

Symposium 20 (S20): Citrus and Other Subtropical and Tropical Fruit Crops: Issues, Advances and Opportunities

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1100–1140

S20–0–1

APPLICATIONS OF BIOTECHNOLOGY TO CITRUS IMPROVEMENT

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Citrus are subject to many biotic and abiotic stresses and markets are continuously requiring fruits of higher quality. These pose important problems in most citrus growing areas that can only be solved with the establishment of citrus improvement programs to recover new and healthy genotypes to be used as rootstocks and varieties. Success of traditional citrus breeding strategies is limited by its peculiar genetic and reproductive characteristics. Biotechnology offers different approaches that can overcome many of these limitations. In this paper the following technologies are reviewed: a) Shoot tip grafting in vitro. It is used worldwide to recover plants free of all known citrus pathogens, and already hundreds of millions of trees originated in this technique have been planted in the field; b) Embryo rescue. It is used in large programs to recover triploid seedless hybrid varieties from aborted seeds from $2n \times 4n$ and $2n \times 2n$ crosses; c) Protoplast fusion. It allows the production of allotetraploid hybrids among sexually compatible and incompatible parents to be used as rootstocks or as parentals for interploid breeding. Fusions between diploid and haploid cell lines are also used to produce triploid hybrids. d) Genetic transformation. Efficient protocols for transformation of several genotypes have been developed and introduction in citrus of genes of potential agronomical interest have been accomplished.

1140–1200

S20–0–2

TO BE ANNOUNCED

1200–1220

S20–0–3

TRANSCRIPTIONAL FACTORS AS “CANDIDATE GENES” TO DEVELOP MOLECULAR GENETIC MARKERS IN TROPICAL TREES

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Molecular genetic markers are powerful tools in selective breeding of agronomically important crops. The “candidate gene” approach identifies genes that may be involved in expression of a desired phenotype and investigates their usefulness as molecular markers within a population segregating for this phenotype. Currently, there is an international effort in improving disease resistance and crop yield in *Theobroma cacao* L., the sole source of cocoa and an economically important crop of the tropics. We are currently developing molecular genetic markers in *T. cacao* L. using a candidate gene approach focusing upon families of transcriptional factors. One such family is WRKY proteins, transcriptional factors associated with regulating defense responses in plants. Approximately 100 of these genes have been identified in the model organism *Arabidopsis thaliana*. They are evenly distributed within the genome and closely associated with defense-related genes. Thus, WRKY genes may serve as useful markers for selecting for improved disease resistance. From *T. cacao* DNA, 16 unique sequences were isolated using degenerate primers designed to a conserved region in the WRKY domain. Three of these sequences are polymorphic by single strand conformational polymorphism capillary electrophoresis (SSCP-CE) and mapped within an F_2 population of *T. cacao* segregating for disease resistance to ‘witches broom’ disease caused by *Crinipellis pernicioso*.

1220–1240

S20–0–4

TRANSFER OF A POTENTIAL CANKER RESISTANCE GENE INTO NAVEL ORANGE (*CITRUS SINENSIS* OSBECK) PROTOPLASTS USING GFP AS THE SELECTABLE MARKER

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Citrus canker disease caused by the bacterial pathogen *Xanthomonas axonopodis* pv. citri is widespread worldwide, and citrus species such as sweet orange, grapefruit, Mexican lime are highly susceptible. Newhall navel orange (*Citrus sinensis* Osbeck) is one of the leading commercial cultivars in China because of its seedlessness and other good qualities. Stems from aseptically germinated nucellar seeds are not available for transformation explants. Consequently, protoplasts isolated from embryogenic callus were used for transformation. Herein, plasmid DNA encoding the non-destructive selectable marker enhanced green fluorescent protein gene (p524EGFP1) and the plasmid DNA of a potential canker resistance gene (pC822) from the Xa21 gene family of rice (which provides broad spectrum *Xanthomonas* resistance in rice) were co-introduced using polyethylene glycol into Newhall navel orange protoplasts. Following protoplast culture in liquid medium and transfer to solid medium, transformed calluses were identified via expression of the GFP, physically separated from non-transformed tissue, and cultured on somatic embryogenesis induction medium. Sixteen transgenic embryoids were recovered from one experiment and are growing rapidly. They are expected to regenerate plantlets soon. Then, the presence of the GFP and Xa21 genes will be confirmed, and their canker resistance will be evaluated.

1340–1440

S20–P–5

GENERATION AND USE OF CAPS MARKERS FOR BREEDING IN SEEDLESS CITRUS

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Seedlessness is an important characteristic in *Citrus* breeding. New seedless cultivars have been released through the breeding program using some different resources including male sterility, embryo abortion and so on. The mapping of such traits on the linkage group is expected to provide the selection markers for breeding as well as the anchor markers for the map-based cloning of the target genes. For the purpose, the co-dominant CAPS markers were commonly used to construct linkage maps of 2 populations which had been derived from different sources of seedless genes. In the population between ‘Kiyomi’ (tangor) x ‘Miyagawase’ (Satsuma, *C. unshiu*), 221 markers constructed 9 linkage groups covering a total of 802 cM, and a possible QTL gene related to a fewer seed number derived from Satsuma mandarin (*C. unshiu*) was localized in K-6 linkage group. The other dominant gene related to abnormal development of embryos from ‘Mukaku-kishu’ (a seedless cultivar of *C. kinokuni*) was mapped in another population, for which linkage map covered 693 cM with 159 markers. The linked markers can be used as the selection tools in the breeding program for seedless citrus. The possibility and problems on marker-assisted selection were investigated.

1340–1440

S20–P–6

COLD HARDINESS AND GENETIC RELATIONSHIPS AMONG SATSUMA MANDARIN SELECTIONS.

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Satsuma mandarin [*Citrus unshui* (Marc.)], one of the most cold-tolerant citrus, is grown commercially along the northern coast of the Gulf of Mexico. Several recent Satsuma introductions from China are being tested for their degree of cold-hardiness and genetic variability. Cold hardiness is being evaluated using electrolyte leakage, callus formation of split stem pieces and triphenyl

tetrazolium chloride assays. Potted plants with roots thermally isolated are being exposed to -4, -6, -8, -10 and -12 °C in a temperature controlled freezer with a temperature decline rate of 2 °C/hr. Genetic variability is being determined from fingerprints using inter-simple sequence repeats (ISSR) and amplified fragment length polymorphisms (AFLP). Genetic distance between introduced accessions, known Satsuma cultivars, and other mandarin and mandarin-like accessions will be calculated by PAUP analysis. Comparisons of cold hardiness and genetic variability will be discussed.

1340-1440

S20-P-7

EXPRESSION ANALYSIS OF GENES ENCODING CELL WALL MODIFYING ENZYMES DURING THE POSTHARVEST PERIOD IN FIG FRUIT (*FICUS CARICA* CV. MASUI DAUPHINE)

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The fig fruit undergoes simultaneous ripening and increase in fruit size during its final stage of maturation. In an effort to understand the molecular basis of postharvest softening in figs, we isolated cDNAs responsible for cell wall expansion and disassembly, basically two cDNAs encoding two divergent Endo-1, 4-b-glucanases (FC-Cel1 and FC-Cel2, respectively) and two cDNAs encoding xyloglucan endotransglycosylase (FC-XET1) from mature figs. Southern blot analysis indicated that FC-Cel1, FC-XET1 and FC-XET2 exist as single copy genes, while FC-Cel2 exists as a two-copy gene in the fig fruit genome. Northern analysis showed that FC-Cel1 mRNA accumulated in the control fruit at harvest but gradually decreased to undetectable levels. FC-Cel1 mRNA accumulation was induced by propylene, however the stimulated expression was observed only after 24 h propylene exposure, but later declined to undetectable levels. FC-Cel1 mRNA accumulation was completely inhibited by 1-MCP, indicating that this gene is positively regulated by ethylene. FC-Cel2 mRNA accumulation increased gradually from the day of harvest and high level accumulation was observed at the later stages of softening in both control and treated fruits. FC-Cel2 mRNA was unaffected by either 1-MCP or propylene indicating that this gene is ethylene-independent. FC-XET1 mRNA accumulation was only detected in the 1-MCP treated fruit suggesting that this gene is negatively regulated by ethylene. Low level accumulation of FC-XET2 was detected at the later stages of softening in all treatments even though relatively high level accumulation of FC-XET2 was detected in the 1-MCP treated fruit. The overlapping expression and differential regulation by ethylene suggest that the Endo-1, 4-b-glucanases and the xyloglucan endotransglycosylases operate in a coordinate manner in the modification of the hemicellulose network during postharvest softening in fig fruit.

1340-1440

S20-P-8

RADP CHARACTERIZATION OF SOME TURKISH CAPRI FIG VARIETIES

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Fig (*Ficus carica* L.) is one of the thousands of *Ficus* species bearing edible fruits. Today it is widely grown in the natural flora of countries where a Mediterranean climate prevails. The Mediterranean basin has been the homeland of fig from time immemorial. In the world market, Turkey is the major supplier of both dried and fresh figs. Fig production of Turkey is estimated as 280 000 tons and 75% of this production comes from Aydin and Izmir which comprises almost all of the dried fig production. Sarilop (Calimyrna) is the main variety for drying and Bursa Black for the fresh market. These varieties, belong to the Smyrna type and need caprification in order to set their main crop. Since caprification was practiced in the region for thousands of year, many male fig cultigens exist besides female. Many studies have been done to describe and characterize their main morphological, physiological and biological characters. In this study, randomly amplified polymorphic DNA (RADP) markers were used to distinguish some major caprifig varieties.

1340-1440

S20-P-9

MOLECULAR CHARACTERIZATION OF INTERGENERIC SOMATIC HYBRIDS OF *CITRUS RETICULATA* WITH *PONCIRUS TRIFOLIATA* BY AFLP AND PCR USING UNIVERSAL PRIMERS

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Citrus exocortis viroid (CEV) is widespread in citrus production areas where trifoliolate orange [*Poncirus trifoliata* (L.) Raf.] is used as rootstock. Another rootstock, i.e., *Citrus reticulata* Blanco cv. Red tangerine is tolerant to CEV. In this paper, embryogenic protoplasts of *C. reticulata* cv. Red tangerine were electrically fused with mesophyll protoplasts from *P. trifoliata* and 5 embryoids were regenerated after 40 days of culture. The embryoids were cut into several parts and subcultured on shoot induction medium. Five months later, after several subcultures, shoots initially regenerated. The plants grew vigorously with well developing root systems and exhibited the trifoliolate leaf character from *P. trifoliata*. Chromosome counting of 4 randomly selected root-tips revealed that they were tetraploids ($2n = 4x = 36$). RAPD analysis of 4 randomly selected plants verified their hybridity. Their hybridity was further confirmed by AFLP analysis using four primer pairs, from which a total of sixty-five specific bands were detected. Cytoplasmic genomes analysis using universal primers revealed that their chloroplast DNA band pattern was identical to that of trifoliolate orange, while the band pattern of mitochondrial DNA was identical to that of Red tangerine. The potential of this somatic hybrid to control tree size and to provide multi-resistance rootstock is discussed. Supported by National Natural Science Foundation of China (NSFC), the International Foundation for Science (IFS), and by Chengguang Youth project of Wuhan City in China.

1340-1440

S20-P-10

GENETIC INTERACTION OF DIFFERENT TISSUES IN CITRUS PERICLINAL CHIMERAS

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Citrus periclinal chimeras NFF (layer constitution: L1-L2-L3=NFF) and FNN (layer constitution L1-L2-L3=FNN) were produced by grafting between *Citrus sinensis* cv Fukuhara orange and *C. natsudaikai* cv. Kawano natudaikai (Kuhara et al., 1988). It was clear that leaf and fruit characters of the two chimeras were significantly modified or altered due to the intercellular interactions of different genotypes. In the present study, DNA markers specific for both parents and chimeras were searched. Of the several RAPD markers, C-64, specific to Kawano natsudaikai, and B-79, unique to Fukuhara orange, were cloned and sequenced respectively. Based on the DNA sequences of these two markers, one pair each of STS (sequence-tagged site) primers was designed and tested in the donor plants, chimeras and chimera-derived progenies. The results showed that the STS markers presented high fidelity to their corresponding tissues, reflecting chimeral tissue constitutions in the chimera. In the FNN progenies tested, however, one plant was found not revealing the STS marker specific to Kawano natsudaikai tissue. Interestingly, its peroxidase-banding pattern also lacked the specific band to Kawano natsudaikai, and its morphological characters were clearly different from those of Kawano natsudaikai. These results indicate that genetic variation or a transformation occurred during the development of the chimera fruit. We have widely observed genetic changes and gene transfers in grafts of red pepper, tomato, eggplant, tobacco and soybean and chimeral plants in *Brassica*. In the case of citrus, similar events may have occurred. These phenomena are very important from the viewpoint of cell-to-cell gene transfer. We are further trying to obtain breeding materials by using grafting and artificial chimeras. In parallel, the precise mechanism of those graft transformations or graft-induced genetic changes is being investigated at the molecular level.

1340-1440

S20-P-11

AGROBACTERIUM TUMEFACIENS-MEDIATED TRANSFORMATION OF JUVENILE EXPLANTS OF YELLOW PASSION FRUIT (*PASSIFLORA EDULIS* F. *FLAVICARPA*)

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During the ripening process of climateric fruits, like yellow passion fruit (*Passiflora edulis* f. *flavicarpa*), 1-carboxylic-1-aminocyclopropane (ACC) is converted into ethylene by the action of the ACCoxidase enzyme. Passion fruits present a high loss of water during fruit ripening, what is a concern for transport. In order to improve fruit quality and storage life, experiments were conducted for regeneration of plants from leaf explants of *Passiflora edulis* and for introduction of an antisense melon ACCoxidase gene (LEM1) via *Agrobacterium tumefaciens* strain carrying binary vectors. For regeneration experiments, Murashige and Skoog (1962) medium (MS) was used, supplemented with three concentrations of benzyladenine (BA): 4.44, 6.66 and 8.87 mM, on two types of plant material (juvenile and adult) and two positions of leaf explants (abaxial face or adaxial face in contact with the culture medium). For transformation experiments, leaf explants were co-cultured with disarmed *A. tumefaciens* vector pGA643 carrying LEM1 gene and the EHA101 strain containing a plasmid harbouring a NOS/NPTII gene. The best results of shoot regeneration were obtained on medium containing 6.66 mM BA for all kinds of explants and for both explant positions. With juvenile material, this treatment resulted in 63.61% of explants regenerating shoots for both positions. With adult material, 50 to 78% of explants regenerated on the same medium, according to the genotype. Three plants of nine growing in the presence of kanamycin were transformed with the NPTII gene, and one plant of six growing in the presence of kanamycin contained the LEM1 gene was transformed, as indicated by PCR analysis. Transformed plants were grown and rooted on half-strength MS medium containing 1 mg/L gibberellic acid.

1340-1440

S20-P-12

MORPHOLOGICAL AND PHYSIOLOGICAL EFFECTS OF ROLABC GENES INTO CITRUS GENOME

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For citrus, unlike other fruit tree species, there are no useful dwarfing rootstocks available and the existing ones have serious limitations in their use because of low adaptability to different environmental conditions or scion incompatibility. For this reason, obtaining dwarfing genotypes is one of the most important goals in citrus genetic improvement. With the aim of modifying the growth habit of an important rootstock, a research program was set up to introduce rolABC genes from *Agrobacterium* rhizogenes into the genome of citrange Troyer [*Citrus sinensis* (L.) Osbeck x *Poncirus trifoliata* (L.) Raf.]. Seedling stem segments were infected with *Agrobacterium tumefaciens* carrying pBin19 plasmid with rolABC genes and selectable marker (nptII). Transgenic shoots were obtained from different experiments and analyzed by PCR and Southern blotting. PCR positive shoots were micrografted or autorooted and the transgenic plantlets were acclimatized in a greenhouse. Six grafted and ten autorooted plants were used to measure growth parameters at regular intervals. Transgenic clones showed a dwarfing habit as the plant height was reduced to half of the control due to a strong reduction of internodal stem length. Photosynthetic activity and other physiological parameters were also influenced.

1340-1440

S20-P-13

INDUCTION OF MUTATIONS IN FRUITS OF TROPICAL AND SUBTROPICAL REGIONS

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Induction of mutations is an effective approach for enhancing natural genetic resources. The FAO/IAEA Coordinated Research Projects (CRP) have established a program on tropical and subtropical fruits including banana and linked with the Technical Co-operation (TC) sub-Regional Project on date palm. The objective is to improve these fruit crops by induced mutations. These programs have four major components: in vitro culture, radiation induction of mutations, mutation screening and characterization of mutants with molecular markers. In most of the important fruit crops, tissue culture is well established

for plant regeneration either via somatic embryogenesis or organogenesis. Since somatic embryo cultures often originate from a single cell, it is an ideal system for induction of mutations as single cell mutations are unlikely to develop undesirable chimeras. The rate of somatic embryo germination is often very poor, which has become a major hurdle for large-scale plant multiplication of desirable induced mutants. The major focus will be on the development of mutant lines of fruits with improved tolerance against abiotic and biotic stresses and other desirable traits such as seedlessness, e.g., in guava and citrus.

