



**XII INTERNATIONAL SYMPOSIUM ON  
INTEGRATING CANOPY, ROOTSTOCK AND  
ENVIRONMENTAL PHYSIOLOGY IN  
ORCHARD SYSTEMS**

**ORAL ABSTRACTS**

## Contents

ENVIRONMENTAL PHYSIOLOGY SESSION 1: MORANDI BRUNELLA CHAIR .....	3
ENVIRONMENTAL PHYSIOLOGY SESSION 2: LUIGI MANFRINI CHAIR .....	9
ENVIRONMENTAL PHYSIOLOGY SESSION 3: MATTHEW WHITING CHAIR.....	14
TRAINING SYSTEM SESSION 1: LEO RUFATO CHAIR .....	21
TRAINING SYSTEM SESSION 2: GREGORY LANG CHAIR .....	25
ORCHARD MANAGEMENT SESSION 1: MICHAEL BLANKE CHAIR .....	29
TRAINING SYSTEMS SESSION 3: IOANNIS MINAS CHAIR.....	34
ROOTSTOCKS SESSION 1: ESMMAEL FALLAHI CHAIR.....	41
ROOTSTOCKS SESSION 2: KEN BREEN CHAIR .....	47
ORCHARD MANAGEMENT SESSION 2: JEF VERCAMMEN CHAIR.....	52
ROOTSTOCKS SESSION 3: GREGORY REIGHARD CHAIR .....	55
CROP LOAD AND THINNING: TORY SCHMIDT CHAIR.....	59
FLOWER BIOLOGY SESSION: TODD EINHORN CHAIR .....	64
PRECISION FARMING SESSION: GWEN HOHEISEL CHAIR .....	68
FRUIT QUALITY SESSION 1: BEN VAN HOOIJDONK CHAIR .....	73
FRUIT QUALITY SESSION 2: SARA SERRA CHAIR .....	76

Monday 26<sup>th</sup> July 2021

## ENVIRONMENTAL PHYSIOLOGY SESSION 1

**ROSA: 104**

**PRESENTER: Corelli Grappadelli, Luca (K1)**

**TITLE: Precise ecophysiology: how physiological studies can lead to innovative management practices on fruit crops**

**ABSTRACT:**

From early leaf studies to the measurement of canopy gas exchanges, the asymptotic response of net photosynthesis (Pn) to photon density was remarkably clear: in every fruit species Pn did not increase above ca 50% of total available light where light intensity is not a limiting factor. Earlier reports on photoinhibition in tropical and subtropical species encouraged us to assess canopy light interception profiles that were not symmetrical around solar noon, in which trees would receive different light intensities at different times of the day. We found that peach trees receiving high radiation loads, in particular in the morning were more photo-inhibited and photo-damaged than trees that only received diffuse light prior to solar noon and were in direct sunlight in the afternoon. As a consequence, total daily photosynthesis was higher in the latter than in the former row configuration. We then verified, both in apple and peach, that up to 50% reduction in light levels did not negatively affect photosynthesis, while it allowed considerable savings in irrigation water. In the case of apple, fruit quality was not affected by shading; shaded peaches were smaller and less sweet than the controls in environment with moderate VPD while, in such areas with very high evapotranspirative demand the concurrent reduction of VPD at optimum values operated by shade ameliorated fruit size and quality. The explanation lies – at least in part – in the different phloem unloading physiology that underpins fruit growth: peach – a symplastic downloader – requires medium/strong VPD's to create the water potential gradients necessary for phloem inflow to the fruit, and subsequent xylem flow. However, when VPD is excessive, the photosynthetic limitation and the high imbalance between the water lost and absorbed could negatively affect fruit growth. Apples, apoplastic phloem downloaders, are much less sensitive to VPD and do not respond so negatively to shading. This work has set the foundation for further studies on the optimization of irrigation, such as improving the water status of the tree when water is needed most for fruit growth, or the design of innovative training system solutions for different species. These studies are at the core of the Precision Orchard Management research programs at the universities of Bologna and Bari.

# ENVIRONMENTAL PHYSIOLOGY SESSION 1

**ROSA: 3**

**PRESENTER: Lauri, Pierre-Eric (SP1)**

**TITLE: Designing a sustainable orchard - Plant diversity as a key and ways to implement it**

**ABSTRACT:**

Conventional fruit-tree farming systems are highly productive but also strongly dependent on external inputs including pesticides, fertilization, and water. To reduce this dependence various initiatives have been developed in past decades such as Integrated Fruit Production that encompasses Integrated Pest Management, Organic Farming, and more recently Agroecology that is strongly inspired by research in ecology. These initiatives include plant diversity as a main driver to improve the sustainability of the orchard. Plant diversity can either be planned (choice of productive and not productive species) or associated (unintentional) and at different scales (within the cultivated plot and/or the surrounding landscape). To increase plant biodiversity, companion plants can be either herbaceous, bushes or trees. The interest of plant diversity to improve the sustainability of agrosystems is documented from three points of view, composition, structure and function. First, companion plants have to be chosen to fulfill precise functions within the system, such as sustaining nitrogen provisioning (e.g., herbaceous legumes between fruit-tree rows), hosting natural enemies of main pests or attracting herbivore insects outside the orchard. Recent works on agroecology analyze multispecies fruit-tree based agroecosystems documenting not only fruit production but also the various “services” (e.g., mitigation of CO<sub>2</sub> emission, soil nitrogen availability) companion plants can provide. Second, to optimize plant functioning, it is necessary to define rules of plant assemblage at spatial (e.g., distance between plants) and temporal (e.g., plantation at a same time period or not) levels. Based on a literature survey and on current experiments we will show that agrosystems that combine trees grown for fruit and possibly for timber or firewood, and agricultural crops, i.e. fruit-tree based agroforestry systems (FT-AFS), provides promising results in the temperate climate context including the mediterranean zones. Further, the introduction of plants providing pest regulation services opens to challenging perspectives towards more friendly fruit-tree based agrosystems.

## ENVIRONMENTAL PHYSIOLOGY SESSION 1

**ROSA: 45**

**PRESENTER: Blanke, Michael (SP2)**

**TITLE: Effects of contamination on optical properties of reflective mulches- and their visualization**

[Reflective mulches promote anthocyanin synthesis in apple fruit - visualisation of light penetration]

**ABSTRACT:**

My farewell contribution summarises three experiments (2017 – 2019) on ninety 9-year-old cv. 'Braeburn Hillwell' apple (slender spindle) trees on M9 rootstock at Klein-Altendorf, University of Bonn: Firstly, soil contaminated reflective mulch (Lumilys) decreased both straight and diffuse UV-B and PAR light reflection in a concentration dependent manner (from 3 to 50g soil/m<sup>2</sup>), but unexpectedly increased straight UV-B and PAR reflection from aluminum foil under the tree. Secondly, the effect of tree position on anthocyanin synthesis as fruit colouration was investigated in-situ using reflective mulches in every alleyway, or just on the West or just on the East side of the tree in N-S planted rows: Apples on the East side or in the lower part of the tree canopy were less coloured. The use of white reflective textile mulch (Lumilys) greatly improved colouration, if used in every alleyway (59.6°hue), every other alleyway (57° hue) or aluminum foil directly under the tree (53.3°hue). Thirdly, penetration of light (PAR) reflected from Lumilys mulch in the alleyways was visualised by 30 colour codes from yellow, orange, light green to dark green based on light measurements every 25 cm within the tree canopy. Control trees were grown without the reflective mulch using grassed alleyway; trees with or without hail net were also separated in the visualisation. Regardless of the material and spreading approach, the reflective mulches showed the best effect on fruit colouring in the more shaded lower parts (< 1m) and on the Eastern side of the tree canopy.

## ENVIRONMENTAL PHYSIOLOGY SESSION 1

**ROSA: 66**

**PRESENTER: Morandi, Brunella (SP3)**

**TITLE: Multifunctional nets can have different effects on water relations, leaf gas exchanges and fruit quality of cherry trees depending on the rootstock vigor**

**ABSTRACT:**

In cherry orchards, multi-functional nets represent very useful protection tools against biotic and abiotic stressors, such as *Drosophila Suzukii*, rain or hail. At the same time, the shading effect of the net can alter the microclimate within the canopy thus affecting physiological processes at tree level. This work aims at testing the effect of “Keep in Touch®” multifunctional nets on water relations, leaf gas exchanges, fruit and vegetative growth of cherry trees (cv. “Black Star”) grafted on the semi-vigorous (CAB6P) and on the semi-dwarfing (Gisela™6) rootstocks. The daily patterns of stem, leaf and fruit water potential, leaf photosynthesis, stomatal conductance and transpiration, shoot and fruit growth were assessed in post-veraison, while productivity and fruit quality were determined at harvest. Results showed how nets did not induce any decrease in photosynthesis in the internal part of the canopy of trees grafted on Gisela6, while they decreased stem water potential thus improving their water status. Furthermore, nets increased fruit growth rate as well as fruit dry matter content on Gisela6 trees. On the contrary, nets induced a reduction of photosynthesis in the internal part of CAB 6P canopies, as they were denser because of their higher vigor. By the same token, fruit growth and quality on CAB6P trees were reduced under the nets due to reduced fruit water potential which caused these fruits to be weaker sinks for water and carbohydrates. Based on these results, we can conclude that Keep in touch® nets, beside their protective function against biotic stressors, can bring benefits to the high density planting systems as they improve their water status and fruit quality, while they can induce some negative effects on fruit quality on high vigorous orchards.

