scale, taking into account the biological phenomena which occur simultaneously with fruit development and those occurring after harvest. Over a longer time scale, the specific tools which allow us to describe, analyse and simulate the year on year development of the structure will be reviewed. Links between these structural models and physiological processes were developed by so-called "structure-functions" models which take into account the plant/environment interactions. Over the next few years, checking the consistency between the observations and the model outputs will probably constitute a key issue. How the integration of physiological functions and the year on year development within a comprehensive framework opens new perspectives will be discussed, in terms of agronomy (fruit production, orchard management) and breeding.

**0940-1000**

**S13-O-156**

**A NEW APPROACH FOR LIGHT MANIPULATION IN FRUIT TREES**

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We introduce here a new approach for improving the utilization of the solar radiation by fruit trees. It is based on selective filtration of the light by plastic shade nets (cloths) of special optical properties, which modify the quality of the natural radiation. A series of colored shade nets were developed, each one specifically modifies the spectrum of the filtered light (in the UV, visible or FR regions), and/or enhances the relative content of scattered-diffused light, and/or affects the thermal components (the IR region). Depending on the pigmentation of the plastic and the knitting design, the nets provide varying mixtures of natural, unmodified light, with spectrally modified diffused light. The approach aims at specific, differential stimulation of desirable physiological responses, which are regulated by light, in addition to providing physical protection. Following the substantial effects of several colored nets on elongation, branching and flowering

in ornamentals (Oren-Shamir, Gussakovsky, Shpiegel, Nissim-Levi, Ratner, Ovadia, Giller and Shahak (2001) *J. Hort. Sci. Biotech.* 76: 353-361), we have applied the colored netting to deciduous fruit trees. The range of shading used for peach and apple orchards was 20-30% (compared with 50-80% shading used in ornamentals). The experiments carried out in apple ('Red Delicious' and 'Granny Smith') and peach orchards, in semi-commercial scales, yielded specific effects of the colored nets on fruit maturation, size and color, in addition to non-specific reduction of superficial damage and sunburns. This approach opens new possibilities for improved performance of fruit tree orchards under selective protection.

**1000-1020****S13-0-157**

#### **SWEET CHERRY FRUIT DISTRIBUTION AND LEAF POPULATIONS: MODELING CANOPY DYNAMICS AND MANAGEMENT STRATEGIES**

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In nature, sweet cherry (*Prunus avium* L.) is a large (15+ m) tree; under orchard management, canopy volume and stature are reduced by pruning, thereby altering fruit and leaf distribution and source:sink relationships in a manner that generally enhances desirable fruit qualities. New rootstocks, such as Gisela 5, exhibit a tendency to increase total floral bud formation, thereby altering fruit and leaf distribution in a manner that can reduce desirable fruit qualities. To quantify these opposing influences and better predict the long-term effects of novel management strategies for sweet cherry production, we have developed working models with the following components for evaluation of seasonal growth dynamics: fruiting (sink) components include Fspur (spur-borne, usually multiple, fruiting buds on 2-yr and older wood) and Fshoot (single fruiting buds on 1-yr-old wood); vegetative sinks include Lspur/f (expanding fruiting spur leaves), Lspur/nf (expanding non-fruiting spur leaves), Llat (expanding lateral shoot leaves), Lterm (expanding terminal shoot leaves), Slat (new lateral shoots), Sterm (new terminal shoots), Rnew (new roots), and TRtotal (total trunk + root storage reserves); photosynthate source components include LAspur/f (leaf area of fruiting spurs), LAspur/nf (leaf area of non-fruiting spurs), LAterm (leaf area of new terminal shoots), LAlat (leaf area of new lateral shoots), SRlocal (storage reserves within the branch), and SRdistal (storage reserves beyond the immediate branch). The dynamic relationships between these components have been modeled empirically for key developmental stages to illustrate theoretical growth of a sweet cherry branch via interactive computer graphics. The implications of these model relationships for predicted performance over time, as young sweet cherry trees fill their orchard space and branches age, under the imposition of two novel canopy management strategies, "spur extinction" and "dormant heading", will be discussed.