1340-1440

S20-P-14

CHROMOSOME TRANSFER, A NEW EFFICIENT METHOD TO BREED CITRUS

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Citrus cultivar improvement by conventional hybridization methods is hampered by the long juvenility period, high heterozygosity and a very complex reproductive biology including sexual incompatibility and sterility in several species that prevent several potentially useful hybridizations from being successful. Additionally, sexual hybridization is virtually useless in breeding programs targeting improvement of two of the most important citrus species, orange and grapefruit. The prevalence of nucellar embryony in these two species prevents the development of large segregating populations for recombination and selection of superior genotypes. Consequently, no cultivar of sweet orange or grapefruit have ever been produced through controlled hybridization. Alternative methods of gene transfer have been successfully used in some citrus species, however the improvement of orange, grapefruit, and other polyembryonic species is still to be addressed. To overcome these barriers, we recently established a new method for partial genome transfer called microprotoplast mediated chromosome transfer (MPMCT). The method consists of producing microprotoplasts containing single chromosomes from a donor citrus species, and the transfer of the chromosome to a recipient species. We completely established the methodology enabling us to produce, for the first time ever, a partial hybrid containing the whole genome of a sweet orange with a few grapefruit chromosomes. The whole chromosome transfer procedure and evidence of chromosome transference from grapefruit to sweet orange will be presented.

1340-1440

S20-P-15

PROTOPLAST MANIPULATION AND CITRUS BREEDING RESEARCH

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Since 1985, a programme aiming at genetic improvement of citrus via protoplast fusion has been conducted. More than 30 interspecific and intergeneric somatic hybrid plants were recovered. More than 100 triploid citrus plants of analysis verified that most of the fusion combinations were genetical stable, except the intergeneric somatic hybrid of kumquat with Valencia sweet orange; its dieback characteristic is related to the abnormal nuclear and cytoplasm behavior. Hexaploid (2n=6x=54) plants were interestingly recovered from the fusion of Huangpi (*Clausena lansium*) with *Citrus*, the plants grew well and GISH analysis is being used to confirm the origin of the extra 2 sets of chromosome since both parents are diploid (2n=2x=18).

1340-1440

S20-P-16

INHERITANCE OF AROMA BIOSYNTHESIS PATHWAYS IN CITRUS TETRAPLOID SOMATIC HYBRIDS

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Citrus somatic hybridization by protoplast fusion generates allotetraploids having chromosomes from both parents and mitochondrial and chloroplastic DNAs from either of their parents. Seedless triploids can subsequently be obtained by hybridization of tetraploid hybrids with diploids; however, these new hybrids must have good aromatic quality for the fresh fruit market. Therefore, a knowledge of

inheritance mechanisms of aroma biosynthesis pathways in somatic hybrids is desirable. Aroma compounds were analyzed in leaves and peel of lime (cv. Mexican lime), grapefruit (cv. Ruby red) and their somatic hybrids grown at the Station de Recherches Agronomiques INRA-CIRAD (San Giuliano, Corsica, France). Lime-originating monoterpene aldehydes (neral, geranial) and grapefruit beta-sinensal were quantitatively recovered in the hybrid leaves while citronellal was massively overproduced in the hybrid leaves and peel with regards to its parents. Nootkatone, a grapefruit-specific sesquiterpene ketone, was fully recovered in the hybrid peel, while alpha-sinensal absent in peels from both parents was found in the hybrid. Other somatic hybrids sharing mandarin (cv. willow leaf) as their common parent, [lemon (cv. Euréká) + mandarin], [lime (cv. Mexican lime) + mandarin], and [kumquat (cv. Marumi) + mandarin], exhibit common features in their leaf aroma distributions: a loss of the non-mandarin parent ability to synthesize aldehydes (neral, geranial) as the aldehyde-free mandarin parent, a strong decrease in sesquiterpenes, and a halved production of methyl *N*-methyl anthranilate with regards to the mandarin parent. Amongst key enzymes in aroma biosynthesis pathways, activities of monoterpene synthases and acid phosphatases were measured in leaves with allylic pyrophosphates as substrates and monoterpene alcohol:NADP⁺ oxydoreductases with monoterpene alcohols. Preliminary results indicate that activities were not enhanced, but lowered in hybrids with regards to their respective parents.

1340-1440

S20-P-17

SELECTION OF VITROVARIANTS OF ROOTSTOCKS OF *CITRUS AURANTIUM* AND *PONCIRUS TRIFOLIATA* TOLERANT TO THE SALINITY

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The comparison of effect of various conditions during morphogenesis on the qualitative and quantitative criteria basis (induction of the callus, color, texture, capacity of morphogenesis and growth) showed that initiation of the embryo-derived calli has been improved meaningfully by MT medium supplemented with 2,4-D and BAP. Orientation of the vitrovariation by sodium chloride tested at different concentrations revealed that 4 weeks is insufficient to distinguish the behavior of cells in the presence of salt and that 9 g/L NaCl can be used as pressure of selection to the salinity tolerance. Otherwise, in presence of 9 g/L NaCl, seeds and embryos showed a reduction of more than half in rate of germination. On the other hand, the survival of some calli in presence of this same concentration of salt, during at least two months of culture, confirms the possibility of selection of salt-tolerant cell lines.

1340-1440

S20-P-18

REGENERATION OF INTERSPECIFIC MIXOPLD SOMATIC HYBRIDS VIA ASYMMETRIC SOMATIC HYBRIDIZATION IN CITRUS

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Embryogenic protoplasts of Dancy tangerine (*Citrus reticulata* Blanco), irradiated with X-ray for different time (60, 90 and 120 min) at 5mA and 80kVp, were electrically fused with embryogenic protoplasts of Page tangelo (*Citrus reticulata* Á x *C. paradisi*) that were treated with 0.25 mM iodoacetic acid (IA) for 15 min. The IA-treated protoplasts of Page could not divide at all. Division of Dancy protoplasts irradiated for 60 min was not prevented but delayed, whereas those irradiated for 90 and 120 min did not divide at all. Instead, they plasmolysed or broke. The fusion-treated protoplasts could develop into embryoids for all of the fusion combinations only when the callus was transferred to MT supplemented with 2% glycerol. However, only embryoids could develop into multiple shoots derived from the fusion combination in which the donor protoplasts were irradiated for 60 min was involved, which were recalcitrant to rooting. In-vitro grafting was employed to obtain complete plants. Cytological observation showed that the plants contained mainly diploid and aneuploid cells, together with very few tetraploid cells, indicating that they were mixoploids. Random amplified polymorphic DNA analyses with three 10-mer arbitrary primers confirmed the plants as true somatic hybrids. This is the first report on regeneration of mixoploid hy-

brid plants via protoplast asymmetric fusion in Citrus. Negative effects of ionizing irradiation on regeneration of embryoids and plantlets and possible agronomic interest of the mixoploid plants are also discussed.

1340-1440

S20-P-19

BREEDING AND SELECTION FOR EARLY BEARING PAPAYAS

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Papaya production in the U.S. Virgin Islands is for the domestic market and has been plagued by the Papaya Ringspot Virus (PRSV) and seasonal hurricanes. This has resulted in papayas now being growing as an annual crop. The need exists in the U.S. Virgin Islands for papayas with early production to ensure a marketable crop within 9–10 months. The local demand is for papayas of the 1–1.5 kg size and this is considerably larger than the 0.25–0.5 kg solo varieties developed for export. Breeding and selection has been on-going for 7 years to develop papayas with tolerance to PRSV and fruit production starting at or less than 1 m from the ground. The height at first fruit set, of papaya cultivars evaluated in the Virgin Islands, ranges from 60 to 253 cm. Generally, female plants start setting fruit lower on the stem than hermaphroditic plants. Through breeding and selection, 3 papaya lines have been developed which set fruit between 40 and 60 cm from the ground. These lower height bearing papaya lines produce fruit that are marketable one month earlier than other cultivars.

1340-1440

S20-P-20

HERITABILITY OF TOLERANCE TO PAPAYA RINGSPOT VIRUS AMONG PAPAYA POPULATIONS BY PARENT-OFFSPRING REGRESSION

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Thirty-five papaya lines including 8 papaya parents and twenty-seven derived progeny lines were used to estimate the heritability of tolerance to papaya ringspot virus (PRSV-P) by parent-offspring regression. The experiment was a RCB Design with 3 replications and 12 plants per each plot. The disease severity ratings and trunk cross sectional area were surveyed once every 2 weeks starting 3 months after planting. The disease index, the area under disease progress curve (AUDPC), and relative growth rate of trunk diameter were used to calculate the heritability, which were 0.61, 0.56, and 0.89 respectively. The regression coefficient for each trait was very significant. There were significance for fruit number, fruit weight, and total soluble solids among papaya populations. The yield traits and total soluble solid contents of papayas were positively associated to the degree of tolerance to PRSV-P.

1340-1440

S20-P-21

BREEDING GUAVA (*PSIDIUM GUAJAVA* L.) FOR RESISTANCE TO RUST CAUSED BY *PUCCINIA PSIDII* WINT. IN BRAZIL

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In Brazil, guava is attacked by several pests and diseases that mainly damage the fruit. Rust, caused by *Puccinia psidii* Wint., is the most serious disease in our conditions, constituting in some areas the limiting factor of the crop due to the injury caused. The only control measure available today is through weekly fungicides sprays, which elevate the production cost. The use of resistant cultivars is the most effective and economic way to control this disease. The objective was to select individual guava plants to obtain rust resistant cultivars. Seeds (22950) from fruit originated through open pollination of 306 accesses were used, constituting half-sib progenies. Seedlings were grouped in different number of accesses as: A: 35 primary selections of white guava, obtained in the breeding program IAC (identification: White LxPy); B: 64 primary selections of red guava, obtained in that same program. (identification: Red LxPy); C: 118 commercial varieties (some with 2 to 6 accesses) as Supreme, Indiana, Weber, FAO, Austra-

lian, Patillo, Paluma, Rica, Rubi Supreme, IAC-4 and others; D: 55 advanced selections of IAC program (with acronym MAS) of Conceição de Almeida, BA (with acronym EFFT) and others named Sigla (II to XIII); E: 34 entries with accesses of difficult identification and even without identification. Selection was applied in the initial stages of the seedlings and after artificial inoculation with the fungus. After two years, 105 individual plants were selected with absolutely no symptoms of the disease and will now go under selection for other traits, such as yield, fruit characteristics, color, and flavor. The heritability for rust resistance was estimated in a broad sense to be $h^2=0.275$

1340-1440

S20-P-22

BREEDING TO PRODUCE A NON-CAPRIFYING, PERSISTENT CALIMYRNA FIG

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The principal objective of this project was the development of a high quality, large size, light colored dried fig, comparable to the Calimyrna fig, that does not require caprification (pollination) by the inedible male caprifig. Figs that set parthenocarpically, without caprification are persistent, common-type, figs. A small closed ostiole restricting insect access to the interior of the fig fruit was a secondary objective. The primary fruit characteristics desired were large fruit size, skin color, light skin quality, a small ostiole, a meaty-dense flesh, low fungal decay potential and good tree productivity. The breeding strategy was to cross previously identified caprifigs, containing the genes for persistence, with Calimyrna type figs possessing desired fruit characteristics. Hybridizations were done in 1991 and 1992. In 1993, 2400 hybrid fig seedlings were planted. By 1996 the most promising 45 seedlings were selected for evaluation through 2000. By 2000 this was reduced to 12 candidates. In 2001, a final four were selected for replicated yield evaluations and designated 6-38W, 12-33E, 12-40E and 23-41E.

1340-1440

S20-P-23

EVALUATION OF MANDARIN CULTIVARS FOR CENTRAL CALIFORNIA PRODUCTION

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California has a small, poorly developed, mandarin industry consisting primarily of satsumas. Yield and fruit quality (fruit size, seediness, and Brix acid ratio) of 8 different mandarin cultivars on 4 different rootstocks were evaluated for potential production under Central California growing conditions. Clausellina and Kuno Wase Satsumas, Clementine Fina, Caffin, Sidi Aissa and Oroval, Fallglo, and W. Murcott Afourer were evaluated on C-35, Rubidoux, Riches 16-6, and Carizzo rootstocks. To date the highest yielding combination is W. Murcott on C-35. All cultivars produced higher yields on C-35. Lowest yields were produced on Clementine Caffin, Clausinella, and Fallglo. The two satsuma cultivars had virtually no seeds and larger fruit size, but lower sugar and acid contents than the other cultivars. W. Murcott had the highest Brix acid ratio at harvest. Within a given cultivar, rootstock did not produce any significant differences in internal or external quality except fruit size distribution. Fallglo is excessively seedy for commercial production in California and should not be considered for production unless seediness can be controlled.

1340-1440

S20-P-24

ADAPTATION AND PERFORMANCE OF 15 AVOCADO CULTIVARS GROWN IN ANTALYA PROVINCE IN SOUTHERN TURKEY

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Avocado (*Persea americana* Mill.) having limited growing area in the world, can be grown in the Mediterranean strips of Turkey. Studies of 4 avocado cultivars (Fuerte, Hass, Bacon, Zutano) were first started in 1970. Adaptation trails

on these cultivars gave successful results in the ecological conditions of Antalya. After these trails, commercial plantation began with these cultivars. Fifteen cultivars (Ettinger, Edranol, Pincerton, Reed, Rincon, Corona, Wurtz, Santana, Jim, Ryan, Susan, Fuerte, Hass, Bacon, Zutano) were used in this study. Fruit and tree characteristics, yield, flowering time and effects of ecological conditions on the cultivars were observed from 1997 to 2001. Fruit characteristics and yield of cultivars were evaluated. Fuerte, Zutano, Reed, Pincerton, Santana produced large fruits (approximately 250-300 g) and Hass and Susan produced small fruits (175-220 g). Yield varied as regard to years. Bacon, Zutano, Susan, Santana and Ettinger produced regular and high yield (average 40-120 kg/tree), however, Pincerton, Reed, Rincon, Corona, Wurtz produced less fruits. Flowering time, which lasted about 4 months, February to June, also varied by years and cultivars. Tree-trunk diameter, height and width of tree canopy were measured. Ettinger, Bacon, Zutano, Santana had upright growing habit however; Fuerte and Hass had spreading growing habit. Other cultivars formed relatively small sized and irregular canopy habit. Effects of climatic conditions on each cultivars were also determined. Low winter temperature caused damages on the vegetative and generative parts of plants in same years. Cold weather conditions affected most vegetative parts of Reed, Pincerton, Hass, Corona cultivars. However Bacon, Zutano, Jim and Santana were not affected or lightly affected by cold damages. On the other hand various amounts of cold damages were observed on the flower buds of these cultivars. So, the situation had negative effects on the yield of the cultivars.

1340-1440

S20-P-25

THE ROLE OF SUCROSE-METABOLIZING ENZYMES IN FRUIT SET AND SIZE OF THE 'WASHINGTON' NAVEL ORANGE

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The navel orange industry of California requires increased production of commercially valuable large size fruit per hectare to remain economically viable. Inflorescences of the 'Washington' navel orange [*Citrus sinensis* (L.) Osbeck] bearing leaves at the base of flowers represent a relatively small proportion of the total number of inflorescences produced each spring. However, these leafy inflorescences set a higher percentage of large size fruit that survive to harvest than inflorescences without leaves, which comprise the majority of bloom each year. Activity of sucrose-metabolizing enzymes that regulate phloem unloading (acid invertase, alkaline invertase, cell wall bound invertase, and sucrose synthase) were assessed in fruit from both leafy and leafless inflorescences to determine the importance of each enzyme in regulating fruit set and size. Activity per unit protein for all four enzymes was greater in fruit from leafy inflorescences for tissues with vascular bundles (areas of extensive phloem unloading and transport) and tissues free of vascular bundles (areas of assimilate storage). Furthermore, activities of one or more of the four sucrose-metabolizing enzymes appear to be related to endogenous concentrations of specific plant growth regulators consistent with hormonal regulation of phloem unloading. The results suggest that a properly timed foliar application of a commercial plant growth regulator might increase the activity of one or more of the sucrose-metabolizing enzymes to increase both the number of fruit set and the size of fruit of leafless inflorescences and thus increase grower income.

1340-1440

S20-P-26

PHYSIOLOGICAL BEHAVIOUR OF SOME SUBTROPICAL SPECIES IN A MEDITERRANEAN AREA

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In recent years a diffusion of tropical and subtropical cultivations in areas climatically similar to the Mediterranean has been observed. The eco-physiological evaluation in areas different from their origin is important to understand the possibility of acclimatizing and diffusion of species. The species observed were avocado (*Persea americana* Mill.), cherimoya (*Annona cherimola* Mill.) and feijoa (*Feijoa sellowiana* Berg.) cultivated in a coastal area of East Sicily (37E 44N). In the present work gas exchanges were measured on the

leaves in-situ at sunlight to determine CER (CO₂ exchange rate) and in darkness to determine the respiration rate and net photosynthesis was calculated. In our climatic conditions, the highest CER and net photosynthesis were observed on avocado leaves, whilst the lowest in feijoa. Moreover, the latter showed markedly the lowest water use efficiency and the highest stomatal conductance. The observed carbon net balances showed that avocado had the lowest CO₂ respiratory release, whilst feijoa the highest. In general, the hypothesis that species with larger leaves result with higher WUE was confirmed.