## ENVIRONMENTAL PHYSIOLOGY SESSION 1

**ROSA: 136**

**PRESENTER: Manfrini, Luigi (SP4)**

**TITLE: *Actinidia deliciosa* Vs. *Actinidia chinensis*: A Comparison of Physiological and Productive Parameters**

**ABSTRACT:**

There are very few studies concerning management practices of *Actinidia chinensis* and usually crop management is based on traditionally known protocols derived from the *deliciosa* species. This is often the cause for poor fruit size, organoleptic quality, and postharvest issues. The current study analyzed the effects of water withholding according to model-based decision support systems on daily physiological parameters, such as fruit growth, leaf gas exchanges, water potentials at different phenological stages and at production of *Actinidia chinensis* during 2019 season. Fruit growth was monitored using highly sensitive, custom-built fruit gauges. Data were compared with the standard management practices applied to *Actinidia deliciosa*. Results showed how *Actinidia chinensis* is, as all *Actinidia* species, an isohydric plant. For this reason, kiwifruit is not tolerant to drought stress. Anyway, if for *deliciosa* a -0.5 MPa water potential is not a limiting factor, it is for *chinensis*. In fact, at this water potential level the plant is reducing all leaf gas exchange parameters and fruit growth, with repercussions on final yield. Such effect was found along the day, in the different phenological stages. This pivotal study may discriminate the effects of environmental conditions which determine the best practices to manage irrigation for the *chinensis* species.

## ENVIRONMENTAL PHYSIOLOGY SESSION 1

**ROSA: 201**

**PRESENTER: Pastore, Chiara (SP5)**

**TITLE: Application of a multidisciplinary approach to understand the effect of night temperatures on anthocyanin accumulation in cv. Corvina (Vitis Vinifera L.)**

**ABSTRACT:**

Night temperatures are expected to increase considerably in Italy over the next decades due to climate change. Nevertheless, research in viticulture has focused mainly on the effects of daily maximum temperatures on anthocyanin biosynthesis, which is strongly affected by light and temperature combination. An integrated approach involving physiological, biochemical and molecular analyses was applied to understand the effect of two different night temperature regimes on anthocyanin biosynthetic pathway, hypothesizing a transcriptional and enzymatic control driven by low temperatures. To test this hypothesis, potted grapevines (cv. Corvina) were cooled overnight (10-11°C) during veraison (LNT) and compared to control vines (C) grown at ambient night temperature (15-21°C). No effects of night temperature on technological ripening were detected, but LNT berries were characterized by a slowdown in anthocyanin accumulation during the treatment and by an accelerated anthocyanin synthesis immediately after the end of the treatment in comparison to C. The expression of several key genes involved in anthocyanin biosynthesis (PAL1, DFR, UFGT, MYBA1) was unexpectedly increased during the night in comparison to the day, regardless of the applied thermal regime. Furthermore, low night temperatures enhanced the expression of the key genes of anthocyanins biosynthesis (PAL1, MYBA1 and UFGT), although gene expression did not always match a simultaneous anthocyanin accumulation. These results suggest that the rising trend in night temperatures may lead to a reduced anthocyanin production in red grapevine berries and wines in the future years. Enzymatic activity analyses on PAL and UFGT are underway to understand the possible role of post-transcriptional control in determining the effect of night temperature on the increase of anthocyanin accumulation of cv. Corvina berries.

Monday 26<sup>th</sup> July 2021

## ENVIRONMENTAL PHYSIOLOGY SESSION 2

**ROSA: 57**

**PRESENTER: Gonzalez Noguera, Carlota (SP6)**

**TITLE: Investigation the effect of warmer temperatures during ecodormancy in time of bud break of two apple cultivars in south-east UK**

**ABSTRACT:**

Cultivar selection in fruit orchards is a crucial decision as they can remain in production for decades. Future climate should be a key factor influencing decision making as projected warmer temperatures will affect the dormancy cycle, which determines the timing and quality of bud break. An absence of chilling can hinder dormancy development, affecting bud break and negatively impacting fruit production.

Models combining winter and spring temperatures have been used for predicting time of bud break. Existing models were developed based on experimental work with particular fruit tree species. However, they are typically used to determine chilling requirement of other fruit tree species, omitting model re-parametrisation and assuming that there is an equal response to temperature amongst all fruit trees. Furthermore, climate change scenarios were not considered when developing these models. Difficulties associated with experimentally determining timing of endodormancy break and a lack of understanding of the physiological mechanisms regulating it hinder the development of accurate models.

We developed cultivar-specific bud break models for a range of commercially important apple varieties, using excised shoots, potted plants and orchard trees. Between 70-93% of the variability in time of bud break is explained by the models developed. Models were selected based on AIC (Akaike information criterion) and indicated that time of bud break declined curvilinearly with increased chilling and linearly with increasing spring temperature, whilst the impact of spring temperature declined linearly with increased chilling. Additional experiments are being carried out to investigate the dynamics of soluble sugars and starch conversion during dormancy. We anticipate that these will provide valuable information on the dormancy status of trees throughout winter.

These models provide the basis for a more predictive understanding of the effects of climate change variables on the phenology of contrasting apple cultivars; a key factor to consider for cultivar selection.

## ENVIRONMENTAL PHYSIOLOGY SESSION 2

**ROSA: 55**

**PRESENTER: Grechi, Isabelle (SP7)**

**TITLE: Pruning intensity and severity affect flowering processes in the mango tree**

### ABSTRACT:

Pruning is one of the most important management practices for the mango tree, and it is known to affect vegetative growth. Pruning may affect mango tree flowering as well, at least indirectly, as close relationships exist between vegetative growth and mango reproduction. The objective of this study was to quantify the effects of pruning on flowering. An experiment was conducted in 2016 in Reunion Island on adult mango trees, cv. Cogshall. Pruning was applied after harvest and characterized by pruning intensity (defined as the amount of fresh biomass removed per unit volume of canopy) and pruning severity (defined as the distance between the distal end of the branch and the pruning point). Vegetative growth was recorded on 30 pruned and 30 unpruned terminal growth units (GUs) per tree. After vegetative growth and the resting period, flowering was described, in terms of occurrence, intensity and dynamics, on five populations of terminal GUs characterized by their age and origin (initial pruned and unpruned GUs that did not grow after pruning, or daughter GUs stemmed from them after pruning). Flowering occurrence, intensity and dynamics were affected by the population of GUs and by pruning intensity and severity. For instance, flowering probability on daughter GUs produced on pruned GUs increased with pruning intensity and decreased with pruning severity. Moreover, some terminal GUs produced on pruned or unpruned GUs of pruned trees flowered late, leading to a second flowering event. Finally, the results showed that pruning affects mango tree flowering through the proportion and flowering ability of the different populations of GUs within the canopy generated by pruning. As a next step, vegetative and flowering responses to pruning at the GU scale may be integrated into a functional-structural mango tree model to further analyze their complex effects and interactions at the tree scale.

## ENVIRONMENTAL PHYSIOLOGY SESSION 2

**ROSA: 117**

**PRESENTER: Belhassine, Fares (SP8)**

**TITLE: Modelling floral induction on 3D structures by simulating transport of inhibiting and activating signals and their combined effects on apple trees**

**ABSTRACT:**

Floral induction (FI) in shoot apical meristems (SAM) is assumed to be triggered by environmental and endogenous signals. In fruit trees, FI occurs in some SAM only and could be determined by antagonistic and endogenous signals, either activating or inhibiting that are assumed to originate from leaves and fruit, respectively. We developed a model to quantify on 3D structures the combined impact of such signals and the distances at which they act on SAM FI. Signal transport was simulated considering an 'attenuation' parameter, whereas SAM fate was determined by probability functions depending on signal amounts. Model behaviour was assessed on simple structures before being calibrated and validated on a unique experimental dataset of 3D digitized apple trees ('Golden delicious') with contrasted crop loads and subjected to leaf and fruit removal at different scales of tree organization. Model parameter estimations and comparisons of the two signal combination functions led us to formulate new assumptions on the mechanisms involved: (i) the activating signal could be transported at shorter distances than the inhibiting one (roughly 50 cm vs 1m) (ii) both signals jointly act to determine FI with SAM being more sensitive to inhibiting signal than activating one. Finally, the genericity of the model is promising to further understand the endogenous physiological and architectural determinisms of FI in fruit trees.