**1020-1040****S13-0-157-A****TO BE ANNOUNCED****1400-1420****S13-0-158**

#### **INTEGRATING APPLE TREE AERIAL AND ROOT ARCHITECTURE IN A STRUCTURE-FONCTION APPROACH**

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In the last few years, architectural studies have been carried out on the aerial development of apple trees, taking into account their genotypic diversity. At the same time, root architecture has remained under investigated. This led us to develop new researches regarding both the tree physiology in interactions with the environment and root architecture. The present work had thus a double objective: (i) the development of a structure function modelling approach relying on the description of the tree's aerial structure and physiology; (ii) the investigation of the structure and growth dynamics of the root system in relation to those of the aerial part. The experiments were carried out at INRA experimental station, Melgueil (France). Two INRA apple hybrids of three years old (X3305 and X6407) and two

varieties of seven years old (Fuji and Braeburn) were used. Aerial systems were described and digitized taking into account both topology and geometry of the tree constituents. Two physiological aspects were examined: carbon assimilation and sap flow. Responses in photosynthesis to different environmental conditions (radiation, humidity and CO<sub>2</sub> concentration) were analysed at a leaf level with a LI-COR 6400. These observations were used to parameterise the RATP model (Radiation, Absorption, Transpiration and Photosynthesis). Other observations, done at the branch scale were used to assess the RATP model: The total gas exchange and the sap flow, were measured by means of branch bags and heat balance methods respectively. The growth dynamics of the root systems were studied by means of land rhizotrons. This paper presents the preliminary results on field experiments and the first applications of RATP model. Moreover, the genotypic diversity study allows us to test the model robustness, and to characterize the architectural development of new INRA varieties with potential agro-economic interest.

**1420-1440****S13-0-159**

#### **AUTONOMOUS PLANT DEVELOPMENT ASSOCIATED WITH ROOT-SHOOT INTERACTIONS**

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A systemic approach is proposed for analyzing plants' physiological organization and cybernetics. To this end, the plant is inspected from the integration of crown and root systems, and its impact on a number of basic epigenetic events. The approach is axiomatic and facilitates the definition of the principles behind the plant's autonomous control of plant size and longevity, and growth and reproduction. Control proves to be localized and peripheral, integrating information from other plant parts and external stimuli. Growth and reproduction homeostases are shown, and the homeoretic shift between them.

**1440-1500****S13-0-160**

#### **CROP LOAD EFFECTS ON APPLE-THE PHOTOSYNTHETIC RESPONSE UNDER THE SPOTLIGHT**

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This paper attempts to summarise results from various crop load studies on apple and discusses possible crop load/ rootstock/ time of thinning/ environment interactions. Leaf and whole canopy photosynthesis is not affected by rootstock but is very dependent upon time and severity of flower/ fruitlet removal, and it seems that the later the thinning occurs the greater the effect on photosynthesis, since proportionally fewer actively growing sinks are available for alternative carbohydrate movement. However, leaves suffering down regulation of photosynthesis can be rejuvenated to high photosynthetic capacity when the sink/ source ratio is increased substantially due to sinks (developing buds, root system) becoming more demanding for carbohydrate. Two factors are important here; firstly how do leaves cope with excess light when demand is low and secondly how important is starch in down-regulating photosynthesis? Early in the growing season leaf and whole canopy photosynthesis per unit area of leaf were not affected by crop load, possibly due to the compensatory response of trees with lower fruit numbers to significantly increase extension shoot growth, leaf area and trunk circumference. In the mid- to late-part of the growing season, leaf and canopy photosynthesis per unit area of leaf were significantly and linearly down regulated with reduced crop load, yet the amount of available light energy absorbed by the leaves was similar. This implies that once the photon requirement for primary photochemistry is met, low sink demand trees diverted proportionally more excess energy through the thermal dissipation pathway (xanthophyll-mediated) or through reaction centre closure in photosystem II compared to high sink demand trees. The regulation of leaf photosynthesis may be due to an observed buildup/ degradation of starch grains within leaf chloroplasts and hence varying exposure levels of the thylakoids depending on sink/ source ratios. The latter also had thicker, heavier leaves, higher leaf air content and more leaf hair. The total amount and the constituents of leaf pigments and leaf carbohydrate were significantly different between heavy- and non-cropping trees. Leaf and canopy

photosynthesis per unit area of leaf were similar across crop loads after fruit harvest, suggesting that other sinks may become increasingly demanding for carbohydrate supply.