1340-1440

S20-P-27

RELATIONSHIPS BETWEEN PHOTOSYNTHESIS AND RESPIRATION OF GRAPEFRUIT AND KUMQUAT LEAVES

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Carbon net balance is determined by the amount of CO₂ that passes in and out of stomata, and this affects the biomass production that differs between species because of their photosynthetic and respiratory rates. With this understanding, two species of citrus, *Fortunella japonica* (Thunb.) Swingle and *Citrus paradisi* Macf., completely different in canopy, fruit size and phenological phases, were compared. Gas exchanges were measured of the leaves in-situ in sunlight to determine CER (CO₂ exchange rate) and in darkness to determine the respiration rate. Net photosynthesis was calculated. At the same PAR (Physiologically Active Radiation) and VPD (Vapour Pressure Deficit) conditions, grapefruit leaves, larger and darker green than kumquat ones, showed higher CER and net photosynthesis. Respiration rates, despite the comparison being carried out on such different leaves, resulted in similar rates between the species, so that carbon net balance was higher in grapefruit than in kumquat. Furthermore, CO₂ respiratory release was markedly higher in both species during blooming.

1340-1440

S20-P-28

HERITABILITY OF TOLERANCE TO PAPAYA RINGSPOT VIRUS AMONG PAPAYA POPULATIONS BY PARENT-OFFSPRING REGRESSION

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Thirty-five papaya lines including 8 papaya parents and twenty-seven derived progeny lines were used to estimate the heritability of tolerance to papaya ringspot virus (PRSV-P) by parent-offspring regression. The experiment was a RCB Design with 3 replications and 12 plants per each plot. The disease severity ratings and trunk cross sectional area were surveyed once every 2 weeks starting 3 months after planting. The disease index, the area under disease progress curve (AUDPC), and relative growth rate of trunk diameter were used to calculate the heritability, which were 0.61, 0.56, and 0.89 respectively. The regression coefficient for each trait was very significant. There were significance for fruit number, fruit weight, and total soluble solids among papaya populations. The yield traits and total soluble solid contents of papayas were positively associated to the degree of tolerance to PRSV-P.

1440-1500

S20-O-29

ISSR VARIATIONS AMONG LEMON CULTIVARS FROM A WIDE RANGE OF GEOGRAPHIC LOCATIONS

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Inter-simple sequence repeats (ISSR) were used to detect genetic diversity, phylogenetic relationships among 57 lemons [*Citrus limon* (L.) Burm. f.]. The samples included many commercially or genetically important Eureka and Lisbon lemons, two main group of lemons, from a wide range of geographic locations. Eight ISSR primers amplified a total of 88 polymorphic fragments among the 57 accessions. Although 88 loci revealed very little variation, some suspected hybrids were found to have considerable degree of variation. Simi-

larity matrices were calculated and phylogenetic trees derived using unweighted pair-group method, arithmetic average cluster analysis. Despite some phenotypic differences, Eureka and Lisbon lemons had no distinctive genetic differences from each other. Most lemons (68 %) had nearly identical marker phenotypes, having a similarity value of, approximately, 1.0, suggesting that they originated from a single clonal parent via a series of mutations. The others had a similarity value above 0.8 and may have a origin involving inter-specific, backcross, selfing or combinations of them.

1500-1520

S20-O-30

GENETIC LINKAGE MAPPING OF RAPD, AFLP AND ISSR MARKERS IN PINEAPPLE

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Partial genetic linkage maps of *Ananas comosus* and *Ananas bracteatus* were constructed employing the two-way pseudo-testcross strategy (Grattapaglia and Sederoff, 1994). RAPD, AFLP and ISSR markers were used for map construction. The *A. bracteatus* map consists in 44 linkage groups with 278 markers covering 1643 cM. Twenty-five groups have at least 4 markers, two groups have only 3 markers and 17 groups are pairs of markers. The average distance between two adjacent markers is 7.02 cM and the average size of the groups is 37.3 cM, ranging from 8.8 to 102.1 cM. The *A. comosus* map consists in 23 linkage groups with 100 markers covering 720 cM. Eleven groups have at least 4 markers, one group has only 3 markers and 11 groups are pairs of markers. The average distance between two adjacent markers is 9.35 cM and the average size of the groups is 31.3 cM, ranging from 7.6 to 97.2 cM. Using "method 3" of Chakravarti et al. (1991), genome lengths were estimated to be 3668 for *A. bracteatus* and 3497 cM for *A. comosus*. Considering these estimates, the maps covered 61.6% and 32.9% of the *A. bracteatus* and *A. comosus* genomes, respectively. Currently, a *A. comosus* x *A. bracteatus* F₂ progeny of about 100 plants, obtained from selfing a F₁ hybrid, is being used for map saturation and for morphological characterisation. The obtained high genome coverage map and morphological descriptions will be further used to find associations of markers to QTLs and to genes controlling characters of interest, such as resistance to fusariosis.

1520-1540

S20-O-31

PROTEIN EXPRESSION OF CAROTENOID BIOSYNTHETIC ENZYMES, PHYTOENE SYNTHASE AND BETA-CAROTENE HYDROXYLASE IN *ESCHERICHIA COLI*

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Previously we isolated two carotenoid biosynthetic genes, phytoene synthase (Psy1) and beta-carotene hydroxylase (CHX1 and CHX2), from *Citrus*. In order to produce the beta-cryptoxanthin in vitro, we constructed recombinant Psy1 and CHX1 expression vectors in which cDNA fragments encoding Psy1 and CHX1 are ligated into pRSET-A, an E. coli expression vector. Expression of recombinant proteins was facilitated by T7 promoter and IPTG induction (1 mM), which resulted in the production of fusion proteins linked with six histidine residues. The Psy1 and CHX1 were isolated through metal affinity chromatography. The protein activities were assayed by two methods. One is the establishment of the production of phytoene, and beta-cryptoxanthin or zeaxanthin by Psy1 and CHX1, respectively. The assay was carried out through high performance liquid chromatographies using mBondapakTM C18 reverse phase column. The other is the color complementation test. We isolated the carotenoid biosynthetic genes from *Erwinia* and then constructed two vectors. In case of Psy1, one contained only Psy1 gene, and the other has phytoene desaturase and lycopene cyclase. In CHX1, one contained only CHX1, and the other has phytoene synthase, phytoene desaturase, and lycopene cyclase. These results confirmed that the Psy1 and CHX1 gene produce the active enzymes and is functional in *Citrus*, and indicated

the Psy1 and CHX1 of Citrus may be useful tools for production of carotenoids including lycopene and beta-cryptoxanthin.

1540-1600

S20-0-32

EFFECTS OF ROOT TEMPERATURE ON GROWTH AND LEAF GAS EXCHANGE OF *ANNONA* SPP.

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The genus *Annona* includes several commercial tropical fruit crops, which are generally grown as seedling trees or grafted, depending on the species. A non-commercial species, *A. glabra* L. (pond apple), has potential as a flood-tolerant rootstock for *Annona* species. Understanding the response of *Annona* species, including *A. glabra* to root temperature should help in rootstock selection since different *Annona* species are adapted to different temperatures. Root temperature effects on growth and leaf gas exchange of *A. glabra* L., *A. muricata* L. (sourp), and 'Gefner' atemoya (*A. squamosa* L. x *A. cherimola* Mill.) grafted on *A. squamosa* rootstock were determined. Trees were exposed to root temperatures of 5, 10, 20, 25 or 35 °C in controlled root temperature chambers in a glasshouse. The fresh and dry weights of roots, stems and leaves decreased almost linearly as temperature decreased. In general, reduced growth at lower temperatures was observed within 1–2 weeks. Net CO₂ assimilation decreased to nearly zero within one week for all species exposed to 5 or 10 °C and remained consistently negative over the remaining experimental period. *A. muricata* and *A. glabra* had the lowest chlorophyll content at 5 or 10 °C, and the highest chlorophyll content at 35 °C. Chlorophyll content of 'Gefner' atemoya on *A. squamosa* rootstock was the least affected by temperature. The least shoot growth was found at 5 or 10 °C for *A. muricata*, 5 °C for 'Gefner' atemoya on *A. squamosa* rootstock, and 10 °C for *A. glabra*. 'Gefner' atemoya on *A. squamosa* rootstock and *A. glabra* had the greatest shoot growth at 25 °C, and *A. muricata* the greatest shoot growth at 35 °C. The results indicate that as expected the more tropical *Annona* species, i.e., *A. muricata* and *A. squamosa* are less tolerant of low root temperatures than *A. glabra*, which is indigenous to subtropical south Florida.

1600-1620

S20-0-33

FRUIT LOAD AND SHADING EFFECTS ON LEAF TEMPERATURE, NITROGEN AND PHOTOSYNTHETIC RESPONSES IN SPRING NAVEL ORANGE TREES

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Well-irrigated 5-year-old Spring Navel (*Citrus sinensis* L. Osbeck) orange trees on Poncirus trifoliata L. rootstock were defruited after physiological drop and after summer, they were shaded for four months before the winter harvest with reflective 50% shade cloth to study effects of fruit load and stomatal conductance (g_s) on net photosynthesis of spring flush leaves. We tested two hypotheses. First, the lack of a fruit carbon sink in defruited trees would decrease net assimilation of CO₂ (ACO₂) below that of normally fruiting trees. One month before harvest, both ACO₂ and g_s of leaves throughout the canopy of defruited trees were more than 40% lower than those on the smaller fruiting trees. Internal CO₂ (Ci) did not differ implying that g_s did not cause the lower ACO₂. Leaves on defruited trees were more photoinhibited (as measured by chlorophyll fluorescence) than leaves on fruiting trees. Leaves immediately adjacent to fruit, however, had lower leaf N, lower ACO₂ and were more photoinhibited than leaves on non-fruiting branches of the same trees. The second hypothesis, lower leaf temperatures (TI) and smaller leaf-to-air vapor pressure deficits (VPD) under the shade would increase g_s and ACO₂ above that of sunlit leaves. On warm bright days when TI were 25–28 EC, shading decreased TI and VPD but increased g_s, ACO₂, and Ci reflecting the strong dependence of g_s and ACO₂ on VPD. There was no effect of shade on chlorophyll fluorescence parameters. On a cool clear day when TI was 22–24 EC, sunlit leaves were

more photoinhibited than shaded leaves. These data provide insights into the relative importance of g_s and leaf vs. fruit carbon sinks in determining ACO₂ and chlorophyll fluorescence characteristics of citrus leaves. There were no effects of shade on canopy growth, yield or fruit size but shaded fruit developed better external color than sun-exposed fruit.

1620-1640

S20-0-33-A

TO BE ANNOUNCED

1640-1700

S20-0-33-B

TO BE ANNOUNCED

Tuesday · August 13

1100-1140

S20-0-34

FLOWERING AND FRUIT SET IN SOME TROPICAL AND SUBTROPICAL FRUIT TREES

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What controls flowering in evergreen tropical and subtropical fruit species? Different theories exist as to the nature of the flower bud induction process. Flower bud induction stimuli usually act on relatively young vegetative buds in the time period prior to growth while some stress such as drought or cold temperatures occurs. The number of buds converted from vegetative to flowering appears related to the strength and duration of the stress. Recent work in Florida suggests that cool temperatures between 10 and 15 °C are optimum for inducing flower buds in orange cultivars. Treatments that enhance the stress level also can increase the number of buds flowering and the flowers per bud and alter the development of reproductive parts in the flower. Growth regulators that effect flowering, like gibberellins, can alter the flower bud induction process and may even act shortly after the flower bud differentiation process has started. For essentially all perennial fruit crops, flower and fruitlet drop from the existing flowers regulates yields, and physiological drop occurs from flowering until 8 to 12 weeks later. Besides lack of complete flower differentiation, ovary pollination or fertilization, factors that influence the level of fruitlet loss include carbohydrate, nutritional and hormonal balance. We present evidence that competition for mineral nutrients at the time of flowering and fruit set may be more important than previously thought.

1140-1200

S20-0-35

TO BE ANNOUNCED

1200-1220

S20-0-36

EXPRESSION SEQUENCE TAGS OF AXILLARY BUD IN FLORAL DIFFERENTIATION STAGE AND ANALYSIS OF EXPRESSION LEVEL OF SEVERAL TAGGED CDNAS FROM *CITRUS*

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In order to understand molecular events during floral differentiation in an axillary bud, 94 expressed sequence tags (ESTs) were generated from axillary buds of *Citrus madurensis* which showed floral differentiation and flowering in a well controlled glasshouse. Fifty-six ESTs out of 94 clones showed a high similarity to previously identified genes. Putative identification described that ESTs were grouped to metabolism (23%), photosynthesis (5%), defense, stress, and aging (23%), signal transduction (3%), DNA metabolism (9%), transla-

tion (10%), transposable element (2%), membrane transport (2%), and others (23%). In particular, a relatively high expression ratio of genes related to defense, stress, and ageing suggests that the concerned physiological events will be closely related to reproductive growth (i.e., floral differentiation). In order to analyze expression levels of tagged cDNAs (CCR protein, *S*-adenosylmethionine decarboxylase, Pto kinase interactor 1, leucine-rich repeat protein, phospholipase D, and Annexin), northern blotting analysis was applied to axillary bud, petal, sepal, and leaves.

1220-1240

S20-0-37

A HIGH RATE OF NITROGEN APPLIED TO THE SOIL AT KEY TIMES IN AVOCADO TREE PHENOLOGY INCREASES YIELD

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Avocado fruit trees in California are harvested sixteen months after flowering. As a result, competition for nitrogen might occur among older maturing fruit, new shoots, and flowers or setting fruit. At times of intense competition in their phenological cycle, avocado trees may require a greater amount of nitrogen fertilizer to avoid nutrient stress. The influence of time and rate of soil-applied nitrogen on fruit size and productivity of 17-yr-old avocado trees (*Persea americana* Mill. cv. Hass) on Duke 7 rootstock in a commercial orchard in the coastal avocado-growing area of California was determined. All trees received nitrogen applied to the soil at 140 kg/ha/yr. Control trees received 28 kg/ha during January, April, July, August and November. Treated trees received double (56 kg/ha) or triple doses (84 kg/ha) of soil-applied nitrogen during one or two of these months. The experimental design was a randomized complete block with 20 trees per treatment. Average yield the first year of the experiment was low (12 kg fruit/tree) due to freeze damage to the trees the previous winter that reduced flowering in the spring; no treatment effects were detected. The following year average yield was 84 kg fruit/tree. Significant increases in yield over the control trees resulted from double and triple doses of nitrogen applied in April, the time of flowering, fruit set and growth of the vegetative shoot of indeterminate inflorescences. A double dose of nitrogen applied during November, when competition between growing fruit and formation of new secondary axes of developing inflorescences occurs, also increased yield. These results are the same as those obtained in a parallel experiment conducted in the avocado-growing area of southern California. For optimum yield of Hass avocado in California, a high rate of nitrogen should be applied in April or November.

1340-1440

S20-P-38

USE OF FOLIAR UREA ON CLEMENTINE MANDARIN TO MANIPULATE CROPPING IN A SUSTAINABLE CITRUS PRODUCTION SYSTEM

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Clementine mandarin (*Citrus reticulata* Blanco) is an alternate-bearing cultivar with problems of low fruit set and small fruit size. Properly timed foliar-applied urea has been shown to increase flower intensity, fruit set, fruit size and yield of citrus. In this research, we investigated effect of urea on fruit set, fruit size and yield of 'Cadoux' clementine mandarin. Urea (containing 46%N) was applied as a foliar spray to fully mature trees during the periods of flower initiation-differentiation, fruit set and 'June drop'. Urea was used at the rate of 1 Kg/100 L and trees were sprayed to the point of run-off. The experiments were run for two consecutive years. Urea increased leaf N levels and total yield. The yield increase was due to an increase in both fruit number per tree and fruit size. As a consequence, the total number of export grade fruit (diameter > 51 mm) was increased by 50%, regardless of timing of urea application. The increase in yield and fruit size was obtained for two years of trial and more fruit were of export grade by the first harvest date indicating an indirect effect of urea on earliness. Multiple urea applications during flower initiation-differentiation did not lead to any additional benefit when compared to a well timed single application. The results are discussed in relation to the use of foliar N nutrition as a supplement or as an alternative to soil N in a sustainable citrus production system.