## ENVIRONMENTAL PHYSIOLOGY SESSION 2

**ROSA: 70**

**PRESENTER: Müller, Anton (SP9)**

**TITLE: The effect of evaporative cooling on yield and flower bud retention during spring of three pistachio cultivars (*Pistacia vera* L.) in a climate with moderate winter chilling and high spring temperatures**

**ABSTRACT:**

Evaporative cooling of three pistachio (*Pistacia vera* L.) cultivars in Prieska (29° 40'S, 22° 45'E, 945 m.a.s.l), South Africa was used to counteract potential negative effects of high maximum day temperatures during autumn and spring on flower bud retention, fruit set and yield. Cooling during autumn (May + June, Southern Hemisphere), spring (August + September, Southern Hemisphere) and the combination of autumn + spring were investigated during two seasons. Flower bud retention during winter and early summer, flowering patterns, as well as yields were evaluated. Each cultivar's autumn cooling treatment flowered consistently first and spring cooling last. Cooling effects on flower bud retention were only found during and after anthesis for all three cultivars. Autumn + Spring cooling resulted in commercial yields for 'Ariyeh' and 'Shufra'. The improved yields obtained with evaporative cooling indicates the important role weather conditions play during entering and exiting dormancy of pistachio nut trees. Although some effects obtained are not easy to explain, the fact that evaporative cooling resulted in substantial yield in an area with sub-optimal pre-blossom temperatures and less than 40% of the required winter chill of pistachios; its potential in postponing flowering, thereby avoiding late frost, emphasized its potential in orchard management.

## ENVIRONMENTAL PHYSIOLOGY SESSION 2

**ROSA: 118**

**PRESENTER: Crane, Omer (SP10)**

**TITLE: Coping with global warming effects on reduced winter chilling for deciduous fruit trees**

### ABSTRACT:

Deciduous fruit trees require exposure to chilling during their dormancy prior to their bud break. This environmental requirement was developed by evolution to allow these trees to endure the low winter temperatures in temperate climates. The dormant organs can survive even under extreme low temperatures. Chilling requirement was developed as a means of protection against accidental exposure to high temperatures before winter was over, thus preventing premature bud break. With global warming, duration and depth of chilling is gradually reduced, leading to levels where the chilling requirement will not be met as in the past. In subtropical weather, like that of Israel, such conditions exist. Clearly breeding low chilling requiring cultivars is the best way to cope with this situation. Nevertheless, the desire to grow existing high-quality cultivars led to find ways to compensate for lack of chilling and get good bud break despite limited exposure to chilling. In Israel for the last 30 years, hydrogen cyanamide -Dormex is commercially used to break dormancy side by side with mineral oil and Meptyldinocap. Due to shown human toxicity there is a strong demand to replace Dormex by other nontoxic chemicals. During the last 6 years we have identified chemical means to compensate for part of the lacking chilling in apple, pear, peach and cherry trees. The chemicals were based either on Oil emulsion (EW) with the addition of Thidiazuron (C<sub>9</sub>H<sub>8</sub>N<sub>4</sub>O<sub>5</sub>) (TDZ), Meptyldinocap (Dinocap) in oil emulsion with and without TDZ or Ammonium Nitrate sprayed with Armobreak (alkyl amine polymer) as adjuvant. In the apple it both the nitrate treatment with Armobreak and TDZ had a strong dormancy breaking effect. In pear it seems that the Nitrate and armobreak treatment equaled the Dormex treatment while TDZ had a somewhat negative effect. High TDZ caused damage to flower buds while nitrate and Armobreak had a too weak effect. Best treatments were lower TDZ levels and oil emulsion (In Dino TDZ and in Pick-up). In peach, we got similar results of bud break and yields in the Dormex, AN, and AN TDZ treatments indicating we have a good substitute to the Oil-Dormex treatment. In cherry nitrate and Armobreak improved fruit set in compare to dormex treatment but delayed fruit ripening. In the cherry cultivar 'Royal Down' the lack of chilling reduced yield but did not influence bud break. Yield lost was due to low fruit set although flowers did not show abnormalities and pollen tube germination did not differ between different chilling treatments. Therefore, we assume that other, yet unknown factor influenced by chilling is correlated to fruit set in cherry trees.

Monday 26<sup>th</sup> July 2021

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 114**

**PRESENTER: Cheng, Lailiang (K2)**

**TITLE: Apple flower development and pollen tube growth in relation to sorbitol**

**ABSTRACT:**

Flower development and pollen tube growth are essential for fruit set and growth of apple. Although it is generally understood that carbon supply provides energy and building blocks for these developmental processes, it remains unclear if sugars, particularly sorbitol, the primary photosynthate and transport carbohydrate play any specific role. We found that transgenic 'Greensleeves' apple trees with antisense repression of ALDOSE-6-PHOSPHATE REDUCTASE had abnormal stamen development, poor pollen germination and reduced pollen tube growth, which were all closely related to lower sorbitol levels in stamens. MdMYB39L, a MYB transcription factor, was identified as a key player in sorbitol-modulated stamen development and pollen tube growth by activating the expression of its downstream target genes involved in sugar uptake, cell wall formation and modification, and microsporogenesis. One of such genes was found to encode a sugar transporter that takes up both sucrose and hexose for pollen tube growth in response to sorbitol. Addition of sorbitol during in vitro pollen tube growth of the transgenic pollen with reduced sorbitol partially restored pollen tube growth, and exogenous application of sorbitol during flower development partially rescued stamen development and pollen tube growth of the transgenic trees by enhancing MdMYB39L expression. The effect of sorbitol on apple pollen tube growth cannot be replaced by equal molar concentration of sucrose or hexoses. Taken together, these findings indicate that sorbitol serves as a sugar signal in regulating apple flower development and pollen tube growth.

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 83**

**PRESENTER: Reginato, Gabino (SP11)**

**TITLE: Fruit size and yield efficiency of 'Fuji' apples grown in Chile depend mainly on winter temperature and weather before harvest**

**ABSTRACT:**

The yield and size of the fruit in apple trees depend on source-sink relationship, which is managed through agronomic practices, such as pruning, girdling and fruit thinning, but also depend on the relationship tree-environment, which is generally less reported, in part because it is not easy to study. The objective of this study was to associate the yielding behavior with weather conditions elapsed since postharvest of the previous season up to the harvest of the current season. The data was taken from 11 thinning trials performed throughout the 2012-2019 seasons in 'Fuji' strains orchards located in central Chile (between 34 and 37 °S). Winter weather conditions were described by total radiation, and maximum (Tmax), minimum (Tmin) and average temperatures. Vegetative periods considered were postharvest (45 days) of the previous season, budbreak to bloom, 50 days after bloom, and periods of 50 to 40 days from early summer to preharvest; weather conditions (Rad, Tmax and Tmin) during all of them were integrated as carbohydrate yield using the MaluSim model developed by Alan Lakso, Cornell University, for apple trees. To standardized the fruit size and yield efficiency, it was discounted the effect of the crop load, expressed as fruits per intercepted PAR. The variability between trials was less explained by cultivar and a specific year, then, each location-year-cultivar was considered as a particular case. Among cases the yield efficiency adjusted by the crop load varied between 7.5 and 9.2 kg/m<sup>2</sup> PARi, being the fruit weight between 225.6 and 289.1 g. It was detected that the yield efficiency and the fruit weight were associated mainly to the average temperature during winter and on weather conditions during 40 days before harvest, being those cases with colder winters and higher carbohydrate yield prior to harvest the ones with the highest yield. Others variable that contribute to obtain greater yields were the period 50 days after petal fall and postharvest period, where weather condition that promote higher carbohydrate availability were desired. In this sense, to obtain the maximum yield potential in 'Fuji' apple, being a late harvest variety, the selection of the site should consider mainly the weather conditions during the winter and during the end of summer-beginning of autumn period.

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 214**

**PRESENTER: Stone, Cameron (SP12)**

**TITLE: Water use of sweet cherry under protected cropping systems**

**ABSTRACT:**

Protected cropping systems (PCS) reduce cracking of cherries due to late season rainfall events but understanding how the modified environment affects the whole growing system is lacking. The objective of this study was to investigate the mesoclimates created by PCS and effects on tree water use (TWU) compared to the standard practice of bird exclusion netting. During the 2019/20 season, weather stations and sap flow sensors were set up in 'Lapins' on Colt rootstock trained as a Spanish Bush under both a rain covered and netted block. Climate data (temperature, relative humidity, solar radiation) and sap flow measurements were taken every 30 minutes over the growing season. Average daily temperature and minimum RH levels were consistently higher under the covers (14.7 °C and 55.4%) compared to netted (13.9 °C and 51.9%). Solar radiation was reduced under the covered (12.9 MJ/m<sup>2</sup>/day) relative to the netted (13.9 MJ/m<sup>2</sup>/day) block. Average daily TWU across the growing season was 3.9 L/day for trees under rain covers compared to 12.2 L/day for trees under netting. The findings of this study will inform grower irrigation practices in the future.