**1500–1520**

**S13–O–161**

**USING L-SYSTEMS TO DEVELOP “BIOINFOGRAPHICS” MODELS OF FRUIT TREE GROWTH AND DRY MATTER PARTITIONING**

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Previously, Grossman and DeJong developed the “PEACH” model to simulate the growth and dry matter partitioning of peach trees based on the hypothesis that dry matter partitioning within the tree is driven by competition among sinks. A major limitation of the PEACH model is that sinks are treated as generalized compartments that include maintenance respiration, leaves, fruits, stems, branches, trunk and roots. Recently, we have begun to use Lindenmayer computer graphics systems (L-systems) to develop biological process-based informational computer graphics (“BioInfoGraphics”) models to extend previous modeling efforts to explicitly include canopy architecture and tree growth processes. This approach has provided a context for exploring the influence of canopy architecture on source-sink interactions within a growing tree canopy. Each internode of the shoot system is represented as a finite element of a resistor network, which functions to connect carbon sources and sinks into a simulated tree canopy. Carbon flow from sources to sinks is determined by the current values for each source and sink potential, combined with the resistance of each internode and the overall topology of the canopy. The “architectural” growth of the canopy is simultaneously simulated based on a set of biological concepts that govern individual shoot growth and branching. The future potential for using “BioInfoGraphics” as a tool to develop and store three dimensional data for describing, studying, understanding, simulating, and communicating plant growth and development processes will be discussed.

**1520–1540**

**S13–O–162**

**INSIGHT INTO THE ALTERNATE BEARING NATURE OF PECAN**

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The primary biological problem for producers of pecan nuts [*Carya illinoensis* (Wangenh.) K. Koch] is alternate bearing, yet a fundamental understanding of alternate bearing remains elusive. Two pecan cultivar populations, comprised of genetically diverse genotypes, were studied to estimate the association of the intensity of alternate bearing (“I”) with horticultural traits such as fruit ripening date (“FRD”), duration of the post-ripening foliation period (“PRFP”), and nut-size. Best-fit regression models comparing “I” to “FRD”, “PRFP”, and nut-size

produced relationships that appear inconsistent with either of the two theories explaining alternate bearing in pecan (i.e., Carbohydrate and Phytohormone Theories). “I” was unassociated with “FRD” and had little or no relationship to “PRFP” in small-nut size cultivars (i.e., >132 nuts per kg), yet there is a moderate to strong inverse linear relationship with “PRFP” of large-nut size cultivars (i.e., < 32 nuts per kg). Thus, “I” declines as duration of the post-ripening foliation period declines and “I” is largely unrelated to date of fruit ripening. Measurement of photoassimilation rates between cultivars exhibiting extremes in “PRFP” indicates that the late season retention of fruit, and the associated positive influence on late-season foliar assimilation rates, plays a key role in determining the magnitude of alternate bearing the following year. Multiple regression models indicated that “FRD” and nut size were poor predictors of “I”, however “PRFP” possessed substantial inverse predictive power. These results confer insight into the complex nature of alternate bearing in pecan and provide evidence for modifying existing alternate bearing theories of pecan.

**1540–1600**

**S13–O–163**

**STATISTICAL RECONSTRUCTION OF A WALNUT TREE CANOPY**

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Canopy geometry, as a plant factor largely determining the complex canopy-microclimate interaction, can regulate such primary activities of the tree as radiation interception and gas exchange. Quick approaches focusing attention on isolated trees to establish efficiently a canopy’s spatial parameters have not been sufficiently developed, disseminated and/or tested. Among the available approaches to acquire canopy architecture, two direct methods are here chosen and compared: the former involves an analytical (by digitizing) technique worked out at INRA, France (Silva Fennica, 31 (3): 265–273) and the latter is based on the statistical approach developed at the Univ. of Bologna (Vitis, 35 (1): 23–28). The analytical method has proved extremely reliable for canopy reproduction, although its application to large tree canopies may be questionable because the acquisition of the experimental data tends to be excessively time-consuming. On the the other hand, the interest in the statistical technique resides in the possibility of quickly collecting the data set necessary for satisfactory canopy reconstruction. In the present study, a set of about 1600 canopy spatial values, collected by digitizing a two-year-old walnut tree having 5.0 m<sup>2</sup> leaf surface area, was processed and statistical samples of different sizes (from about 1/3 to 1/5 of the available data, i.e. from 500 to 300 values) were taken. The virtual images generated by the whole data set and shown as reproducing the real canopy, represent the reference for the canopy’s reconstruction (generation) as rendered by all the statistical samples. The data analysis thus far indicates that the statistical canopy reconstruction with one-third of all the data is satisfactory; canopy reconstruction from smaller samples appears promising and the results are expected in the near future.