1340-1440

S20-P-39

RESPONSES OF ATEMOYA TO NATURAL AND ARTIFICIAL POLLINATION IN BRAZIL

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An experiment was carried out to study the problem of atemoya (*Annona squamosa* x *A. cherimola*) pollination and to determine the pollination method that produces fruits in larger amount and quality. The experiment was accomplished with the cultivar Gefner, in the period of November 2000 to March 2001, in a commercial orchard located in the county of Lins (State of São Paulo, Brazil), at an altitude of 424 meters. The plants were 13 years old. The experimental design was a randomized blocks, with 5 treatments and 6 replicates. The treatments were the following: 1) hand pollination using pollen of *Annona squamosa* L.; 2) hand pollination using pollen of the atemoya cultivar Gefner; 3) hand pollination using pollen of atemoya cultivar African Pride; 4) hand pollination using pollen of atemoya cultivar PR-3; 5) natural (open) pollination. The evaluation of fruit set happened 10 days after the pollination and the amount of fruits with perfect or defective shape after 40 days. Atemoya fruits were picked 120 days after the pollination and individually weighed. Three fruit samples of each treatment were taken for the following determinations: seed and pulp weigh, number of seeds per 100 g of pulp, total soluble solids content, total acidity and soluble solids/acidity ratio. For atemoya, the pollination with pollen of *Annona squamosa* L. was more effective, increasing the fruit set (80.5% compared to less than 22% in the other treatments), fruit production and percentage of perfect fruits.

1340-1440

S20-P-40

THE EFFECT OF CROSS-POLLINATION BY NURSE LIMBS ON HASS AVOCADO PRODUCTION AFTER TOPWORKING

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Thirty 20-year-old Bacon avocado trees were topworked by bark-grafting to the more profitable Hass avocado cultivar in May 1994. Nurse limbs of the Bacon cultivar were left on all of the trees to induce more scion growth. Nurse limbs were removed from half of the trees at random but left on the other half of the trees to observe any benefit by cross-pollination. The first Hass crop (1997) after topworking had significantly more fruit on the trees with nurse limbs, however the 1998 and 1999 crops had lower fruit numbers on trees with nurse limbs. The sum of the three crop years had slightly greater fruit numbers for nurse limb-treated trees, however this was not significant. The study demonstrated that cross-pollination of Hass avocado trees with nurse limbs of the Bacon avocado can significantly increase fruit numbers in some seasons. Climatic and alternate bearing effects may need to be studied.

1340-1440

S20-P-41

REGULATION OF ABSCISIC ACID AND ITS INHIBITOR OF BIOSYNTHESIS ON POMEGRANATE POLLEN GERMINATION AND TUBE GROWTH

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The effects of abscisic acid (ABA) on pollen germination and tube growth were studied in pomegranate (*Punica granatum* L.). Results showed that ABA inhibited pollen germination and tube growth significantly in higher concentration over 50 mmol/L, while low ABA concentration, 0.05 mmol/L–5 mmol/L, improved the growth of pollen tube. The rate of germination did not change, but both tube growth and the effects of ABA on tube growth were inhibited after 10 mg/g cycloheximide treatment. The inhibitors of ABA biosynthesis, NDGA (nordihydroguaiaretic acid) and fluridone, inhibited pollen germination and tube growth. The degree of inhibition increased gradually along with the raise of concentration to 20 mmol/L–100 mmol/L, and the inhibiting degree to tube growth was more significant. ABA (1 mmol/L) could abate the inhibition degree of NDGA and fluridone to tube growth but could not change the inhibition to germination.

The result indicated that low ABA concentration was necessary to pollen's natural growth.

1340-1440

S20-P-42

SUSTAINABLE LITCHI (*LITCHI CHINENSIS* SONN.) PRODUCTION IN WEST BENGAL, INDIA

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Litchi originated in the area near southern China and northern Vietnam and was introduced in India in the 18th Century. It is now an important commercial fruit of India. Cultivation of litchi is widely spread in eastern India, which provides livelihood opportunities to millions of people. Frost-free cool and dry winter and humid summer weather, free from hot and dry winds characterize this growing zone. In West Bengal about 3600 hectares is under litchi cultivation. More than 15 cultivars are growing in this region; however, 'Bombai' is the commercial cultivar of the state. Air layering is the commonly adopted method of propagation. Integrated nutrient management based on leaf nutrient standards for sustainable production has been worked out. To combat irregular bearing, the essential practices are focussed on the regulation of trees vegetative growth by physical and chemical means. Growth regulators are applied to discourage winter flushing in favour of flower initiation, to prevent excessive fruit drop and to minimize fruit cracking.

1340-1440

S20-P-43

EFFECT OF A COTTON AND LEGUME BASED INTERCROPPING SYSTEM ON NUTRIENT STATUS OF CITRUS ORCHARD

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Cotton, cowpea and cotton along with cowpea were sown and grown continuously for two years between the rows of sweet orange trees cv. Jaffa planted at a distance of 20 x 20 feet to study their effects on soil and tree nutrition along with yield and fruit quality. Data after two years of intercropping revealed that cotton crop depleted maximum soil nitrogen whereas cowpea maintained it. Soil phosphorus content was considerably reduced by both of the intercrops crops and their combinations relative to no crop plot soil. Cotton alone or its combination with cowpea increased soil potassium content, but cowpea alone reduced the soil potassium. Cotton intercropping reduced the nitrogen, cotton with cowpea reduced phosphorus and cowpea alone reduced potassium content in citrus leaves. The leaf zinc content of citrus leaves was considerably reduced under different intercropping systems than the iron content of the leaves. Citrus fruit yield was reduced where cotton was sown. Trees intercropped with cotton and cowpea combination maintained the fruit yield of bigger size and higher average weight with lower acidity, total soluble solids and vitamin C content than the fruits collected from other crop treatments.

1340-1440

S20-P-44

DETERMINATION OF OPTIMUM SIZE AND SHAPE OF PLOTS AND BLOCKS THROUGH UNIFORMITY TRIALS FOR EXPERIMENTS IN KINNOW (*C. NOBILIS* X *C. DELICIOSA*)

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Efficient planning of field experiments requires knowledge of variability among experimental units with the crop. The size and shape of plots and blocks depends upon the variability of experimental material from the practical point of view on one hand and efficient, valid results on the other. Uniformity trials or examining the data of actual field trials with the crop provide estimates of the variability. In this aspect, the focus has been on annual crops in the literature but very little work has been done on perennial horticultural crops. A uniformity trial was conducted at HAU, Hisar for Kinnow , a mandarin hybrid, planted in a square system with a distance of 20' x 20' consisting of 192 trees in the

whole field. At the time of harvest the data on 132 trees situated in the centre area was recorded while one guard row all around the experimental area was left as non-experimental. The yields of the adjacent units were combined suitably to form plots of different sizes having 1, 2, 3, 4, 6, 8, 9, 12 trees each and were arranged in different shapes. The coefficients of variation (c.v.) for different arrangements were calculated and on the basis of these c.v.s, optimum size and shape of plots was obtained by studying the relationship through Smith's law (1938) and Freeman's formula (1963). The relative efficiency of various plot sizes was calculated by the formula proposed by Aggarwal (1968). For a fixed plot size, the arrangements of trees either in a row or column gave less coefficient of variation while for any fixed shape of plots, the coefficient of variation decreased with the increase in plot size irrespective of block size and shape. The relative efficiencies of various plot sizes and shapes were examined and single tree plots were found to be optimum in size. The relative efficiencies varied from 0.02 to 1 for various plot sizes comprising trees from 12 to 1.

1340-1440

S20-P-45

NONDESTRUCTIVE ESTIMATION OF LEAF CHLOROPHYLL AND NITROGEN IN CITRUS GENOTYPES: A COMPARISON OF THREE TYPES OF METERS

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Rapid nondestructive techniques for evaluating the nitrogen (N) status of crops can be useful for fertilizer N management and yield prediction. Available tools require accurate standardization for genotype, growth conditions and cultural practices. Nondestructive leaf chlorophyll (greenness) values taken with 1) SPAD-502 (Minolta; based on light transmittance), 2) Chlorophyll Content Meter (CCM, Opti-Sciences; based on transmittance) and 3) OBSERVER? (Spectrum Technologies; based on reflectance), were compared with a standard, chlorophyll extraction technique (N, N-dimethylformamide extraction). Relationships between chlorophyll meter indices and actual total chlorophyll (TCHL) and N content in different aged leaves from seven Citrus varieties were developed. Recently matured field and greenhouse-grown leaves with different N concentrations provided a wide range of TCHL. Extractable TCHL (leaf area basis) was significantly correlated ($r = 0.42$ to 0.98) with leaf greenness readings but regression models differed among cultivars using the same meter, and between meters for a given cultivar. The SPAD-502 consistently gave the highest r^2 values and least variability compared to the CMM and OBSERVER?. The transmittance-based meters (SPAD-502 & CCM) tended to overestimate TCHL at concentrations above $0.5 \text{ mmol} \cdot \text{m}^{-2}$, perhaps due to the high dry weight per area (DW/a, $\text{kg} \cdot \text{m}^{-2}$) of leaves with high N content. Linear relationships between leaf greenness values and leaf N content were weaker (r^2 , 0.10 – 0.70) for all cultivars and meters compared to the relationships with TCHL. The accuracy of these meters for estimating TCHL and N in citrus leaves is limited to leaves with low to medium N and TCHL contents and low DW/a. Although portable chlorophyll meters are convenient and rapid, standardization for genotype and growth conditions is required.

1340-1440

S20-P-46

EFFECT OF THE REDUCTION OF CHEMICAL FERTILIZERS FOR CITRUS ORCHARDS ON VESICULAR-ARBUSCULAR MYCORRHIZAL DEVELOPMENT, TREE GROWTH, LEAF MINERAL CONTENT, AND FRUIT QUALITY

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We reported that satsuma mandarin trees which were inoculated with vesicular-arbuscular mycorrhizal (VAM) fungi grew bigger and had better fruit quality as compared with no-VAM control trees under low concentrations of applied phosphorus (P) (Shrestha et al., 1995; 1996). Low percentage of VAM infection in citrus roots was also observed in the orchards in which high concentrations of P in the soil were detected. We examined the effect of the reduction of chemical fertilizers for citrus orchards on VAM development, tree growth,

leaf mineral content, and fruit quality for 6 years. This experiment was started in mid-March 1994 in a *Citrus iyo* (cv. Katsuyama, 8 years old) orchard where herbicides have been applied. Three plots were prepared: 1) Control, 2) Reduced application of chemical fertilizers, especially P (–CF), and 3) –CF with charcoal (–CF+CH). Tree growth and mineral absorption was not depressed by the reduction of chemical fertilizers, because the percentage of VAM infection in the root and the number of VAM spores in the soil in the plots of –CF and –CF+CH were higher than those of the control plot. Sugar content in the juice, the ratio of sugars to acids, and the a/b value of peel color at the plots of –CF and –CF+CH increased as compared with the control. These results suggest that we should revise large-scale consumption of chemical fertilizers and consider lower fertilizer applications by using mycorrhizal fungi.

1340-1440

S20-P-47

EFFECT OF MINERAL NUTRIENT SPRAYS ON GROWTH, YIELD AND QUALITY OF ACID LIME (*CITRUS AURANTIFOLIA* SWINGLE)

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Foliar feeding of nutrients is known to influence the metabolic activity of the plants apart from serving as a mode of supplementary feeding, thereby mobilising the yields and other potentialities of plants (Bruin, 1967). Acid Lime (*Citrus aurantifolia* Swingle) is an important citrus fruit in India by virtue of its high vitamin C content and its common use in every household. The present investigations were undertaken to observe the effect of mineral nutrient sprays on growth, yield and quality of Acid Lime fruit under the existing agro-climatic conditions. The investigations were carried out on ten-year old Acid Lime seedlings of uniform vigour and size. Treatments included foliar sprays of calcium in the form of calcium nitrate and calcium chloride (0.5 and 1.0 per cent each), boron in the form of Borax (0.5 and 1.0 per cent), nitrogen in the form of urea (600 g and 800 g N/tree) and water sprays. Teepol at 0.1% was used as a sticking agent. There were thus ten treatments replicated four times in a randomized block design. One tree was taken as a unit of treatment in a replication. Foliar sprays were applied in the months of November, January and March at flowering, fruit set and pea stage. Fruit drop varied from 40.32 to 42.26% in trees sprayed with 0.5 and 1.0% borax respectively as against 69.32% in controls. Reduction in fruit drop by borax sprays can be attributed to the indirect action of boron in auxin synthesis that delayed the formation of the abscission layer during the early stages of fruit development (Skooog, 1940). There was significant increase in growth and yield of Acid Lime with application of 600 g and 800 g N with 309 and 401 fruits per plant as compared to 253 fruits in the control. Maximum acidity was found in treatments with 800 g and 600 g N respectively, which is a desirable aspect in Acid Lime. The results of the present investigation will be discussed in the light of similar findings.

1340-1440

S20-P-48

STUDY OF INFLUENCE OF THE IONS NO³⁻, SO₄⁻², PO₄⁻³, K⁺, CA⁺², NH⁴⁺ AND BENZYLAMINOPURINE FOR PROLIFERATION IN VITRO MICROSHOOTS APPLE, PLUM, TRIFOLIATA ORANGE AND BLACK CURRANT BY SYSTEMATIC VARIANCE METHOD

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The systematic variance method allows discovery of the influence and interaction of 6 ions in the media. It is simple and economic and gives possibilities to calculate optimum medium for every process in vitro. For studying the influence of ions NO³⁻, SO₄⁻², PO₄⁻³, K⁺, Ca⁺², NH⁴⁺ and benzylaminopurine (BAP) media were used with a high concentration of one of the ions without changing the levels of the rest, in combination with BAP for apple rootstocks M-7 and M-9: 0, 1-3, 0 mg/L; for MM-106 and Marubakaido 0, 1-4, 0 mg/L for plum Kantimirovskaja and Jaichnaja Sinaja: 0, 1-1, 5 mg/L, for Trifoliata orange: 0, 1-1, 0 mg/L and for black currant Zagadka 0, 1-2, 0 g/L. The influence of growth regulators was more pronounced on the medium with the high level of the most important ion and the influence of the ion also increased when the medium with optimum concentration of growth regulators. Proliferation of every species and

variety growth depended ions were correlated between each other in medium. For Trifoliata orange the most important ion was K⁺, for plum Kantimirovskaja ions NO³⁻ and K⁺, for apple rootstocks M-7 ion NH⁴⁺, for M9, MM106 and Marubakaido NO₃⁻, for black currant Zagadka NO₃⁻ and Ca⁺². Growth of shoots and formation of buds was often stimulated by different ions. For formation of microshoots of the apple rootstock Marubakaido NO₃⁻ was most important, for elongation of shoots ion Ca⁺², for formation on those more buds ion NO₃⁻. On all calculated mediums better proliferation was observed than on a Murachige-Skug media. Efficiency of those mediums was vastly greater for hardy propagated varieties, coefficient of propagation for black currant Chulkovskaia increased 7.5 times and Ranneia Sladkaia 9 times.

1340-1440

S20-P-49

EFFECTS OF DIFFERENT GROWTH MEDIUM AND FERTILIZER ON GROWTH OF PAPAYA SEEDLINGS

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The behavior of papaya (*Carica papaya* L. cv. 'Sunrise Solo' and 'Tainung 1') seedlings grown in polystyrene trays (72 cells) with growth medium (Plantmax = pine bark + vermiculite + peat), amended with 4% of organic fertilizer (humus; composted cattle manure and Nutriplanta) or combined with 0.05% of inorganic fertilizer (Osmocote-slow release-NPK 14-14-14 and normal release NPK 14-14-14) was evaluated in this study. Germination in cv. 'Sunrise Solo' and hybrid 'Tainung 1' occurred 12 and 14 days after sowing, respectively. Higher germination rate in both plant materials was obtained in the growth medium fertilized with Osmocote plus humus and composted cattle manure, respectively. The slow release type fertilizer hastened growth compared with normal fertilizer. Growth medium amended with Nutriplanta gave good results but there was no significant difference from using other organic fertilizers. The seedlings grown in growth medium amended with composted cattle manure + normal release NPK showed the poorest results in almost all analyzed parameters such as height, stem diameter, dry weight-root and top-and total leaf area. The nutrient contents (NPK) found in the leaf analyses samples were higher in treatments using slow release fertilizer (~20% for hybrid 'Tainung 1' and ~+10% for cv. 'Sunrise Solo') compared with the normal fertilizer.

1340-1440

S20-P-50

IN VITRO SHOOT PROLIFERATION IN GUAVA AS INFLUENCED BY GENOTYPE

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Guava (*Psidium guajava* L., Family Myrtaceae) is rich in ascorbic acid, dietary fiber, and other vitamins and minerals. Intake of guava reduces LDL cholesterol, triglycerides, and hypertension. It is used for treating gastroenteritis, diarrhea, dysentery, and athletics-foot. Recently, the enlarging niche market in America for exotic fruits like guava has increased demand for their supply. Being a prolific bearer with extended harvest season, guava has potential for alternative high value cash crop for small farmers in the USA. Our experience with growing guava in Georgia since 1990, indicated a need for production in the Southeast. Despite being grown in more than 50 nations, guava is confined to few states in the USA. Moreover, narrow germplasm base, limited genetic studies, small acreage, and lack of cold tolerant cultivars, have impeded guava cultivation in America. Cold susceptibility of guava in Georgia needs costly frost protection. In vitro plant regeneration system, amenable to gene delivery techniques could circumvent these problems. Guava is a recalcitrant species with heavy phenolic exudation that kills explants from sources outside the laboratory. Therefore, developing efficient regeneration protocols for guava, was the primary objective of this investigation. Germinating embryos of Beaumont, KaHuaKula, and Lucknow-49 cultivars were utilized as explants. Seeds were germinated in dark in MS basal medium supplemented with 2 mg·L⁻¹ BAP. Following 10 weeks incubation, Beaumont had the highest germination (83%) but explants were taken from all cultivars. For shoot proliferation and elongation, explants were subcultured on IAA or TDZ media. Shoot elongation was influenced by both PGR and guava genotype. Shoot proliferation was higher in IAA than TDZ medium whereas Beaumont explants produced maximum number (10+) of shoots/explant. No phenolic exudation was

observed from any of the explants. It is concluded that the use embryonic explants minimizes phenolics in the medium and thus improves shoot proliferation.