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 69**

**PRESENTER: Moran, Renae (SP13)**

**TITLE: Shoot and flower bud cold temperature tolerance in three peach cultivars exposed to four days of warm deacclimating temperatures**

### ABSTRACT:

Warm temperature in winter and late spring can lead to premature loss of hardiness in peach shoots making them vulnerable to subsequent freezing temperatures. On 14 Feb. 2019, 30 shoots from 3 peach cultivars, Bailey, Starfire and Harrow Beauty were exposed to 4 days at 17 °C or to -6.7 °C as a control. Shoots were recut under water and placed in plastic buckets with water during the deacclimation period. On 18 Feb., shoots were placed in a programmable freezer set to -5 °C for 17 hours at which time a set of shoots was removed, 3 shoots per treatment and cultivar. The temperature was decreased at a rate of 5 °C per hour and held at a designated temperature for 1 hour at which time another set of shoots was removed. Treatment temperatures were -10, -15, -20, -25 and -30 °C. Following removal from the freezer, shoots were placed in cold storage for 2 days at 5 °C followed by two days at 17 °C. Oxidative browning of shoot tissues was rated on a scale of 0 to 10 with 10 indicating 100% of the tissue with browning, and on a scale of 0 to 5 with 5 indicating severe discoloration (darkest brown). Flower bud survival was measured as percentage of living buds per shoot. The inflection point of a nonlinear regression was estimated as the lethal temperature with a 95% confidence interval to determine treatment differences.

Flower buds in each cultivar deacclimated by 5 to 6 °C after 4 days of warm temperatures. The lethal temperature (LT) for flower buds in shoots not deacclimated was similar among the 3 cultivars, and in the range of -24 to -26 °C. The LT in deacclimated shoots was -20 °C for 'Bailey' and 'Starfire', significantly colder than for 'Harrow Beauty', -18 °C. Xylem hardiness in 'Bailey' was hardy to -25.6 °C and was unchanged after 4 days of warm temperatures. 'Starfire' xylem lost 3.5 °C of hardiness from -28.5 to -25.0 °C. 'Harrow beauty' xylem injury occurred at -25.5 in both treatments, but a greater degree of xylem injury (100%) occurred in deacclimated shoots compared with the control (70%) at -30 °C. 'Bailey' had the greatest cambial hardiness, -30 °C, and this decreased to -25.5 °C after 4 days of deacclimation. Cambium in 'Starfire' was hardy to -18 °C in both treatments, but a greater degree of injury (100%) occurred at colder temperatures in deacclimated shoots compared with the control (40%). In 'Harrow Beauty', the cambium was hardy to -20 °C with no difference between the two treatments and nearly 100% injury at -30 °C. In phloem tissue of 'Bailey', no injury occurred in either treatment at temperatures as cold as -30 °C. In 'Starfire', cambium was hardy to -30 °C in control shoots, and partial injury occurred at -17 °C in deacclimated shoots with no increase at colder temperatures. The cambium in 'Harrow Beauty' was partially injured (25%) at -19 °C in control shoots and -17 °C (40%) in deacclimated shoots, with no further increase at colder temperatures. Results indicate that genotypic differences occur in loss of shoot hardiness, but not in loss of flower bud hardiness.

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 169**

**PRESENTER: Whiting, Matthew (SP14)**

**TITLE: A precision pollination system for yield security in tree fruit**

### ABSTRACT:

Tree fruit production could not exist without the temporary introduction of pollinators (predominantly *Apis mellifera*) and utilization of pollinizer trees dispersed orchard wide. Despite the importance of pollination, tree fruit growers continue to utilize this archaic pollinator + pollinizer system that is particularly fraught with variability. Facing global decline in pollinators, climate change, and the myriad perennial challenges growers face with the pollinator + pollinizer model, we are investigating artificial, precision pollination systems. This presentation describes our vision for productive orchard systems in the absence of both insect pollinators and pollinizers, and results of field trials with our precision pollination system utilizing liquid pollen suspensions applied with electrostatic sprayer technology. Supplemental pollination (i.e., in the presence of pollinators and pollenizers) with a single application of pollen (ca. 37 g/ha) improved 'Tieton' sweet cherry (*Prunus avium* L.) fruit set by 15% compared to open-pollinated limbs. Fruit yield was similar for open-pollinated trees and those treated with two applications (at ca. 50% and 100% full bloom) of pollen suspensions through bee-exclusion netting deployed prior to flowering (i.e., in the absence of natural pollinators). Between 2016 and 2019, commercial-scale field trials in sweet cherry, apple (*Malus domestica* Borkh.), and pear (*Pyrus communis*) have revealed improvements in fruit set (+12 – 45%) and yield from both single and double applications of supplemental pollination at both 37 and 74 g/ha pollen. Our results suggest that artificial, precision pollination systems are effective for either supplemental or replacement pollination.

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 84**

**PRESENTER: Serra, Sara (SP15)**

**TITLE: Assessing 'WA 38' Pollination and Fruit Development**

### ABSTRACT:

'WA 38' ('Enterprise' × 'Honeycrisp') is considered a late apple variety (bloom at the end of April in WA) with optimal harvest time about three weeks after 'Honeycrisp' (late September - early October). The 'WA 38' tree is characterized by a self-thinning trait whereby most of the fruitlets abscise following a profuse bloom, and usually only one or two fruitlets set in an inflorescence. For this reason, adequate pollination becomes crucial to fruit set and consistent production. Hence, there is a need to understand the effective pollination period (EPP) for the variety and to find viable and genetically compatible pollinizers to overlap with 'WA 38' bloom window. The main objectives of this study were to assess the EPP in 'WA 38' king flowers (stigmatic receptivity-pollen tube growth-ovule longevity), test the pollen tube growth of 5 compatible pollinizers ('Snowdrift', 'Evereste', 'Mt Blanc', 'Indian Summer', 'Granny Smith') suitable for the variety and investigate natural fruitlets shedding for 100 clusters, fruit growth and seed set after harvest. EPP for 'WA 38' king flowers lasted 2 days in 2019 and the stigmatic receptivity was not a limiting factor. Regarding the different compatible pollen sources used to hand-pollinate 'WA 38' flowers, few differences in pollen tube growth kinetics were observed and all pollen tubes were able to reach the base of 'WA 38' styles between day 4 and 5 after pollination. Tracking clusters from pre-bloom to harvest shed light on the natural shedding of 'WA 38': after 8 weeks from full bloom, the fruit drop ceased with 17% of total fruitlets retained on trees and 83% dropped. Moreover, 51% of clusters ended up holding a single apple (that for the 78% of the cases was originated by a king flower), while only 12 % of the clusters bore two apples and 35% resulted unfruitful.

## ENVIRONMENTAL PHYSIOLOGY SESSION 3

**ROSA: 134**

**PRESENTER: Roeder, Stefan (SP16)**

**TITLE: Standardization of in vitro bioassay to assess the pollen germination and tube growth performance in apples**

**ABSTRACT:**

In vitro assays have been used since the early 1900's to assess the performance of apple pollen. Over decades, researchers have optimized different aspects of those bioassays, resulting in a variety of different protocols. Because of those various methods, results from different studies might not always be comparable. A standardized assay would be beneficial in order to allow for an unbiased comparison between multiple studies across several apple cultivars and pollinizers. The aims of this research were twofold. Firstly, to evaluate the variability of in vitro pollen germination protocols specifically for apple, by performing a critical literature review and analyzing import features such as the research subject, research design and the composition of the germination media. Secondly, to screen the pollen tube performance of 45 individuals at different temperatures. Minimum, average, and maximum pollen tube length at different temperatures were calculated for each individual, and K-means clustering was used to group the individuals based on their performance pattern. Principle component analysis was utilized to reduce the dimensionality and to visualize the data. A literature review of publications on in vitro pollen germination in apples, published from 1909 to 2019, showed that over 180 individuals have been screened on more than 50 different germination medias. So far, it seems that apple pollen does not require calcium nitrate, magnesium sulfate or potassium nitrate in order to achieve high germination rates. The 45 individuals investigated in our research were clustered into three performance groups. The average pollen tube length of all cluster 1 cultivars was 583  $\mu\text{m}$  at 15 °C and 910  $\mu\text{m}$  at 25 °C. This was significant longer than the length of cluster 2 cultivars which grew 378  $\mu\text{m}$  and 657  $\mu\text{m}$  at 15 and 25 °C, respectively. Cluster 3 contained two triploid cultivars ('Adirondack', 'Jonastar') which were used as control.