1340-1440

S20-P-51

STUDY ON CITRUS EXOCORTIS-LIKE VIROID IN MAZANDARAN (IRAN)

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A citrus exocortis-like viroid could readily be transmitted to Etrog citron (*Citrus medica*) through mechanical inoculation and bud grafting. The symptoms after 90 days were epinasty of middle and lower leaves and dwarfing of infected plant. Mechanical transmission of the viroid to *Gynura sarmantosa* and tomato cvs. VF13, VF14 and Red cloud caused epinasty and stunting in these plants within 30-45 days. Inoculation of *Chrysanthemum morifolium* resulted in the appearance of chlorotic spots on the upper surface of leaves after 180 days, which turned necrotic later. Comparison of the electrophoretic patterns in 5% polyacrylamide gels indicated the presence of an extra nucleic acid band in infected samples of tomato cvs compared to healthy plants. Inoculation of extracted nucleic acid from this band to tomato cvs. VF13 and VF14 and *G. sarmantosa* resulted in the appearance of the typical symptoms of CEVd infection. Re-isolation and electrophoretic analysis of nucleic acids from the inoculated tomato cvs. VF13 and VF14 indicated the presence of the same additional band. On the bases of the symptoms on *G. sarmantosa* and other test plants and the presence of a viroid-like RNA in polyacrylamide gel, the cause of the citrus disorder in the Mazandran province, appears to be similar to CEVd.

1340-1440

S20-P-52

ALLELOPATHIC EFFECT OF OLD ORCHARDS SOILS ON THE ROOT PROLIFERATION OF CITRUS ROOTSTOCK SEEDLINGS

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Soil samples of 32 years old orchards of mango (*Mangifera indica*), grapes (*Vitis vinifera*), guava (*Psidium guajava*), citrus (*C. paradisi* Macf) and jujube (*Ziziphus mauritiana*) were collected near the secondary, tertiary and feeder roots to observe the residual effect of these rhizospheres on the root proliferation of three species of citrus rootstock seedlings two years after seed germination, i.e. rough lemon, pectinifera and troyer citrange. Prolific root system with lengthy primary roots and higher moisture content were observed in citrus rootstock seedlings irrespective of the species when raised in guava soils, whereas less root development occurred when grown in jujube soil. The effect of other rhizosphere soils was intermediate and at par with each other. Maximum primary root length with higher density of feeder roots were recorded in pectinifera seedlings raised in guava followed by mango soils with no significant difference with troyer citrange seedlings raised in citrus soil. All the rootstocks raised in rest of the rhizosphere soils exhibited poor root development.

1340-1440

S20-P-53

NUCLEIC ACID, PROTEINS AND TOTAL PHENOLS OF THE CITRUS ROOTSTOCK SEEDLINGS RAISED IN DIFFERENT OLD ORCHARD'S SOILS

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Soil samples of 32-year-old orchards of mango (*Mangifera indica*), grapes (*Vitis vinifera*), guava (*Psidium guajava*), Citrus (*C. paradisi* Macf.) and Jujube (*Ziziphus mauritiana*) were collected near the secondary, tertiary and feeder roots in the year 1998 to observe the residual effect of these rhizosphere soils on the biochemical and molecular constituents of the cells of the three species of citrus rootstocks i.e. rough lemon, troyer citrange and pectinifera. Results revealed that ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) content were maximum in the seedlings irrespective of the rootstocks when raised in grapes soils with no significant differences with the seedlings raised in mango and guava soils. Among

the rootstocks, pectinifera and rough lemon were on the two extremes in both RNA and DNA content being highest in the former and least in the latter rootstock. Interactions indicate that Troyer seedlings raised in grapes soils showed the highest RNA & DNA content. Seedlings of all the citrus rootstocks exhibited minimum DNA, RNA and protein content when raised in jujube orchard soils. The reverse was true in the total phenolic content, which was highest in all the seedlings raised in jujube soil irrespective of the rootstocks, relative to the seedlings raised in other soils. Pectinifera, among the rootstocks, contained the maximum total phenols which was more when raised in grapes soils.

1340-1440

S20-P-54

DIFFERENTIATION OF CITRUS TRISTEZA CLOSTEROVIRUS ISOLATES FROM VERACRUZ, MÉXICO, BY HYBRIDISATION WITH DIGOXIGENIN-LABELLED CDNA PROBES

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Ten sweet orange trees from Veracruz showing yellowing and slow growth tested positive by ELISA using MCA13. Before trees were burned, tissue prints were produced onto nylon membranes by cutting transversely tender shoots or leaf petioles and gently pressed the cut surface to the membrane (5 prints/tree/membrane). In this study three trees from the field (CZ1, CZ2 and CZ3, respectively) and some shoots from them (CZ1a, CZ2a, CZ3a, CZ4a, CZ8b and CZ6a) were tested. Membranes were air-dried and then UV fixed (light 50 mJ) in a cross-linking oven. The following cDNA DIG-labeled probes were used for the hybridization: CP305, CP385 (the coat protein ?CP- gene of isolates T305 and T-385, respectively), p20-305, p20-385 (the p20 gene of isolates T-305 and T-385, respectively), PM33, PM34, PM35 (the 5'-terminal non-coding region of isolates T388, T385 and T36, respectively), and B2 (the 3'-terminal 291 nucleotides of CTV isolate T36). The hybridization were done according to Narváez et al., (1999). No hybridization was observed in membranes treated with PM33 and PM35 probes in any of the trees. Membranes treated with CP385, p20-385 and B2 probes showed a strong chemiluminiscent dot only with CZ1a, CZ4a and CZ6 samples. These samples showed a light reaction with CP305, p20-305 and PM34 probes. Apparently the original trees from the field lost the CTV or more likely its concentration was reduced drastically as well as the grafted trees derived from them, except CZ1a, CZ4a and CZ6a which showed a strong reaction to the CP385, p20-385 (mild strain of CTV, T385) and B2 probes. The light reaction observed with CP305 and p20-305 (from the severe strain T305) as well as the strong reaction observed with B2 probe (from severe isolate T36), probably indicates the presence in a minor degree of such isolates in sampled trees.

1340-1440

S20-P-55

DEGREE DAYS REQUIREMENT OF CITRUS PSYLLA, *DIAPHORINA CITRI* KUWAYAMA, IN CENTRAL INDIA

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In the recent past citrus psylla, *Diaphorina citri* Kuwayama attained an endemic pest status causing cognizable damage to citrus groves in central India. Excessive desapping by the nymphs and adults from new flush results in curling and dying of leaves followed by defoliation, flower drop and death of branches from tip downwards. At times psylla alone caused losses ranging from 83 to 95%. It also acts as the active vector of the causal organism of greening disease that accelerates citrus decline. Atmospheric temperature is the critical factor on the growth and development of the immature stages of the citrus psylla. The present study was carried out to find out the heat unit requirement of citrus psylla in central India. Observations on different stages of the pest during spring (Feb.-March), summer (June-July) and autumn (Oct.-Nov.) flushing broods in relation to their heat unit requirements were recorded. The degree-days accumulated in each generation during the period under study were calculated from the meteorological data. It was observed that the degree day requirement for summer brood (June-July) of the pest was highest followed by spring brood (Feb-March) as compared to autumn brood (Oct.-Nov.). Therefore,

citrus psylla took longer period for completion of its life cycle during the autumn flushing period as the degree-day units accumulated were very low.

1340–1440

S20–P–56

DYNAMICS OF CITRUS PSYLLA (*DIAPHORINA CITRI KUWAYAMA*) AND ITS BIOAGENTS IN THE VIDARBHA REGION OF CENTRAL INDIA

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Citrus Psylla, *Diaphorina citri Kuwayama*, is one of the major insect pests of Nagpur mandarin, *Citrus reticulata* Blanco. It attacks the new flush of all the three flushing seasons viz., Ambia, Mrig and Hasta bahars, causing heavy drop of flush, thereby affecting the fruit-set adversely. Understanding the population dynamics of citrus psylla and its natural enemies is a pre-requisite in developing the mass multiplication technique of predominant bioagents. Population dynamics of psylla and its bioagents studied in citrus orchards of central India during 1998 to 2000 indicated that the incidence of psylla and its predators were higher in Ambia (Feb.–March with 22.3–28.5 nymphs/5 cm twig; 10.1–13.8 predators/plant) and Mrig bahars (June–July with 15–19.2 nymphs/5cm twig; 10.1–13.8 predators/plant) than in Hasta bahar (5.4–9.5 nymphs/5cm twig; 8.7–12.2 predators/plant) irrespective of the sites surveyed. The parasitism due to *Tamarixia radiata* on psylla was significantly greater in Ambia (80.6 to 91.7%) than in Mrig (13.4 to 19.5%) and Hasta (10.0 to 15.0%) bahars. The bioagent populations were generally dependent on the population density of the pest.

1440–1500

S20–O–57

SELECTED CULTURAL TECHNIQUES FOR SUBTROPICAL AND TROPICAL FRUIT CROPS

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Selective pruning, drought stress, and branch girdling have been utilized with varying success in tropical fruit production. Generally, selective pruning is more common in areas with low labor costs and drought stress and branch girdling is more common in production areas where climatic conditions are not always favorable for flowering or as a means to produce off-season fruit. In production areas where labor costs are high, large commercial orchards generally employ mechanical pruning as a means to control trees size and increase light penetration into trees. However, while selective pruning is not a common practice in some commercial tropical fruit orchards it may be used to maintain tree size, increase light penetration and air movement, and induce off-season fruit production. Successful use of selective pruning has been accomplished in avocado, mango, guava, and carambola. Drought stress may be utilized as a tool to force vegetative quiescence, induce off-season flowering, enhance the potential for flowering, and increase flowering intensity. This technique has been successfully used in mango, 'Tahiti' lime, lemon, guava, lychee, and longan production. Branch girdling has been used periodically to induce early bloom and fruiting for young trees and as a technique to induce flowering and fruiting of recalcitrant tropical fruit species. Generally, the results of girdling have not been consistent, however, the practice has been employed in avocado, lychee, and longan production.

1500–1520

S20–O–58

MANAGEMENT IMPLICATIONS OF THE DISTRIBUTION OF FRUITS ON BREADFRUIT TREES

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The objective of the study was to determine whether orientation, position on the tree, location of the tree within the row and time influenced fruit number distribution and the implications for managing a breadfruit (*Artocarpus altilis*

Fosberg) orchard. The distribution of fruits on 18 seven-year-old trees growing in two east to west-oriented rows and spaced at 12 m x 12 m in an orchard at the Univ. Field Station in Trinidad and Tobago was recorded in 1999. Each tree was divided into four quadrants, designated as east top, east bottom, west top and west bottom according to their orientation and position on the tree. The total number of fruit present in each quadrant was counted at two- to three-week intervals. Orientation did not significantly affect mean fruit number/quadrant, although during the early yield development period, the eastern quadrants bore twice as many fruits as the western quadrants. Generally, significantly ($P < 0.000$) more fruit were borne at the top of the trees than at the bottom. However, there was a significant ($P < 0.002$) interaction between orientation and position on the tree so that the west bottom quadrant bore more fruit than the west top quadrant. There were significant ($P < 0.000$) differences among trees within the row with a trend for mean fruit number/quadrant and hence fruit number per tree to decline from east to west but other factors such as tree height appeared to influence fruit number. These results indicated that even in the short rows of this orchard, most fruit were borne in the upper part of the tree, which suggests that light distribution was affected. Since breadfruit trees can attain considerable height, which makes harvesting difficult, height control and increased inter-row spacing for improved light distribution and easier harvesting should be investigated.

1520–1540

S20–O–59

EFFECTS OF DIFFERENT PLANTING SPACE ON THE VEGETATIVE GROWTH, YIELD AND FRUIT QUALITY OF LOQUAT

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Loquat is an evergreen species from the Rosaceae family, which is grown in subtropical conditions. In Turkey, the Mediterranean region has the most suitable ecological conditions for this fruit. As a matter of fact, according to the 1999 statistics, 97% of total loquat production of Turkey is from the coastal zone of Mediterranean region. This study was conducted in Hatay, which is located in the eastern Mediterranean of Turkey, and was aimed to research the advantage of high density planting compared to the ordinary cultivation. Gold Nugget, Sayda and Hafif Çukurgöbek loquat cultivars were propagated by budding at Horticulture Dept., Agriculture Faculty, Mustafa Kemal Univ., Hatay, Turkey, in 1996. These young trees were planted at 3 different planting spacings (3 x 3 m, 3 x 6 m and 6 x 6 m) and pruned to an open centre system in an experimental orchard in May 1997. In trials, phenological observations, pomological characteristics, yield/per tree and per unit area were determined. With increasing planting density, yields per tree decreased whereas cumulative yields per hectare increased. According to the average value of two years, the highest yield (yield/tree and yield/hectare) was obtained from Hafif Çukurgöbek with 4.12 kg/tree, 5380kg/ hectare, respectively. The highest yield/per unit was obtained with 3 x 3 m density (6670kg/ha), followed by 3x6m and 6x6m with 3400kg/ha, 2940kg/ha, respectively.

1540–1600

S20–O–60

NUTRIENT CONTENTS IN THE LEAF DRY MATTER AS ASSOCIATED WITH SEASONAL PHENOLOGY, NITROGEN AND BORON FERTILIZATION OF SUGAR APPLE (*ANNONA SQUAMOSA* L.)

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Two field experiments were carried out in Rio de Janeiro State, Brazil, to evaluate the effect of nitrogen levels and forms of boron application on the organic N, NO_3^- , P, K, Ca, Mg, Cl, Zn, Fe, Na, Mn, Cu, B and Na leaf contents in sugar apple. In the first experiment, four nitrogen levels were tested (0, 200, 400 and 800 g/plant of N), using urea as the source of N, and three forms of boron application (without boron, boron in the soil and boron on the leaves), boric acid was the boron source. In the second experiment, four nitrogen levels were tested (0, 100, 200 and 400 g/plant of N) using urea as the N source and boric acid as in the previous experiment. The nutrient contents in sugar apple leaves that correlated to greatest fruit yield ($2,285 \text{ kg} \cdot \text{ha}^{-1}$) in the first experiment were: $13.2\text{--}33.2 \text{ g} \cdot \text{kg}^{-1}$

Tuesday August 13

¹ of organic N; 1.23–1.73 g·kg⁻¹ of P; 8.3–13.4 g·kg⁻¹ of K; 10.9–20.6 g·kg⁻¹ of Ca; 2.63–6.08 g·kg⁻¹ of Mg; 1.41–3.17 g·kg⁻¹ of S; 3.60–7.95 g·kg⁻¹ of Cl; 63–221 mg·kg⁻¹ of Fe; 9.3–15.7 mg·kg⁻¹ of Zn; 67–235 mg·kg⁻¹ of Mn; 6.6–13.3 mg·kg⁻¹ of Cu and 29.6–79.3 mg·kg⁻¹ of B. The nutrient contents in sugar apple leaves related to greatest fruit yield (7,065 kg·ha⁻¹) in the second experiment were: 26.5–39.4 g·kg⁻¹ of organic N; 0.97–1.28 g·kg⁻¹ of NO₃⁻; 1.43–2.49 g·kg⁻¹ of P; 10.7–20.5 g·kg⁻¹ of K; 9.5–13.8 g·kg⁻¹ of Ca; 3.27–4.18 g·kg⁻¹ of Mg; 1.87–2.63 g·kg⁻¹ of S; 7.24–9.05 g·kg⁻¹ of Cl; 60–133 mg·kg⁻¹ of Fe; 13.5–22.8 mg·kg⁻¹ of Zn; 148–190 mg·kg⁻¹ of Mn; 8.1–15.6 mg·kg⁻¹ of Cu, 32.1–46.6 mg·kg⁻¹ of B and 93–350 mg·kg⁻¹ of Na. A decrease the leaf contents of N, P and K in the period of flowering and fruit production was observed. Nitrogen fertilization increased the leaf contents of N, Mn and Cu and decreased Ca, Cl, Na and B levels. The contents of B in sugar apple leaf were higher when boric acid was applied in the soil.

1600–1620

S20–0–61

TO BE ANNOUNCED

1620–1640

S20–0–62

TO BE ANNOUNCED

1640–1700

S20–0–62–A

TO BE ANNOUNCED

Thursday · August 15

1100–1120

S20–0–63

QUALITY OF CITRUS FOR FRESH CONSUMPTION AS AFFECTED BY WATER RELATIONSHIPS

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Citrus fruit quality can be diminished by several physiological disorders. It is particularly important, under commercial point of view, when fruits are grown for fresh consumption, since the presence of any symptom on the peel is enough to reject the fruit. Most of these disorders have been related with climatic conditions, especially temperature and relative humidity, they affecting endogenous and exogenous water relationships. Peel pitting of grapefruit and mandarins and rind stain of navel oranges, their morphological, histological and physiological characteristic and their causes and ways of control will be discussed.

1120–1140

S20–0–63–A

GENETIC AND ENVIRONMENTAL CONTROL OF QUALITY IN SUBTROPICAL FRUIT AND NUT CROPS

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The subtropical horticultural sector in Australia has undergone profound change in the last 20 years and many producers are now focused on meeting market demands rather than simply maximising yield. There is now a strong emphasis on quality as high quality produce results in better returns to growers. Commercial gains may result from a better understanding of the mechanisms regulating fruit development and the ability to manipulate these to produce a better quality product. Pollination has long been known to affect fruit set and yield. Pollination is also an important influence on quality in subtropical crops such as citrus and macadamia. For example, pollination with different pollen genotypes may influence quality measures such as sugar content, fruit size and seediness in some citrus cultivars. Pollen genotype may also influence the size of

kernel, kernel breakage, and the ratio of kernel to shell in macadamia. Pollen genotype determines the genetic make-up of both the embryo and the endosperm. This may affect the rate of seed development and therefore the rate of fruit development and the ability of the fruit to compete for often-scarce maternal resources. Genetic controls of fruit set and development may be modified by environmental conditions and in macadamia the distribution of maternal resources may moderate some pollen genotype effects. The focus of current research is to find how pollen genotype changes the anatomy and growth rates of fruit throughout the season.

1140–1200

S20–0–64

ROOTSTOCKS AND PLANT WATER RELATIONS AFFECT SOLUBLE SOLIDS ACCUMULATION OF 'VALENCIA' SWEET ORANGE VIA OSMOTIC ADJUSTMENT

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Citrus rootstocks have well-known effects on tree vigor and size, crop load, fruit size, and various fruit quality factors. Fruit from trees budded on vigorous rootstocks are generally larger, and lower in soluble solids concentration (SSC) and titratable acidity compared with fruit from trees budded on less vigorous rootstocks. Though it is unclear how rootstocks exert their influence on juice quality of *Citrus* spp., plant water relations is thought to play a central role. To determine how rootstock type affects SSC in fruit of *Citrus* spp., controlled water-deficit stress was applied to 'Valencia' sweet orange trees on Carrizo citrange or rough lemon rootstocks. Withholding water from the root zone of citrus trees during stage II of fruit development decreased midday stem water potential and increased the concentrations of primary osmotica, fructose and glucose, without affecting sucrose concentration, suggesting that sucrose hydrolysis took place. Increased concentrations of sugars and SSC in fruit from moderately water-stressed trees occurred independently of fruit size and juice content, indicating that passive dehydration of juice sacs, and concentration of soluble solids, was not the primary cause of differences in sugar accumulation among irrigation treatments. Controlled water-deficit stress caused active accumulation of solutes in fruit of 'Valencia' sweet orange by osmotic adjustment. The evidence presented supports the hypothesis that differential sugar accumulation of *Citrus* fruit from trees on rootstocks of contrasting vigor is caused by differences in tree water status and the enhancement of sucrose hydrolysis into component hexose sugars via osmotic adjustment. Therefore, inherent rootstock differences affecting plant water relations is proposed as a primary cause of differences in juice quality among citrus rootstocks. This mechanism provides a possible explanation of how rootstock type affects juice SSC in fruit of *Citrus* spp.

1200–1220

S20–0–65

AUTOCATALYTIC ETHYLENE PRODUCTION IN CITRUS FRUIT: MOLECULAR EVIDENCE SUPPORTS THE EXISTENCE OF TWO SYSTEMS OF ETHYLENE PRODUCTION

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Citrus fruits, which are classified as non-climacteric, produce very low levels of ethylene during ripening but respond to exogenous ethylene by accelerated respiration and ripening-related pigment changes. Our results confirm the existence of two systems of ethylene production, system I and system II, in citrus fruit. Young citrus fruit, but not mature ones, exhibited a climacteric rise in ethylene production following harvest (ca. 100 nL·g⁻¹·h⁻¹), preceded by induction of ACC synthase 1 (CSACS1), ACC oxidase 1 (CSACO1) and the ethylene receptor CSERS1 gene expression. This induction was enhanced by exogenous ethylene or propylene treatments, indicating an autocatalytic effect. The ethylene action inhibitors, 1-methylcyclopropene (1-MCP) and 2,5-norbornadiene (2,5-NBD), delayed this autocatalytic ethylene production as well as the increase in CSACS1, CSACO1 and CSERS1 gene expression (system II). In mature fruit, a constant ACC synthase 2 (CSACS2) and ethylene receptor CSETR1 gene expression was

associated with a very low rate of ethylene production (ca. $0.012 \text{ nL}\cdot\text{g}^{-1}\cdot\text{h}^{-1}$) (system I). At this stage, CSACS1 gene expression was undetectable, even after ethylene treatment, and CSERS1 gene expression remained constant, indicating that no autocatalytic response had occurred. Fruit attached to the tree showed a sharp decrease in ethylene production from May ($0.5 \text{ nL}\cdot\text{g}^{-1}\cdot\text{h}^{-1}$) to mid July, remaining subsequently at a constant, low level ($0.01 \text{ nL}\cdot\text{g}^{-1}\cdot\text{h}^{-1}$). Ethylene production in response to mechanical wounding also diminished during the course of fruit development. We conclude that young citrus fruit have a high ethylene production potential, which decreases during development toward maturity. Young fruit reveal autocatalytic ethylene production (system II), whereas mature fruit have only system I activity.

1220-1240

S20-0-66

CHANGES OF PERICARP STRUCTURE AND CALCIUM DISTRIBUTION IN LITCHI CULTIVARS DIFFERING IN CRACKING RESISTANCE

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Changes in pericarp structure and calcium distribution within pericarp were comparatively studied in cracking-resistant 'Huaizhi' and -susceptible 'Nuomici'. Pericarp of both cultivars underwent thickening before rapid aril growth and became thinner afterwards. The thickening of pericarp in early stage consisted of cell number and volume increase. Meanwhile, spongy tissue was formed outwards from the inner part of the mesocarp. With aril expansion, the pericarp was stretched, the spongy tissue squeezed and the cracks flattened. As a result, the vertical arrangement of some pericarp cells changed into horizontal arrangements. Significant cell expansion was not observed within the tubercles during aril expansion, while endocarp cells underwent continuous extension throughout fruit development. The results indicated that growth of the pericarp was contributed to not only by cell division and expansion but also by cell rearrangement. Spongy tissue formation played an important role in buffering the stress from the expanding aril, therefore it might have a role in cracking resistance. This was in accordance with this observation that the spongy tissue in pericarp of 'Huaizhi' was larger than that of 'Nuomici'. However, there was no noticeable difference in endocarp structure between the two cultivars. Transmission electron microscope revealed a thicker and more highly branched cuticle layer outside the epidermis in the former. In situ X-ray microanalysis of calcium distribution displayed a calcium-rich zone coinciding with the spongy tissue formation zone in the early stage. The calcium-rich bodies in 'Huaizhi' were larger than those in 'Nuomici'. They disappeared in the former as the spongy tissue formed, while many remained in the latter, suggesting significant difference in calcium. Calcium-rich bodies were also observed in epidermis throughout the fruit development in both cultivars. Calcium content in the endocarp cell walls in 'Huaizhi' was noticeably higher than in 'Nuomici'. The cracking resistant pericarp of 'Huaizhi' is therefore characterized by larger spongy tissue, thicker cuticle layer, higher calcium in the endocarp cell walls and higher calcium mobilization in the pericarp.

1340-1440

S20-P-67

EVALUATION OF FRUITING CHARACTERISTICS AND ORNAMENTAL VALUE OF PAWPAP [*ASIMINA TRILOBA* (L.) DUNAL]

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Pawpaw [*Asimina triloba* (L.) Dunal] is a small understory tree native to the Southeastern United States, growing 5-10 m with a loose and open habit. Its unusual fruit has long been harvested from native populations and consumed fresh or processed by local consumers. The Pawpaw Regional Variety Trial was initiated in 1995 involving 28 cultivars and seedling selections planted at locations throughout the Southeastern United States. The trial evaluated selections and cropping methods for commercial fruit production. In Louisiana, this study was established at the Burden Center in Baton Rouge and included named selections as well as additional seedlings collected in Arkansas and Louisiana. Fruit size, soluble solids content and post harvest physiology are variables being examined to evaluate market appeal. Traditional cropping methods have proved challenging as understory tree selections adapt to full sun conditions in the or-

chard. Pawpaw grown under orchard conditions have distinct morphological differences compared to trees grown in native habitats. Trees appear more compact with a dense canopy and distinct form. From the original planting, four seedlings were selected with outstanding ornamental characteristics. These selections were made strictly on the ornamental traits. Plant form, growth rate and disease resistance were recognized for selection. Selections were then grafted to seedling rootstock and evaluated in container production and later landscape establishment and culture.

1340-1440

S20-P-68

SWEET XOCONOSTLE OR TUNILLO (*STENOECEREUS STELLATUS* P.) AS AN ALTERNATIVE RESOURCE FOR THE MEXICAN MIXTECA REGION

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Sweet xoconostle, tunillo or rainy season Pitaya is the fruit of a columnar cactus tree, *Stenocereus stellatus* P., native to the semiarid southern regions in the States of Oaxaca and Puebla, Mexico. This fruit has been locally used as a source of fresh fruit and dessert for more than a century. However, very few studies have been made about its potential as a regular, commercial exploitation. We made some studies about the production system and postharvest quality in order to determine this fruit's potential as a sustainable resource. The plant is a columnar cactus growing with long but few branches, not quite ramified, with a maximum of 4.5 m height. Although it grows naturally, in a deciduous forest of the region, people cut branches and use them as an ornament in their backyard. Fruit develop at the top of each branch and seldom on one of its sides. Fruit production concentrates between September and October and one single arm may produce up to 20 fruit (156 ± 15 grams, 10-25 cm diameter on average), although variability among arms and individuals is high. Fruit shape is similar to that of prickly pear, with a thorned epidermis, which can be red, green or yellowish-green colored when ripe, but the pulp's colors may vary from red, purple, orange, yellow thru white. Its seeds are small, black and soft. It is a non-climacteric fruit with respiration of $0.0139 \text{ mL CO}_2/\text{Kg/hr}$, an average pH of 5.2 and 9-12 Brix. A proximal analysis was made to determine its potential as a healthy, natural dessert as well as for its properties for processing. Pigments' content characterization was made in order to relate its epidermis color to its pulp's color and to choose features to select varieties to consider this produce as sustainable.

1340-1440

S20-P-69

JIOTILLA (*ESCONTRIA CHIOTILLA* L.) AS A NEW RESOURCE NATIVE TO SOUTH MEXICO

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Jiotilla is the fruit of a cactus tree (*Escontria chiotilla* L.) which grows in the semiarid Mixteca region in Oaxaca, Mexico. The plant is a medium sized, multi-branched, columnar cactus between 3-6 m tall. Canopy may cover up to 100 m^2 , with up to 150 thorned branches, conforming the upper part. At the top of each branch fruits develop normally in small bunches, from 3-5 at a time during the production period, which lasts from June through mid September. A single branch may produce up to 20 fruits. Fruit are small, 3.5 cm on average. They are purple berries when ripe and the epidermis has soft, yellow, paper-like scales. It has no spines like other cactus fruits. Its pulp is also purple, sometimes red, with numerous little, black, soft seeds embedded in it. It is a non-climacteric fruit with respiration of $1.62 \text{ mL CO}_2/\text{Kg/hr}$ on average. Its flavour is bittersweet, similar to that of blueberries. Its pH is about 4.2, with 10-12 Brix, which makes it tasty as a natural dessert, a minimally processed product, frozen with sugar. A proximal analysis determined its suitability for marmalades and jams, as well as dressing products. However, the main problem derives from the lack of a harvest index, thus, a characterization was made for pigments and its possible relationship with fruit maturity stages. In spite of this problem Jiotilla fruits seem to be eligible as a sustainable agricultural produce.

1340-1440

S20-P-70

NITROGEN DEFICIENCY IN PEACH PALM (*BACTRIS GASIPAES* KUNTH)

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Nitrogen plays an important role on plant growth and development. Fast growth is particularly important for peach palm (*Bactris gasipaes* Kunth), a new crop cultivated in many countries as a source of high quality heart-of-palm or palmito. Palms are very responsive to nitrogen and potassium, and maximum growth has been related to well balanced amendment schedules. This paper shows the effects of nitrogen deficiency in peach palm growth, using data of a field factorial NPK trial, with four nutrient rates, and a nearby-cultivated area, with a natural gradient of organic matter through the top-soil layer. The research was performed at Ubatuba, São Paulo, Brazil, with three-year-old plants, cultivated in a sandy soil, in both areas. Palm responses to nitrogen were evaluated by leaf measurements, leaf chlorophyll content, gas exchange rates, leaf area index, stomata counting, and were correlated with mineral contents in soil and leaves. Soil organic matter varied from 0.7 to 32%. Leaf nitrogen content varied from 2.91 to 3.20%. The results show a typical change in leaf color and morphology in response to long-term nitrogen deficiency, with a decrease in length, width and area, and an increase in leaf thickness. Leaflets length varied from 41.07 to 69.71 cm, and width from 1.46 to 3.16 cm. Leaf chlorophyll content varied from 3.1 to 55.4% on a leaflet base. The assimilation rate also presented a linear relationship with nitrogen leaf content, varying from 0.26 to 10.12 mmol CO₂ m⁻²s⁻¹. The same pattern was detected for transpiration rate (0.81 to 2.05 mmol H₂O m⁻²s⁻¹). There was no relationship between leaf nutrient status and stomata counting, which varied from 51.95 to 65.65 stomata mm⁻² on the abaxial surface. Long-term nitrogen deficiency affected also leaf expansion rate and number, with serious consequences in peach palm growth and heart-of-palm yield.

1340-1440

S20-P-71

SUBSOIL CITRUS IRRIGATION WITH RECLAIMED SEWAGE WATER

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Reclaimed sewage water might be the main source for agriculture irrigation in arid zones. Citrus, in most cases, can utilize the nutrients dissolved in water and thus the citrus soil system can serve as a bio-filter to minimize the pollution of underground water. Subsoil drip irrigation is the recommended method for effluent application by the Israeli Ministry for Health in order to prevent fruit contamination. The overall goal of the study was to develop an irrigation scheme that minimizes ground water pollution with optimal fruit yield. An experiment was conducted on a sandy to sandy loam soil, on 'Star Ruby' red grapefruit with: 1) reclaimed and tap water 2) surface and subsoil drip irrigation 3) one and two laterals 4) three quantity levels of water and 5) two irrigation intervals. Each treatment consisted of 6 replicates with 4 weighing trees. The drip laterals were placed 75cm offside the trunk and/or at a depth of 25 cm. The emitters have a discharge of 3.8 L·h⁻¹ and were spaced at 50 cm intervals. Yields were not affected by reclaimed water but decreased vegetative growth. Low water amounts significantly reduced fruit size, yield and vegetative growth. Reclaimed water increased boron in leaf, which might affect trees performance in the future. Soil soluble inorganic salts, up to 150 cm depth, were similar for all treatments while deeper in the soil, reclaimed water increased the inorganic salts, especially chloride and sodium. Two laterals with daily irrigation and low water amount decreased water loss beneath the root system. Subsoil drip irrigation had no adverse effect on yield or water loss beneath the root system.

1340-1440

S20-P-72

CITRUS ROOTSTOCK RESPONSE TO IRRIGATION RATES WITH RECLAIMED WATER

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Two citrus varieties, Hamlin sweet orange and Orlando tangelo, were grown on four rootstocks, Carrizo citrange, Cleopatra mandarin, sour orange, and Swingle citrumelo at a central Florida site with a deep, sandy soil. Irrigation rates of 400, 1250, and 2500 mm per year were applied to determine how moderate and very high application rates with reclaimed water would affect tree growth and performance. Canopy growth and fruit yield were better at the higher irrigation rates. Canopy volume and tree height were greatest on Cleopatra and smallest on Swingle rootstocks. Trees on Cleopatra grew similarly at the different irrigation rates, but trees on Swingle grew less at the lower rate than at the higher rate. Because yields were consistently good on Swingle, crop efficiency or fruit production per unit of canopy volume was higher on Swingle and lower on Cleopatra. Juice soluble solids concentration was lower at the highest irrigation rate, but total soluble solids per hectare increased at the highest rate because of the greater fruit production. While dilution of fruit soluble solids was common at the highest irrigation rate, a decrease in soluble solids was not seen in the trees on Carrizo. Juice soluble solids, total soluble solid/ha, solids/acid ratio, and juice color were highest on Swingle. Though fertilized identically, trees on Swingle usually had higher leaf nitrogen and phosphorous levels but lower magnesium levels than the other rootstocks. On well-drained soils, excessively high irrigation rates do not damage the trees and can enhance growth. Once considered to be a disposal problem, reclaimed water is a sustainable irrigation source that can reduce groundwater pumping. Recent droughts have increased acceptance of reclaimed water.