## TRAINING SYSTEM SESSION 1

**ROSA: 173**

**PRESENTER: Robinson, Terence (K3)**

**TITLE: A Re-examination of the Physiological Basis of Orchard System Performance with Respect to Light Interception and Light Conversion Efficiency**

**ABSTRACT:**

In 1991 we published a study on the physiological basis of orchard system performance which showed that 86% of the variation in orchard system cumulative yield was explained by the amount of light (MJ) intercepted by the canopy and 11% was explained by the efficiency of converting light energy into fruit (g/MJ). Others showed that yield was more closely related to light interception of spur leaves than light interception by shoot leaves. Early orchard yield during the development years is also related to the amount of light energy intercepted, thus over the lifetime of an orchard the cumulative light interception by the spur canopy becomes the most important variable in explaining cumulative yield. The amount of light intercepted by the canopy is controlled by tree shape (V vs vertical) and the ratio of tree height to between row spacing while the efficiency of energy conversion to fruit is controlled by several factors including rootstock, tree vigor, pruning severity, crop load and climate. In recent years new training systems, rootstocks and pruning systems have been developed but often they have not been evaluated rigorously with respect to early life and lifetime light interception and conversion efficiency. In the last few years we have attempted to evaluate new training systems on the basis of early and lifetime light interception and conversion efficiency. We have also attempted to evaluate rootstocks not only on the basis of yield efficiency but also on the basis of light interception. Results from our work show that early life light interception is tightly related to tree planting density and any system such as multi-leader or cordon systems that uses lower tree density as a way to reduce costs also has lower light interception than higher tree densities. Our work also shows that V shaped canopies intercept more light than vertical canopies. The lower light interception of vertical wall systems can be partially overcome by increasing tree height of vertical canopies. Another result has shown that efforts to produce narrow fruiting walls (2-dimensional canopies) result in lower light interception and a yield penalty compared to 3-dimensional canopies unless between row spacing of the 2-dimensional system is reduced beyond currently acceptable row spacings. Rootstock is the major factor influencing conversion efficiency but in some cases rootstocks with high conversion efficiency don't have high light interception at a given spacing and thus have lower cumulative yield. These physiological realities must be considered in evaluating systems and rootstocks and future studies should include measurements on light interception and conversion efficiency. Lastly, we believe climate affects conversion efficiency and suggest an international study to evaluate the effect of climate on both light interception and conversion efficiency.

Tuesday 27<sup>th</sup> July 2021

## TRAINING SYSTEM SESSION 1

**ROSA: 174**

**PRESENTER: Iglesias, Ignasi (SP17)**

**TITLE: Developing high-density training systems in Prunus tree species for a sustainable and efficient production**

**ABSTRACT:**

In Spain the total surface occupied in 2018 by deciduous fruit species and almond accounted for 875,913 million ha, ranking the first position in Europe. Making fruit tree production economically and ecologically sustainable is the main challenge for future orchards. Sustainable production requires an efficient use of inputs, in particular labour, water, fertilizers, herbicides and pest and diseases control to reduce the cost of production. Economically sustainable production requires early and high-quality yields in order to recover as soon as possible the initial investment. Intensification is required to achieve these objectives, but also to get an easier orchard management and a more efficient use of inputs. In addition, planar canopies result in a better sunlight distribution into the canopy improving fruit quality, providing better accessibility to labour, allowing partial or total mechanization, resulting also in a better efficiency of treatments in terms of coverage and drift reduction. SHD (Super High Density) training system or hedge, started to be developed in Spain 25 years ago by Agromillora in olive trees and 10 years ago in almond trees, peaches and plums. This hedge system allows in almond, plum trees for drying and peaches for canning graded on Rootpac-20 and almost a full mechanization of pruning and harvest, the main cost of production. In peach intensification has been possible thanks to the use of dwarfing and semi-dwarfing rootstocks as the ones from Rootpac series (Rootpac-20, Rootpac-40, Rootpac-R) from Agromillora. Combining intensification with planar canopies allowed to get in the 3rd year from 70 to 100 t/ha cumulative yield with a reduction of production cost around 30%, compared to traditional open vase.

## TRAINING SYSTEM SESSION 1

**ROSA: 122**

**PRESENTER: Lodolini, Enrico Maria (SP18)**

**TITLE: Damages induced by an over-the-row harvester in ten varieties in a high-density olive orchard**

**ABSTRACT:**

The damages induced by an over-the-row harvester were studied in 10 olive varieties in a high-density orchard (1,250 trees ha<sup>-1</sup>) planted in 2011 in Central Italy. 'Maurino', 'Sargano di Fermo', 'Ascolana tenera', 'Rosciola', 'Piantone di Mogliano', 'Piantone di Falerone', 'Arbequina', 'Tosca<sup>®</sup>', 'Don Carlo<sup>®</sup>' and 'FS17<sup>®</sup>') were harvested by a tow-behind machine in 3 consecutive years (2016, 2017 and 2018). Trees were pruned with a conical shape since planting removing too long branches perpendicularly to the row. The canopy average height ranged from 2.88 ±0.32m to 3.3 ±0.20m and the transversal diameter (perpendicular to the row) from 1.78 ±0.24m to 2.4 ±0.20m in 2016 and 2018, respectively. The damages (hurts and breakings) were monitored in twenty homogeneous trees per cultivar at the end of the harvest. 'Maurino' and 'Arbequina' were averagely less damaged compared to the others studied varieties, whereas 'Don Carlo<sup>®</sup>' and 'FS17<sup>®</sup>' showed a higher number of hurts and breakings. However, the different growth evolution of the canopy during the three years affected the susceptibility to damages of the cultivars. Results are discussed to identify most and least damaged cultivars and to detect architectural predictors to classify them according to their susceptibility to damages. This study supplies useful information on the adaptability of local, national and international olive varieties to high-density plantation and their suitability to over-the-row mechanical harvest.

## TRAINING SYSTEM SESSION 1

**ROSA: 171**

**PRESENTER: Meland, Mekjell (SP19)**

**TITLE: Determination of suitable high-density planting systems of 'Celina' pears in a Nordic climate**

### ABSTRACT:

An intensive planting of 'Celina' pears grafted on quince 'Adams' was established in May 2015 at the experimental orchard at Nibio Ullensvang, western Norway (lat. 60°19'8.03"N, long. 6°39'14.31"E). The Norwegian newly bred pear cultivar, Celina/QTee® ('Colorée de Juillet' x 'Williams'), which was launched in 2010, has been released from the Norwegian breeding program Graminor. It has large attractive fruits with red blush and planted in many countries. Five different training systems (super spindles, V-hedge of trees with two leaders perpendicular and parallel to the row directions, slender spindles and V-hedge of trees with 4 leaders) were evaluated in this study. Row distance was 3.5 m and planting distance was 1.0 m except for super spindle trees and V-hedge with two leaders perpendicular (0.5 m). Cultivars 'Anna' and 'Fritjof', used as pollenizers, were evenly distributed in the orchard. In order to have better establishment, the trees were headed back in winter 2016 when the formation of the five different tree training systems was started. The first fruits were harvested in 2018. Due to the unfavorable pollination conditions, the fruit set in 2018 was very low. Average yields varied between 2.7 t/ha for the super spindle trees to 8.7 t/ha for the spindle trees. As a result of ample flowering and optimum pollination conditions, fruit set in 2019 was excellent and average yields varied between 18 t/ha for the 2-leader trees planted parallel to the row direction to 47 t/ha for the 2-leader V-hedge trees. Fruit size was inversely related to number of fruit number per tree. Fruit weight depended on crop load per canopy volume and varied between 130 g for the two smallest trees (super spindles and 2-leader V-hedge system) and 180 g for the 2-leader trees planted parallel to the row direction. The soluble solid contents of all pears tested were high (11% in average) and no differences between the training systems. At present the spindle trees and V-hedge with 4 leaders per tree seems to be the most profitable systems, since both yields were only 16% less as that of the super spindle and 2-leader V-hedge system with twice the number of trees planted per hectare.

Tuesday 27<sup>th</sup> July 2021

## TRAINING SYSTEM SESSION 2

**ROSA: 126**

**PRESENTER: Raffo Benegas, Maria Dolores (SP20)**

**TITLE: New planting systems to increase apple orchard profitability: preliminary results in Argentina**

### ABSTRACT:

Apples and pears are the main fruit production of the north Patagonian valleys. A large number of training systems suitable to be mechanized (pruning, thinning, use of platforms), are used in different fruit growing areas, according to improve yield and precocity. As results depend on environmental conditions, local studies are needed to compare the performance of different training systems in Argentina. The aim of the study was to compare four training systems (central axe, 4 axes obtained by headed back at plantation time, and 2 axes and “multileaders” obtained by bending trees) in ‘Washington Spur’, ‘Brookfield’ and ‘Rosy Glow’ apple trees. The plot was planted in an orchard located in Rio Negro, Argentina in June of 2016 at 3.5 m row space, and different distances between trees according to the variety rootstock combinations (0.5, 1.0, 1.5 and 2 m). Light interception yield as well as fruit size and maturity indexes were recorded on each cultivar. Efficiency of the use of labor will be assessed in pruning, thinning, training and harvest. In 2018-19 season, the highest yield was observed in central axe at 1.0 m (2941 plants ha<sup>-1</sup>) in ‘Brookfield’/EM9 and ‘Rosy Glow’/EM9 (16.3 and 23.7 t ha<sup>-1</sup> respectively), and at 0.5 m (5882 plants ha<sup>-1</sup>) in ‘Washington Spur’/MI793 (15.7 t ha<sup>-1</sup>). Interestingly, bending trees to obtain more than one axis reduced production only in ‘Brookfield’. As expected, heading back the trees at the time of planting delayed production in all cultivars.