1340-1440

S20-P-73

CORONATINE AS AN ABSCISSION AGENT FOR CITRUS

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An objective of our research program is to identify abscission agents that favorably enhance citrus fruit removal without negatively affecting leaf abscission, yield, and tree health. We previously showed that foliar applications of methyl jasmonate (MJ) to 'Valencia' orange trees caused mature fruit drop without causing flower drop or abscission of young fruit. However, concentrations of MJ necessary to cause acceptable fruit loosening induced unacceptable defoliation. Coronatine (COR) is a phytotoxin produced by several pathogens of *Pseudomonas syringae* that has biological activities similar to MJ. COR was produced by fermentation and applied to whole tree canopies or individual branches of Citrus sinensis Osb. cv. Valencia and Hamlin at 200 mg per liter. Solutions contained 0.15% Kinetic adjuvant. Trees were 10 years of age and 3 m in height and COR was applied at a rate of 5 L/tree. A significant reduction in fruit detachment force was measured in COR-treated trees 3 to 5 days after application. No flower or young developing fruitlet loss was observed in COR-treated Valencia trees, but leaf drop ranged from 10% to 20% in both 'Hamlin' and 'Valencia' trees. A small but significant increase in ethylene evolution was measured in mature fruit and leaves of COR-treated trees. Northern blot hybridization indicated that expression of ACC oxidase and polygalacturonase genes were low in mature fruit abscission zones of COR-treated trees compared with Ethephon or CMN-P treatments, a model abscission agent. Expression of 12-oxophytodiene reductase could be detected in mature fruit abscission zones of all treatments. The results demonstrate that COR is a viable abscission agent candidate for citrus.

1340-1440

S20-P-74

FRUIT SIZE AND MATURITY AT HARVEST ARE INCREASED IN SOME FLORIDA CITRUS ORCHARDS FOLLOWING WINTER GA₃ ALTERATION OF BLOOM

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Cool and/or dry periods stimulate floral induction in citrus. In some circumstances it is desirable to reduce flowering in citrus, and GA₃ applied during the inductive period typically reduces total bloom and increases the proportion of leafy bloom. In Australia, winter GA₃ has been used to reduce cropload and enhance fruit size, while in Spain and Florida, winter GA₃ treatments are reported to reduce flowering and actually increase cropping in some citrus orchards with

excessive bloom. In subtropical Florida, floral induction periods are separated by warm conditions, which permit some bloom development, and winter GA₃ appears to suppress flower populations at specific stages of development to markedly shift time of bloom. GA₃ (32 ppm + 0.05% Silwet L-77) was applied via airblast sprayer near Ft. Pierce, Fla. during the late fall or winter to Navel, Late Navel, Valencia, Ambersweet, Minneola, Marsh, and Ruby Red grapefruit. Some experiments included treatments with two GA₃ applications. When total yield was not enhanced by reduced flowering, fruit size was often increased with no significant effect on yield. Such increases in fruit size have been observed in Navel, Valencia, Marsh, and Ruby grapefruit. Trees treated in January or early February typically completed bloom prior to controls. In some cases, fruit maturity was significantly advanced in these trees. GA₃ applied in late November to early December typically delayed bloom and in some varieties stimulated a vegetative flush several weeks before bloom. Bloom manipulation of citrus with GA₃ appears promising and needs further study for efficient use. Earlier flushing and bloom following some GA₃ treatments indicates that winter hardiness may be compromised and suggests caution in regions subject to cold-injury.

1340-1440

S20-P-75

EFFECTS OF MANUAL AND CHEMICAL FRUIT THINNING ON FRUIT SIZE OF 'SIMETO' MANDARIN

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'Simeto' is a mandarin hybrid obtained from a cross between 'Miho' satsuma and 'Avana seedless' mandarin at Univ. of Catania. It is very productive with excellent fruit quality, but its heavy crop often causes complete inhibition of vegetative growth and consequently induces alternative bearing. Therefore it is essential to practice fruit thinning to overcome this problem. In the present experiment, manual thinning was compared with NAA treatment at 3 concentrations (350, 500 and 800 ppm). All the treatments were done at the end of June drop. In the manual thinning 209 fruits/plant were eliminated. The fallen fruits from all the treatments were collected and counted at intervals of two weeks for 3 times. NAA showed effective fruit thinning as indicated by the number of dropped fruits/plant: 165 for 350 ppm, 274 for 500 ppm, 463 for 800 ppm, while only 55 dropped from the control trees. From June 26, at an interval of two weeks, the diameter of 20 fruits from each treatment was measured. Two weeks later, fruits from both manual and NAA thinning treatments demonstrated much faster growth (about 8 mm larger in diameter) and more uniform in size than those from control. Between various thinning treatments, no significant difference was observed. The results indicated that NAA at lower concentration should be suitable for fruit thinning.

1340-1440

S20-P-76

GIBBERELIC ACID TREATMENT AFFECTS CARBOHYDRATE BALANCE AND PEEL COLOR OF CITRUS FRUIT

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Gibberellic acid (GA₃) applied to sweet oranges in the late summer and fall delays development of yellow peel color (color break). Color break is preceded by an increase in peel sugar levels. Carbohydrate feeding studies have shown that high sugar levels stimulate color break. Therefore, we investigated the effect of GA₃-treatment before or after color break on fruit carbohydrate levels and fruit respiration to determine if GA₃-treatment effects on peel color were related to effects on peel carbohydrates. Fruit were treated with GA₃ before or after color break and compared to non-treated fruit. Peel color (hue angle), whole-fruit respiration (R), and levels of sucrose and hexoses in the flavedo and albedo were determined 2, 12 and 54 days after treatment (DAT), except for fruit treated or non-treated after color break. These were not evaluated on 54 DAT because freezing temperatures damaged the fruit. Peel hue angles decreased (were less green) at each harvest, but fruit treated with GA₃ before, or after, color break had higher hue angles than non-treated fruit 12 and 54 DAT. Treated fruit had lower R than non-treated fruit 12 DAT, but R of treated and non-treated fruit were similar on other dates. Sucrose and hexose levels of flavedo and albedo generally increased in both treated and non-treated fruit at each harvest date. However, the flavedo and albedo of treated fruit generally had greater sucrose levels, or lower hexose

levels, or both, at 12 and 54 DAT. For treated and non-treated fruit, before color break, levels of total sugars, sucrose, and hexoses were negatively correlated with peel hue angle ($r^2 = 0.67, 0.49, \text{ and } 0.62$, respectively). Therefore, treatment with GA₃ reduced the ratio of hexoses:total sugars, perhaps through sucrose metabolism. Effects on peel color appeared to be mediated by changes in sugar levels of the flavedo.

1340-1440

S20-P-77

EFFECT OF GIBBERELIC ACID, UREA AND KNO₃ ON COMPOSITION AND QUALITY OF CLEMENTINE MANDARIN FRUIT JUICE

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Clementine mandarin is an easy peeling fruit of small to medium size, juicy and with excellent eating quality. It has been reported that preharvest as well as postharvest factors (such as cultural practices and storage conditions) affect composition and quality of citrus fruit. This study reports on research carried out to assess the influence of foliar sprays of i) urea (containing 46% N) at 1 and 1.6% (w/v) at flower initiation-differentiation to increase flowering, ii) gibberellic acid (GA₃, 10 ppm) applied twice during flowering to increase fruit set and iii) KNO₃ (at 5% w/v) applied at 'June drop' to increase fruit size on juice quality of 'Cadoux' clementine fruit. Mature trees were used and foliar sprays were applied to the point of run-off. Juice content of mature fruit was not affected by treatment nor was the maturity index or NO₃⁻ content of the juice. Free amino acid content was lowest in fruit of untreated trees and in fruit of urea treated trees and greatest in fruit of GA₃ and KNO₃-treated trees whereas NH₄⁺ content had the opposite trend. Ascorbic acid content was greatest in fruit from trees treated with urea (1.6%), GA₃ and KNO₃⁻. Significance of these results in respect to nutritional value of the fruit is discussed.

1340-1440

S20-P-78

EFFECT OF 1-METHYLCYCLOPROPENE ON ETHYLENE-INDUCED ABSCISSION OF *CITRUS SINENSIS* LEAVES

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The principles of ethylene-induced abscission, in *Citrus*, will be presented briefly concentrating on anatomical changes and the involvement of hydrolytic enzymes in the process, as a background to the following experimental report: 1-methylcyclopropene (1-MCP) induced endogenous ethylene production when leaves were further incubated in air up to 80 h. The inhibitor concomitantly delayed abscission. Following pre-treatment, for 6 h, with 1-MCP, or co-treatment with ethylene, resulted by delayed abscission. 1-MCP at 10-80 nL·L⁻¹ competed kinetically with ethylene with a Ki value of 1.4-5.5 nL·L⁻¹ 1-MCP. However, ethylene was not able to completely counteract the inhibitory effect of 1-MCP. Pre-treatment with 1-MCP, followed by exogenous ethylene treatment, suppressed the induction of endo-β-glucanase (EG) activity at the laminar abscission zone. It also blocked the expression of ethylene-induced esterase (EIE), and ethylene-induced hydroxynitril lyase (HNL) genes in leaves. The ethylene-dependent activation of the EG gene CsCel a1 mRNA was convincingly demonstrated, since pre-treatment of leaves with MCP inhibited the induction of CsCel a1. Six hours of exposure of leaves to 1-MCP, at various times during a 24 h period of ethylene treatment, efficiently reversed the expression of CsCel a1 up to 18 h. The results demonstrate that the induction of abscission by ethylene is controlled at the mRNA level.

1340-1440

S20-P-79

SOLUBLE SOLIDS, ACID AND ABSCISIC ACID CONTENTS IN DIFFERENT PORTIONS OF OKITSU SATSUMA FRUIT SUBJECTED OR NOT SUBJECTED TO WATER STRESS DURING MATURATION

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Effect of water stress on SSC, acid and abscisic acid content in different portions of the fruit was examined in maturing Okitsu satsuma mandarin (*C. unshiu* Marc.). In the control and water-stressed fruit, the difference in SSC in the radial direction increased with fruit maturity. The difference in SSC in the radial direction was greater in water-stressed than control fruit. This difference started 30 days earlier in water-stressed fruit as compared with control fruit. The difference in acidity declined with maturation at the styler end in the radial direction and at the outer portion in the axial direction. The difference in acid content in the radial direction was greatest at the mid section and lowest at the styler end in both control and water-stressed fruit. Water stress caused a 12% to 47% increase in SSC in all fruit parts as compared with control fruit from 140 to 230 DAA, the effect being most noticeable at the stem end. On the other hand, water stress caused an 11–17% increase in acid content in the central portion of the mid section whereas a 4–13% reduction was recorded in the outer portions from 190 to 230 DAA and a 0–22% increase in citric acid in the central portion with a 3–6% reduction in the outer portions toward the axial direction at 190 DAA. Abscisic acid content in different portions of fruit increased by 2–111% in water-stressed fruit as compared with the control at 160 DAA. Also, ABA was highest in the central portion in both water-stressed and control fruit. Thus it seems that, overall, water stress induces an increase in SSC and ABA, and an increase or decrease in acid content in different portions of fruit.

1440–1500

S20–0–80

EFFECT OF GIBBERELIC ACID AND BENOMYL ON PERSIAN LIME POSTBLOOM FRUIT DROP DISEASE IN RIO DE JANEIRO STATE, BRAZIL

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In Brazil, blooming of Persian lime (*Citrus latifolia*) after spring, allows a harvest period in the second half of the year, meaning greater incomes for citrus growers. Blooming during the rain season enhances susceptibility to anthracnose fungi, causing young fruit drop and reduction in harvest production. Disease control is usually made by spraying of the fungicide Benomyl during the blooming period. Nevertheless those fungicide sprays do not always control the disease. On the other hand, gibberelic acid has a positive effect on citrus fruit set, but the effect of gibberelic acid on fruit set under anthracnose infection, is not well known. The objective of this work was to compare the effect of benomyl and gibberelic acid sprays on fruit set under anthracnose infection conditions. The experimental design was carried out in infected blocks with each experimental parcel constituted by 9 branches of the citrus trees and each treatment had 9 repetitions. Treatments were applied by sprayings as follows: T1 = water; T2 = Gibberelic Acid (100 mg·L⁻¹); T3 = Benomyl (1 g·L⁻¹). Average fruit set was evaluated after sprays in two periods, two weeks and two months after flowering. Spraying of gibberelic acid during the flowering period enhanced fruit set even under anthracnose infection. Fruit set observed in treatment with sprays of Benomyl was the 100% base.

1500–1520

S20–0–81

THE PHYSIOLOGICAL CONTROL OF CITRUS CREASING

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Citrus creasing is a disorder characterized by multiple cracking in the albedo, resulting in weak rind. Such fruit is not packed. Various attempts at control of the disorder have been made. In South Africa, gibberelic acid is sprayed in the late summer. However, this only delays creasing development. Calcium sprays have only limited success. Using five data orchards in the Eastern Cape region of South Africa, fruit pectin analysis during fruit development, indicated rapid changes in total as well as constituents during the first six weeks post petal fall. Activity of an enzyme, believed to be uronic acid oxidase, correlated with creasing incidence at harvest, if assayed at four to five weeks post petal fall. Simultaneous mineral analysis of fruits explained, through multiple regression, over 90% of variation in pectin gelling, and in turn was successful in predicting creasing. While a number of ele-

ments appeared to play a role, the cause of creasing is probably multivariate, with molybdenum being of critical importance. It is suggested that this element acts as a co-factor in ureide synthesis, required in the formation of galacturonic acid, a major component of pectins. Of further importance was sulphur, believed to be a component of uronic acid oxidase. Calcium was found to be of lesser importance. It is suggested that creasing occurs due to a lack of adequate pectin formation and cross-linking. A major cause of this problem is a lack of ureide formation, in which molybdenum plays a considerable role as a co-factor, although in some orchards other points in the pectin formation pathway may be important. It is suggested that the solution to creasing is through identification of the critical restriction to pectin synthesis at any particular site, and application of the required element, which under South African conditions appears to be primarily molybdenum.

1520–1540

S20–0–82

CONSERVATION AND UTILIZATION OF GENETIC RESOURCES OF BAEI (*AEGLA MARMELOS CORREA*)—A POTENTIAL UNDERUTILIZED FRUIT

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The bael tree is hard and has wide adaptability to soil and climatic condition and can be grown successfully in vast barren, eroded and salt affected wastelands. The tree has a significant role in preservation of the environment. The tree may be very effective in the amelioration of soils and prevention of soil erosion and are therefore an important component of sustainable development. The importance of bael fruit lies in its curative properties, which makes the tree one of the most useful medicinal plants. Every part of this tree, i.e., fruits, seeds, trunk, bark, leaf and root, are important ingredients of several Ayurvedic prescriptions. In spite of much importance and possibilities of extension of cultivation of this underutilized fruit in our state, very little work has been done on selection of their improved types from the available vast genetic resources. In order to select superior genotypes of bael, survey, evaluation and collection work was initiated in 1994 and over the years nearly 1200 trees were evaluated. Initially 48 trees were selected, based on tree characters, yield potentiality and fruit characters. After five years of regular evaluation, finally six types were selected. The selection characters of identified types will be discussed based on various utility.

1540–1600

S20–0–83

TO BE ANNOUNCED

1600–1620

S20–0–84

TO BE ANNOUNCED

1620–1640

S20–0–85

TO BE ANNOUNCED

1640–1700

S20–0–86

TO BE ANNOUNCED

Friday · August 16

0800–0900

S20–P–89

EFFECT OF PREHARVEST APPLICATION OF N, K AND CA ON FRUIT PEEL PITTING OF FORTUNE AND AFOURER MANDARIN IN LOW TEMPERATURE STORAGE

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Low temperatures below 8 °C cause severe peel pitting of Fortune mandarin fruit. In this study, we have investigated the effect of foliar application of fertilizers containing nitrogen, calcium and potassium on the incidence of this disorder. Fruits harvested from treated trees showed less peel pitting when compared to untreated trees when stored at 4 or 8 °C. The severity of chilling injury symptoms increases with lower temperature and increasing storage duration. Fruit internal quality was not significantly affected by various treatments at both storage temperatures. Mineral content of nitrogen, potassium, calcium and magnesium in addition to micronutrients boron, iron and manganese in the peel of fruits was analyzed. The relationship between applied foliar fertilizers, peel mineral content and skin disorders will be discussed. Peroxidase activity in the peel of fruits coming from various treatments varies following storage duration and temperature of storage. More results will be presented and commented on.

0800-0900

S20-P-90

CONTROLLED ATMOSPHERE STORAGE OF LOQUAT FRUITS

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'Gold Nugget' loquats (*Eriobotrya japonica* Lindl.) were stored in 3% O₂ + 1% CO₂; 3% O₂ + 2% CO₂ or 3% O₂ + 3% CO₂ at OEC with 90% relative humidity for 2 months. Weight loss, flesh firmness, titratable acidity, soluble solids, skin colour, chilling injury and amount of decayed fruits were evaluated during storage. Loquat fruits stored at 3% O₂ and 2% CO₂ retained a better taste and flavour than other CA treatments and normal atmosphere storage (control fruit). CA-storage reduced weight loss and chilling injury. Loquats stored in CA retained a higher content of titratable acids and soluble solids.

0800-0900

S20-P-91

POSSIBILITY OF ARTIFICIAL RIPENING OF MAZAFATI DATE FRUITS (*PHOENIX DACTYLIFERA* L.)

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To determine the effects of postharvest treatments on ripening and quality of date fruits, ethephon, sodium chloride, acetic acid and their combination were applied to Mazafati date fruit in our study. Fruit of the Mazafati date cultivar were harvested at the end of khalal stage and immediately after harvest, fruits were washed and treated with ethephon (0, 500, 1000, 1500, 2000, 2500 ppm), acetic acid (2%), sodium chloride (2%) or a combination of the last two compounds (acetic acid 2% + sodium chloride 2%). Fruit were dipped in ethephon and sprayed with the other compounds. Treated fruit were stored at 38–40 °C and RH = 85 to 90% for 72 hrs and then transferred to cold storage (T = 0 °C, RH = 85 to 90%) for 3 months. Ethephon significantly increased TSS proportionally to the concentration of ethephon. Sodium chloride, acetic acid both at 2% and their combinations significantly increased TSS, reduced fruit firmness and moisture content of the fruit. Treated fruits after 3 months of storage had very good taste and appearance.

0800-0900

S20-P-92

EFFECT OF THE USE OF COATINGS ON STORAGE LIFE OF MEXICAN LIME (*CITRUS AURANTIFOLIA* SWINGLE) FROM COLIMA, MEXICO HARVESTED IN TWO DIFFERENT PERIODS

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Most subtropical origin crops are cold susceptible, any decrease below the

critical storage temperature (10–13 °C) reduces storage life. Degreening and chilling injury are the major postharvest problems found in Mexican limes, having as a consequence a loss of up to 50% of production. Therefore, the use of three different natural coatings was studied and compared with a commercial wax on Mexican limes harvested in the beginning (June 2001) and at the end (August 2001) of the harvesting season and stored at 4, 7, 10 and 20 °C and 90% RH. The coatings were based on: (1 and 2) candelilla–mezquite–mineral oil (CMMO) in a ratio 1:1 and in a ratio 2:1 and (3) the aforementioned components with Tween Span 60 added. Chilling injury percentage, peel color, physiological weight loss percentage (% PWL), juice percentage, titratable acidity (expressed as % of citric acid), total soluble solid content (TSS) were determined every three days in triplicate. No differences among treatments were found in TSS, juice percentage and titratable acidity. A synergistic effect was found when CMMO 1:1 was applied on limes stored at 10 °C, resulting in less chilling injury, less % PWL and greener color, in general the best quality in limes. Differences were observed between harvesting periods, demonstrating that the overall quality of limes harvested at the beginning of the season was the best.

0800-0900

S20-P-93

OSMOTIC DRYING BEHAVIOR OF MANGO, PINEAPPLE AND PAPAYA FRUITS

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Three kinds of tropical fruits-mango, pineapples and papaya- have been studied as experimental material to analyse the effect of fruit maturity, sucrose concentration and the fruit/syrup ratio. The experiment was carried out with 3 fruit maturity stages, 3 levels of sugar concentration (50, 60 and 70 °Brix) and 3 fruit/syrup ratios (1:2; 1:3 and 1:4). Following the osmotic pre-concentration, the fruit samples were dried at 50 °C, 2800 ft/min air flow for 12 h. The fruit pieces were analyzed for humidity, total soluble solids and water activity. Statistical analysis of data indicated a significant effect of syrup concentration occurring at 70 °Brix resulting in higher solute transference. Water activity in mango and pineapple fruit showed a higher decrease with osmotic solution at 70 °Brix while the same behavior was observed in papaya fruit with any sugar concentration.

0800-0900

S20-P-94

CORRELATION BETWEEN SAP POLIPHENOLOXIDASE ACTIVITY OF MANGOES AND SAPBURN SUSCEPTIBILITY IN DIFFERENT HARVEST PERIODS OF TOMMY ATKINS AND HADEN CULTIVARS

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Sapburn (S) is a very important problem in Mexico, affecting exportation mango quality and causing losses of up to 10% of the total amount produced. S is produced when exuded sap enters in contact with the skin and its main characteristic is an initial browning surrounding the lenticels, from which necrotic zones can be generated, causing appearance, flavour, and firmness loss in fruits. Browning of the fruits has been associated to the polyphenoloxidases activity (PPOs) that exist in the skin and sap of mangoes. The objective of this work was to determine the correlation between the activity of PPOs in sap of cultivars Tommy Atkins (TA) and Haden harvested in April, May and June. The enzymatic activity was measured spectrophotometrically. The sensitivity to S was quantified by measuring the percentage of the damaged area of the fruit. Results show that the activity of the PPOs, is higher in sap of TA than in Haden cultivar. Furthermore, the percentage of area damaged by the sap in TA is greater in April and May, diminishing in June. Meanwhile in Haden cultivar, the area damaged is very low in April and May, and increases in June. The activity of the polyphenoloxidase enzymes in sap do not completely explain the sapburn susceptibility change of both cultivars during different harvesting seasons. Acknowledgment to EMEX (Exportation packing mango association).

0800-0900

S20-P-95

IMPROVEMENT OF FRUIT QUALITY BY DELAYED HARVEST AFTER OVERWINTERING ON TREE IN EARLY-MATURING SATSUMA MANDARIN

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In order to overcome the problems of low content of total soluble solids (TSS) and high content of acid in fruit juice of early-maturing Satsuma mandarin associated with harvesting in early or mid November in Jeju island, Korea, the practice of delayed harvest after overwintering on trees either in an unheated plastic film house or with wrapping of the part of canopy in the open field was developed. The peel puffiness and TSS contents in juice of the fruit harvested in March after overwintering in the plastic film house were significantly affected by the soil moisture level not only during winter but also during fruit development; the drier the soil, the lower the degree of peel puffiness and the higher the TSS content. It was possible to produce quality fruit with high TSS (more than 12%) and low acid (less than 0.8%) by the control of soil moisture in the plastic house. Severe water stress, however, during winter with leaf water potential lower than -1.0 MPa caused leaf drop and delayed spouting in the following season. Wrapping the lateral shoot or the part of canopy with various materials in the open field was effective in protecting fruit from attacks by birds and improving the fruit quality. Peel puffiness, TSS content and fruit decay were influenced by the wrapping materials.

0800-0900

S20-P-96

STUDY OF FLAVONOID CONTENTS IN FRUITS OF DIFFERENT CITRUS GENOTYPES

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It is well-known that *Citrus* have many healthful properties. Among the *Citrus* constituents, flavonoids are very important secondary metabolites with anticancer, antiviral and anti-inflammatory activities due to their antioxidant and antimutagenic activities. Although there is some evidences of the effects of rootstock and of environment on secondary metabolite production in *Citrus*, flavonoid contents in fruits mainly depend on genetic characteristics. The knowledge of this characteristic could be interesting in view of alternative commercial employments of *Citrus* as a source of phytochemicals for pharmaceutical purposes. The present study has been carried out to investigate the flavonoid content of fruits of several clones of *Citrus aurantium* L., *Citrus limon* Burm., *Citrus sinensis* (L.) Osbeck, *Citrus clementina* Hort. Ex Tan., *Citrus reticulata* Blanco and *Citrus paradisi* Macf., collected at different ripening stages. Flavonoid contents were determined by HPLC analyses.

0800-0900

S20-P-97

FRUIT QUALITY OF JAFFNA MANGOES

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The most popular mango variety in Jaffna is Karthacolomban especially known as Jaffna mango. Other popular dessert varieties are Ampalavi and Willard. Mature unripened mangoes of Karthacolomban, Ampalavi and Willard were harvested after ninety days from full bloom stage and kept for ripening. Taste panel results showed that the taste of Karthacolomban mangoes was excellent. Quantitatively taste was the balance between Brix and acidity. Brix/acidity value of Karthacolomban was 19.79/0.15 after ripening. Average weight range of Karthacolomban was 175-500 grams and storage life was 8 days with poor color development. Twenty percent of the fruits were rejected for marketing due to stem-end rot and anthracnose during ripening. Ampalavi mangoes were considerably larger in size. Disappearance of green color and appearance of dark yellow color was observed after 7 days of ripening. Qualitatively, taste was fairly good and Brix/acidity of Ampalavi was 22.79/0.21. Seventy percent

of the fruits were acceptable for marketing and 30% of the fruits were severely affected by stem-end rot. Willard mangoes had excellent taste after 7 days of ripening. The Brix/acidity was 24.8/0.15 and color of Willard mangoes was bright yellow with red color stem-end part. These fruits were very small and susceptible to anthracnose. Thirty percent of the Willard mangoes were not acceptable for marketing due to anthracnose. Warm water dip of temperature ranging from 53- 50 °C for 5 minutes were effectively in reducing the symptoms of anthracnose and stem-end rot by 20-30% in Karthacolomban, Ampalavi and Willard mangoes. A warm water dip gave attractive orange color to Karthacolomban mangoes when ripe. It also enhanced the fruit quality by achieving uniform ripening in Karthacolomban, Ampalavi and Willard mangoes and increases the marketing value.

0800-0900

S20-P-98

BREEDING PAPAYA FOR RESISTANCE TO RINGSPOT VIRUS DISEASE IN MALAYSIA

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Papaya is one of the most important export fruit in Malaysia, grossing RM59 million in export revenue in 2000. However, both varieties commonly grown in the country i.e., Sekaki and Eksotika are very susceptible to the papaya ringspot virus (PRSV) disease. First detected in the southern state of Johor in 1991, this devastating disease had effectively stopped papaya growing in the south and forced cultivation to shift to the middle and northern regions. MARDI initiated a breeding programme for resistance to PRSV in 1991, using the Tainung No. 5 and Cariflora as tolerant parents. The F1 hybrids with Eksotika showed very good tolerance. From this stage each of the 2000 progenies of the Tainung x Eksotika cross was represented by a single seed to the next generation (single seed descent method) until the F5 was reached. No selection pressure was exerted on any traits and each tree was not prejudiced in perpetuation into the next generation. This method ensured development of inbred lines with a wide genetic base and produced lines with Eksotika characteristics and PRSV resistance. At the F5, the 2000 progenies were screened for disease resistance by artificial inoculation of nursery plants at the 12-leaf stage. Twelve elite lines were selected and these were tested over 2 'hot-spot' diseased locations in the south. Results of the trials indicated that 3 lines i.e., Line 41, Line 90 and Line 248 exhibited high tolerance. Fruits of Line 90 rarely showed any ringspot symptoms while Lines 41 and 248 were very tolerant, showed only mild symptoms and continued yielding fruits long after susceptible trees were killed. A comparison is made between tolerant lines and susceptible ones on the onset and expression of disease symptoms as well as their performance in fruit yield and quality. Future breeding strategies using the selected tolerant lines for further improvement of current local cultivars is discussed.

0900-0940

S20-O-99

TROPICAL FRUIT POSTHARVEST: THE IMPACT OF BIOTECHNOLOGY

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High quality tropical fruit, when exported to distant markets, are limited by their postharvest characteristics. These limitations include limited supplies, irregular quality of many of the minor fruit crops, chilling sensitivity, insect disinfestation treatments, shipping and storage duration, and lack of understanding of storage limitations. Any success in improving postharvest quality by extending shelf life or preventing postharvest decay is advantageous in enlarging markets and broadening consumer appeal. Significant advances are being made in applying biotechnology to banana, papaya, pineapple, and mango to improve postharvest quality. The major limitations to the application of biotechnology are a lack of efficient transformation protocols and limited understanding of the molecular biology, biochemistry and physiology of these crops. This technology also needs to take into consideration commercial and economic impacts. Fruit packers, shippers, handlers and consumers may not see a significant advantage of modified handling and ripening characteristics and hence may not be willing to pay a premium price, particularly if the crop is already available all year around

from a single or multiple sources, such as banana and papaya. Three approaches are being utilized to extend postharvest life and maintain quality; the first is to select for slower ripening lines, and the modification of either ethylene responses or softening rate. For example, papaya varieties having slow ripening characteristics have been selected, delayed ripening by the down-regulation of ethylene synthesis enzymes (ACS and ACO) is being tested for banana and papaya, and the modification of fruit softening related enzymes. The new cultivars developed from these programs could significantly influence tropical tree fruit marketing.

0940-1000

S20-O-100

TO BE ANNOUNCED

1000-1020

S20-O-101

CORRELATION BETWEEN LIPOPEROXIDATION LEVELS, PEROXIDASE ACTIVITY AND CHILLING INJURY ON TEMPERATURE CONDITIONED AND COATED PERSIAN LIME (*CITRUS LATIFOLIA* TANAKA) STORED AT 6 °C

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Most subtropical crops are cold susceptible, any decrease below critical storage temperature (10–13 °C) reduces storage life. It seems that moderate cold stress might induce an adaptation response in fruits (cross-tolerance), toward a severe cold stress conditions. The objective of this study was to evaluate the effect of the application of temperature conditioning (13 °C for 48 hours) and waxing (coating based on candelilla–mezquite–mineral oil (CMMO) or the commercial wax used in the region) on the reduction of chilling injury in Persian lime (*Citrus latifolia* Tanaka) from Martínez de la Torre, Ver. Mexico, stored at 6 °C, RH 90% for 30 days. Chilling injury percentage, peel color, physiological weight loss percentage (% PWL), juice percentage, titratable acidity (expressed as % of citric acid), total soluble solid content (TSS), liperoxidation levels and peroxidase activity were evaluated. No differences among treatments were found in chemical composition. Cold temperature conditioning (13 °C for 48 hours) combined with the application of the commercial wax resulted in the least chilling injury (less than 1% of the flavedo damaged) and the greenest color, showing a direct correlation with liperoxidation levels (a measure of membrane injury) that were the lowest. Additionally, peroxidase activity exhibited the highest levels and the least % PWL (less than 10% after 30 days of storage).

1020-1040

S20-O-101-A

TO BE ANNOUNCED

1400-1420

S20-O-102

CAROTENOIDS AND VITAMIN C CHANGES BY SEMI-COMMERCIAL ULTRA-LOW OXYGEN STORAGE IN GRAPEFRUIT

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Grapefruits (*Citrus paradisi* Macf.) shipped to certain US states and some export markets such as Japan and South Korea, must be certified free of quarantine pests. Refrigerated (140 C), ultra-low oxygen (0.05 kPa), short-term (21 days) storage is being investigated as a novel way to disinfest fresh grapefruit of Mexican fruit fly (Shellie, K.C. and K. Rodde. 2000. HortScience 35:412). Grapefruit functional compounds such as carotenoids (lycopene, beta carotene), flavanones [naringin, narirutinosides (NR)], limonin 17-b-D glucopyranoside (LG), and vitamin C have potential human health benefits including prevention of cancer and cardiovascular disease. This study was undertaken to determine whether storage in refrigerated ultra-low oxygen altered grapefruit functional components. 'Rio Red' grapefruit was washed and waxed on a commercial packing line the day of harvest. Three commercial shipping cartons of grapefruit that were harvested from each of three trees were stored for 21 days inside a 20 ft marine container maintained at 140 C and 0.05 kPa oxygen (treated) or a walk-in cooler in air at 1000 C (controls). Both treated and control fruit were stored for 14 additional days in air at 210 C. Thirty treated and control fruit were analyzed for quality (total soluble solids and titratable acidity) and functional components after the initial 21 day storage and again after 14 additional days of storage in air. Fruit stored under ultra-low oxygen had significantly higher concentrations of beta carotene, lycopene and ascorbic acid, but similar levels of naringin, narirutin, and LG after 35 days. However, after 21 days of storage, no significant differences in any functional components were observed between treated and control fruit. Results suggest that short-term ultra-low refrigerated storage may have potential for enhancing fruit functional components as well as disinfesting fruit of insect pests.

1420-1440

S20-O-103

MODIFIED ATMOSPHERE STORAGE AND ETHYLENE ABSORBENT ENABLES PROLONGED STORAGE OF 'HAYWARD' KIWIFRUIT

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In this study, the effects of modified atmosphere storage and ethylene absorbent on flesh firmness, titratable acids, soluble solids, ascorbic acids, chilling injury and percentage of decay of 'Hayward' kiwifruit were evaluated. Experiments were performed at 0 °C and 90% relative humidity using 50 x 70 cm polyethylene bags. Fruit stored in modified atmosphere and use of a ethylene absorbent during storage resulted in firmer fruits, higher titratable acids, ascorbic acids and lower weight loss than the control fruit. After a 6 month storage period, the highest percentage marketable kiwifruits was obtained from the fruit kept at modified atmosphere with a ethylene absorbent. In modified atmosphere conditions, the percentage of O₂ concentration decreased to 6–8% and CO₂ percentage increased to 7–9% at the end of 6 months storage.

1440-1500

S20-O-103-A

TO BE ANNOUNCED

1500-1520

S20-O-103-B

TO BE ANNOUNCED

1520-1540

S20-O-103-C

TO BE ANNOUNCED

1540-1600

S20-O-103-D

TO BE ANNOUNCED