## TRAINING SYSTEM SESSION 2

**ROSA: 176**

**PRESENTER: Lang, Gregory (SP21)**

**TITLE: Experimental canopy training effects on peach/nectarine vigor advance planar training system development as well as evaluation and adoption of vigor-limiting rootstocks**

### ABSTRACT:

Initial trials (planted 2011) of alternative canopy architecture training techniques for nectarines identified Super Slender Axe (SSA) dormant short-pruning and summer hedging as promising methods for maintaining high density, compact trees that are more labor-efficient for fruit thinning. The SSA short-pruning reduced potential crop load before bloom and simplified post-bloom hand-thinning. Three next generation trials were established in 2017 at the MSU Southwest Michigan Research and Extension Center to examine the interactions between leader number and SSA-style short dormant pruning and summer hedging of trees on standard vigor (seedling) rootstocks. One 60 m row of 'Sunglo', 'SilverGem', and 'Jade' nectarines was planted at a 1 m tree spacing for single leader trees and another row was planted at a 2 m tree spacing for dual-leader (bi-axis) trees, resulting in an equal number of SSA-trained leaders per row (although each row is a separate experiment). Replicated treatments of three summer hedging times were imposed on each row. The first potential crop was lost to winter bud damage in 2019; in the absence of a crop, leader heights were similar, demonstrating comparable development even with different tree spacing and leader number, and timing of hedging. The most extensive trial consists of five 55 m rows of multi-leader SSA-trained trees with 'Fantasia' nectarine. Five training treatments – 1, 2, 4, 6, and 8 SSA-trained leaders (corresponding to tree spacings at 1, 2, 2, 3, and 4 m, respectively) – were imposed with 5-tree plots and 5 randomized complete block replications. The first potential crop was lost to winter bud damage in 2019; in the absence of a crop, treatment effects on diffusion of tree vigor are clearly apparent and directly proportional to tree spacing and leader number, as measured by tree trunk cross-sectional area, individual leader cross-sectional area at 1.5 m above the ground, and individual leader height. For all three trials, data for canopy training treatment effects on flowering, fruit set, hand-thinning labor, and annual replacement shoot formation will be taken in spring 2020 and reported.

## TRAINING SYSTEM SESSION 2

**ROSA: 96**

**PRESENTER: Fallahi, Esmail (SP22)**

**TITLE: Tree Spacing, Architecture, and Branch Configuration Impacts on Growth, Yield, Fruit Quality, and Leaf Minerals in 'Aztec Fuji' Apple over Five Years**

### ABSTRACT:

Tree architectures, in-row spacing, and branch configuration play critical roles in the productivity and fruit quality of high-density orchards. To understand the impacts of these factors, two separate experiments were conducted at the University of Idaho Parma Research and Extension Center, each over five years. In Study 1, effects of two tree spacings at 0.46 x 3.66 m and 0.91 x 3.66 m and two branch configurations consisting of Overlapped Arm (OA) and Tipped Arm (TA) in a Tatura trellis system on tree growth, yield components, fruit quality attributes and leaf minerals in 'Aztec Fuji' apple (*Malus domestica* Bork.) on Budagovsky 9 (Bud 9) were evaluated during five years in 2012-2016. In this study, trees spaced at 0.91 x 3.66 m had significantly greater trunk cross sectional area (TCSA), yield per tree, yield efficiency crop efficiency, fruit color, russet, soluble solids concentration (SSC), and water core but lower bitter pit and leaf potassium (K) concentration than those planted at 0.46 x 3.66 m. Trees with a TA configuration had larger TCSA and larger fruit than those with an OA training. In Study 1, no significant difference was found between TA and OA trainings in yield or other fruit quality attributes and no interaction existed between years and either trees spacing or branch configurations. In Study 2, the impact of three branch configurations, consisting of Tall Spindle (TA) and OA on the same yield, quality and mineral parameters as Study 1 were evaluated in an upright single-row high density 'Aztec Fuji' apple on Bud 9 rootstocks over 2012-2016. This study revealed that trees trained into a TS had larger TCSA than those with an OA system. Trees receiving a TA training had lower biennial bearing index between all consecutive years. In Study 2, trees with an OA training had smaller fruit than those with either a TA or TS training in all years. In this study, training systems did not have any effect on fruit color, SSC, or starch degradation pattern at harvest. However, fruit from trees with an OA training had higher firmness and lower water core than those from trees with a TS or TA training. In Study 2, leaves from trees receiving a TA training had greater leaf area, fresh weight, K and magnesium (Mn) concentrations than those with other trainings. Leaves from trees receiving an OA training tended to have higher concentrations of Fe, Zn, and Cu than those from other trainings. Overall, training branches into a TA seem to be preferred over an OA system.

## TRAINING SYSTEM SESSION 2

**ROSA: 30**

**PRESENTER: Kallsen, Craig (SP23)**

**TITLE: Conceptions of a Novel Crop Ideotype for Pistachio Production in the San Joaquin Valley (SJV) of California**

### ABSTRACT:

A crop ideotype is defined as a conceptual model incorporating observed plant phenotypic characteristics into a model cultivar and crop production system designed for increased profit. Breeding for crop ideotypes, generally, has been limited to annual and forest tree crops. However, the concept is applicable to pistachio, where both the phenotypic characters of the rootstock and the scion, along with complementary production practices such as irrigation and plant density, are combined into a model crop ideotype. An ideotype is designed for a specific environment and a number of ideotypes could be successful in a given area depending upon specific goals. In the SJV, trees in pistachio orchards are planted using a female scion grafted to a vigorous rootstock. These vigorous rootstock and scion combinations require extensive tree training and pruning to remove suckers (rootstock overgrowth) and form scaffolds suitable for machine harvesting. Pistachio trees are not precocious. Often, to maximize early nut yields, trees are planted too closely, relative to their vigor. A dense planting of vigorous trees ensures that pruning costs, necessary to maintain trees within an allotted space for machine harvest and for free access of equipment into the orchard, will remain high for the life of the orchard. Also, vigorous growth produces large trees that become increasingly difficult to shake with time. A model crop ideotype is proposed for the southern SJV based on phenotypic characters observed in both rootstock and scion selections from the U.C. breeding program. This model crop ideotype includes the following: high tree density, potential rootstocks and scions that each constrain vegetative growth and produce smaller trees yet produce comparative per hectare nut yield within a full irrigation and nutrition program. Comparative data are presented comparing some phenotypic characters of standard industry trees with possible selections for the proposed crop ideotype.

Tuesday 27th July 2021

## ORCHARD MANAGEMENT SESSION 1

**ROSA: 153**

**PRESENTER: Girona, Joan (SP24)**

**TITLE: Growth sensitivity of young almond trees to water deficits: Quantifying the dependence and Verifying the effects on yield on subsequent years**

**ABSTRACT:**

Water deficit is one of the most limiting factors on plant growth. Consequently, those crops whose final yield is highly dependent on canopy volume, will have a significant reduction in their yield under water deficit. That is the case of almond trees. However, the effect of water deficit on canopy volume of young almond trees has not been quantified being extremely difficult to forecast the negative impact of water deficit during early stages of tree development on subsequent years. The lack of information may be related with the fact that young almond trees are not still producing yield but it can be hypothesized that a significant lost in canopy volume during early stages of almond growth may affect yield in the following years. The aim of the present work was first to quantify the effect of different water deficit levels applied for a period of six months (from May to September) on tree canopy volume for two-year old "Vairo" almond trees grown in a semi commercial orchard in Lleida (Spain). The levels of water deficit were decided to obtain a continuous range of midday stem water potential between -0.9 MPa (no deficit) and -2.0 MPa (severe water stress) in several trees of the orchard. A second objective was to define thresholds midday stem water potential for optimal irrigation in young almond orchard. to develop this information, besides canopy volume, irrigation applied water, soil water content, stem and leaf water potential, stomatal conductance and net CO<sub>2</sub> assimilation rate was exhaustively evaluated during the experimental period (from daily to 15 days controls). The third objective was to verify is the short-term model identified in these six months is robust enough to forecast plant growth on the following years. The results helped quantifying the sensitivity of young almond trees growth to water deficits and to, predict growth and yields in subsequent years for different scenarios that can be expected in growing areas with limited water availability. As main conclusion it can be said that it is extremely important to maintain midday stem water potential above -0.9 MPa to avoid any potential lost in canopy size during early tree development.

## ORCHARD MANAGEMENT SESSION 1

**ROSA: 31**

**PRESENTER: Andergassen, Christian (SP25)**

**TITLE: Mechanical defoliation of apple trees for colour improvement**

**ABSTRACT:**

Bicoloured apple cv. quite commonly are affected by a lack of red colouration, especially on the bottom part of the trees. Different treatments, such as manual leaf removal, summer pruning or reflective white woven mulch cloth, for example Extenday™, have proven their potential of improving the skin colour of apples. The objective of the present work was to examine the effect of mechanical leaf removal on skin colour improvement of the bicolored apple cv. Nicoter/Kanzi® and Cripps Pink/Pink Lady®. For this purpose, different trials with a pneumatic leaf blower built by Olmi (Italy) were conducted in two commercial orchards at the Research Center Laimburg near Bozen (Italy) in autumn 2018 and 2019. The first results were very promising, depending on cv. and year. Trees treated with the mechanical leaf blower reached a yield of 90.1% of first quality fruit, whereas the untreated control only reached 53,3%. This brought in some cases a financial net gain of 11,999€ ha<sup>-1</sup>. No differences in ripening and starch breakdown were observed in the different trials, however, some minor effects on fruit size were detected.

# ORCHARD MANAGEMENT SESSION 1

**ROSA: 211**

**PRESENTER: Blanke, Michael (SP26)**

**TITLE: Colour improvement under hail net with reflective mulches - light distribution and its visualization**

**[Reflective mulch promotes fruit colouration ' visualisation of results]**

**ABSTRACT:**

This contribution summarises many years of research on reflective ground covers in order to improve fruit colouration in an orchard. The majority of experiments concentrated on apples, using poorly colouring varieties such as Braeburn Hilwell, Pinova and Fuji. Potential applications, however, include particularly club varieties in such cases, where the required colour standards are not fulfilled e.g. with Pink Lady, Kanzi, Modi or Honeycrunch, or the fruit crop is grown under hail net and greater returns can be obtained from well-coloured fruit. Climate change with warm autumn nights also increasingly hampers fruit colouration. Apricot, peach, nectarine, red pear and kaki are also potential candidates. The underlying mechanism of fruit colour improvement in the autumn are a stimulation of anthocyanin synthesis, the PAL enzyme activity and the MdMYB 1 transcription factor/gene. The reflective fabric is hence spread in the alleyways 2-4 weeks prior to harvest, the time of the anthocyanin synthesis. The effectiveness of the white, woven polypropylene fabric such as Lumilys™ (Beaulieu Technical Textiles) is through diffuse light reflection from the ground cover in the alleyways into the tree canopy. Light measurements show a 3-4-fold increase in light reflection from the ground cover in comparison with uncovered grassed alleyway (control). The different and improved light distribution inside the tree with Lumilys™ is visualised in the talk by colour coding. The effect of the fabric is most pronounced on the inner and lower, otherwise greener side of the fruit and also eminent on cloudy days and can also reduce the number of picks. The Lumilys™ fabric comes with a 7-year warranty and is durable for at least 8 years. It can be used once or twice (early and late crop) a year, assigning materials cost of ca. US \$ 800 per hectare per spreading, where the profit margin can be calculated by their online tool.

## ORCHARD MANAGEMENT SESSION 1

**ROSA: 195**

**PRESENTER: Volder, Astrid (SP27)**

**TITLE: Almond and Walnut root population dynamics in response to irrigation and other management practices**

**ABSTRACT:**

Root, shoot, and vascular traits are tightly linked to expected survival and growth rate under drought conditions. The supply of water to and within plants is determined by soil water availability (water content and soil type), plant architectural traits (e.g., root:shoot ratio, root depth, root surface area, leaf area, tissue density), as well as axial and radial hydraulic conductance of the root system. Generally, there are tradeoffs between characteristics that confer stress resistance and those that allow a high physiological activity. Traits aimed at resource conservation that are beneficial under natural conditions may slow down productivity under orchard conditions. To complicate things, in commercial orchards scions are generally grafted on rootstocks with specific disease resistant traits with little understanding as to how scions may affect root traits and root population dynamics. We are collecting data for both almond and walnut trees growing under different irrigation regimes (ranging from drought to prolonged flooded conditions) to study both population dynamics and root traits. Preliminary data show that water availability affects total root production, but not the timing of root production. In general, in California, the vast majority of new roots were produced from March-June and we did not observe significant new root production in the Fall. We found that the scion affects carbohydrate storage in the roots, depending on the season when samples were collected. Orchard practices that reduced tree canopy size early in the season (e.g., heading at planting or heavy pruning) had a particularly negative impact on deep root production and in almonds had a stronger negative effect on root production than reducing irrigation by 30%.

## ORCHARD MANAGEMENT SESSION 1

**ROSA: 34**

**PRESENTER: Melgar, Juan Carlos (SP28)**

**TITLE: Tolerance of Peach Fruitlets to Late Spring Freezes**

**ABSTRACT:**

The genetic potential for freeze tolerance of peach remains unknown even though freezes are a major environmental limitation to stone fruit production. In this study, we used the electrolyte leakage method as a simulation tool for assessing the susceptibility of peach fruitlets to late spring freezes. We used fruitlets nearly a hundred accessions and cultivars of peach. Our results showed that there were accessions such as Cumberland and cultivars such as 'White Lady', 'Scarletpearl' and 'Raritan Rose' that had an increased freeze tolerance compared to most accessions and commercial cultivars. These results need to be confirmed with one more year of data, but these accessions and commercial cultivars are worth exploring as promising materials for breeding purposes.

Tuesday 27<sup>th</sup> July 2021

## TRAINING SYSTEMS SESSION 3

**ROSA: 80**

**PRESENTER: Tustin, Stuart (K4)**

**TITLE: Orchard systems for the 21st century: perspectives, considerations and critique**

**ABSTRACT:**

How should orchard systems evolve to meet the multiple demands for sustainable fruit production in the 21st Century? Constraints in fractional light interception currently limit orchard productivity and fruit quality because orchard layouts cause discontinuous leaf canopies. Yet extrapolated productivity-light interception responses show potential to markedly increase orchard productivity. Our studies of new apple narrow-row, two-dimensional planting systems for this purpose, have defined a new leaf area index (LAI): light interception response with an asymptote above 80% light interception at LAI of 3.5 – 4.5 and yields up to 167 t/ha by the sixth year. Overcoming this longstanding light utilisation barrier to higher productivity and fruit quality, alone, is a too simplistic perspective for sustainable orchard systems in a future of resource constraints. Yet the pomology and physiology enabling successful planar, narrow-row orchard designs provide a platform to examine orchard systems sustainability which considers total resource requirements alongside of environmental footprints, natural capital and ecosystem services, guides adaptation of digital and automation technologies and redefines labour demands of operations. The early experience in such considerations suggests innovation for greater sustainability depends on using simplified, narrow planar orchard canopies. Increasing orchard systems' biological potential (e.g. LAI: light interception relationship) also relies on planar canopies that reduce redundant leaf area and improve the light environment. A context for analysing orchard system sustainability is explored whereby the canopy standing dry mass represents the biological capital of the orchard system, and growth adds new capital. Orchard technologies cause responses with positive or negative effects on biological capital. 'Productivity x fruit quality' quantifies the investment return on capital. We discuss how such analysis can guide innovation towards system sustainability using examples from orchard design and light relations; hypotheses on orchard water use; pruning, training and growth responses; and applying emerging digital technologies and automation.

## TRAINING SYSTEMS SESSION 3

**ROSA: 13**

**PRESENTER: Stanley, Jill (SP29)**

**TITLE: Establishment of planar sweet cherry canopies using physiological principles**

### ABSTRACT:

New orchard growing systems for sweet cherry are being designed and tested with the aim of doubling productivity. This may be achieved by reducing row spacing to increase canopy light interception and using a planar canopy design to increase within-tree light transmission and minimise shading. Canopies are comprised of two opposing near-horizontal cordon axes, each with six upright shoots, planted at 3 m between plants and 2 m between rows. Rapid and uniform upright shoot development is required for successful system establishment. A mono-axis planar canopy system has previously been developed for cherry (Upright Fruiting Offshoots, or UFO), which encourages upright shoot development by selecting buds on the top of the cordon and removing all other buds along the cordon. The cordon apex is bent upwards to form the final upright shoot. We compared a modified version of UFO with a system designed following physiological principles (Planar Cordon), both on bi-axis trees. The Planar Cordon system involved tipping cordons when they reached the required length. Simultaneously, buds on the top of the cordon were removed but all other buds, which would photosynthesise and contribute to canopy development, were retained. The additional buds could also provide floral sites and alternative upright shoots if required. Some of these were trained downwards to form additional short shoots. Upright shoots that showed excessively vigorous growth were stubbed back to encourage uniform growth. Both systems resulted in a similar proportion of upright shoot development and similar upright shoot basal diameters after the second and third seasons from planting. We speculate that upright shoots arising from the top of the cordon in the UFO system may become unacceptably large earlier in the canopy life and require earlier renewal. A subsequent season of data will be presented.

## TRAINING SYSTEMS SESSION 3

**ROSA: 89**

**PRESENTER: Scofield, Claire (SP30)**

**TITLE: Relationships between light, yield and fruit quality of sweet cherries grown on narrow row, planar canopy systems**

### ABSTRACT:

Orchard productivity and yield potential is positively correlated with the seasonal fractional light interception of the mature tree canopy. Fruit quality is thought to be dependent on the proportional irradiance (light transmission) experienced by the tree's reproductive structures. New planting systems for cherry trees are being investigated in New Zealand, using designs that reduce inter-row distances to increase canopy light interception, aimed at increasing fruit yields. However, reduction of inter-row spacing introduces risks of reduced within-canopy light transmission. To improve light transmission within closer row spacing, narrow planar configurations were chosen for the trials. Trees were planted 3 m apart in the row and were comprised of two opposing cordons oriented along the row and positioned slightly above horizontal. Each cordon has six vertical, minimally branched, fruiting shoots spaced 25 cm apart, with an anticipated height of 3 to 3.5 m. In 2014, three cultivars of sweet cherry were planted at 2-m and 1.5-m inter-row spacings, in a replicated design of 4 blocks. In the 2018/19 season, fruit quality attributes in the upper and lower halves of fully developed vertical fruit stems in the planar cherry system were analysed for fruit size (mm diameter) and total soluble solids concentration (TSS, %). Both fruit size and TSS were higher from the upper canopy, although differences were not commercially significant. In the 2019/20 season, photosynthetically active radiation (PAR) at vertical positions within these canopies will be measured to better understand light transmission within planar canopy systems. The relationship between light, bud age, yield and fruit quality of sweet cherry grown in these systems will also be examined.

## TRAINING SYSTEMS SESSION 3

**ROSA: 4**

**PRESENTER: O'Connell, Mark (SP31)**

**TITLE: Crop load and canopy architecture effect yield and fruit quality of 'Golden May' Apricot**

**ABSTRACT:**

This study examined the effect of crop load and canopy architecture (Tatura Trellis, vase) on apricot yield and fruit quality at Tatura, Australia during three consecutive growing seasons. Crop loads were applied to induce a range of competitive source/sink responses between fruit and available assimilate. Discrete fruit thinning regimes were: (1) minimally thinned; (2) moderately thinned (commercial standard as control); and (3) heavily thinned. Larger canopy size (fPAR) occurred on Tatura Trellis compared to vase trees, provided capacity to support greater fruiting levels and high yields. For a given canopy architecture, crop load did not affect flowering date, trunk diameter or fPAR. However, greater pruning biomass occurred on vase trees in early years (seasons 1–2). Trunk cross-sectional area was 16–47 % greater on vase compared to Tatura Trellis trees. Low crop load increased pruning biomass on Tatura Trellis (season 1) and vase (season 3) trees. For seasons 1 and 3, low crop load resulted in larger fruit weight at the expense of yield under both planting systems. In season 2, frost damage at bloom masked crop load effects on yield and fruit quality. Fruit sweetness averaged 9.4–9.9 °Brix, with coefficients of variation  $\leq 28\%$ . For vase trees, fruit sweetness, maturity and firmness were similar across crop load treatments. However, on Tatura Trellis, high fruiting levels reduced fruit sweetness. Irrespective of canopy system or cropping level, approximately 35–40% of fruit failed to reach 9 °Brix. Likewise, high variability occurred in fruit maturity and firmness, irrespective of canopy system/cropping level with high variability (CVs of  $\geq 62\%$  and  $\geq 91\%$ , respectively). This study showed the need to optimize fruit number to tree fPAR for high fruit quality and maximum marketable yields in 'Golden May' apricot.

## TRAINING SYSTEMS SESSION 3

**ROSA: 199**

**PRESENTER: McClymont, Lexie (SP32)**

**TITLE: Yield and canopy radiation interception of three blush pear selections in Australia**

### ABSTRACT:

Rootstock selection is critical to maximise precocity and sustain yield of new fresh market cultivars as pear orchards in Australia transition to higher tree density and trellising systems. Three blush pear selections ('ANP0-131', 'ANP-0118', and 'ANP-0534') from the Australian National Pear Breeding program were evaluated for rootstock and interstem (D6, D6 with a 'Nijisseiki' interstem, BP1, Quince A with Beurre Hardy interstem and Quince C with Beurre Hardy interstem) effects on canopy radiation interception and yield. In Australia, *Pyrus pyrifolia* (including 'Nijisseiki') have high incidence of virus. To investigate the effects of virus, independent of effects of interstem, a treatment of D6 rootstock with 'Nijisseiki' summer-budded to the scion was included in the study. Trees were trained with four-leaders on Open Tatura trellis at a density of 2222 trees/ha. Canopy radiation interception each season and cumulative yield were highest for 'ANP-0131' (marketed as Rico®). For each scion, use of BP1 rootstock decreased canopy radiation interception and cumulative yield of the first five bearing seasons (third to seventh seasons after planting). A reduction in cumulative yield was also observed for 'ANP-0131' trees grown on D6 rootstock with a 'Nijisseiki' interstem compared to trees on D6 rootstock. Maximum yields were achieved for all selections in the fifth season after planting, after which yields of approximately 60 t/ha ('ANP-0131') and 30 – 40 t/ha ('ANP-0118' and 'ANP-0534') were achieved each season. Alternate bearing index was significantly affected by rootstock and scion. Relationships between yield, fruit number and fruit weight were determined for each selection and the implications for crop load management are discussed.

## TRAINING SYSTEMS SESSION 3

**ROSA: 149**

**PRESENTER: Ibell, Paula (SP33)**

**TITLE: Alternate high-density, training systems influence tree growth and yields in young intensive mango (*Mangifera indica*) orchards**

**ABSTRACT:**

Mango (*Mangifera indica*) orchards are typically grown using a conventional closed-vase training systems in low density orchards. Orchards grown with higher planting densities has increased orchard yields. However, there is little information available on what the best training systems to be applied in high density planting systems and how their management influences tree canopy growth, light interception and yield at early establishment. The aim of this research was to review how three different training systems (palmette, cordon and espalier systems (single leader on trellis)) planted at high density (1250 trees/ha) influenced the canopy characteristics and yield of three different mango varieties (Keitt, Calypso and NMBP 1243) between 3 and 5 years of age. Light interception and canopy characteristics (volume and canopy dimensions) were assessed along with number of inflorescences, tree and orchard yields. We also compared the time required to prune and train the different training systems. We found training system and variety affected mango canopy characteristics and light interception, the time required to train and prune and yield. Although the single leader systems took longer to train and prune, they resulted in increased yields compared to conventional, low density orchards of the same age.

## TRAINING SYSTEMS SESSION 3

**ROSA: 166**

**PRESENTER: Stanica, Florin (SP34)**

**TITLE: Behaviour of some Romanian pear cultivars under Parallel U and Trident canopy**

### ABSTRACT:

Four disease resistant pear cultivars (Corina, Euras, Orizont, Romcor) and two new hybrid selections (R3-146-F, H12-83-79) registered by Voinești Research Station for Fruit Growing were planted in the Experimental Orchard of the Faculty of Horticulture within the University of Agronomic Sciences and Veterinary Medicine of Bucharest. Trees grafted on CTS 212 quince rootstock, on Farold 40 pear rootstock and on own roots, in vitro propagated, were planted at 3.0 x 0.8 m, for Parallel U and at 3.0 x 1.6 m, for Trident canopy. A trellis with 3 wires and concrete poles was used for canopy formation and an integrated orchard management was applied, including drip irrigation. The interrow was kept covered with grass and mowed periodically, while the soil on the tree row was cleaned with herbicide. Comparative biometrical data for each cultivar and rootstock combinations, as: average tree height, trunk cross sectional area, type, number and average length of annual fruiting shoots, were studied. Farold 40 induced a higher vegetative growth in comparison with CTS 212 quince and the self-rooted pear trees. Even so, the use of Trident canopy offered the advantage of distributing/dividing the excessive growth on three vertical axes. All the studied cultivars produced a high number of short fruiting shoots (spurs and dards) with the exception of Orizont, where the long shoots, brindles and offshoots were predominant. Influence of experimental variants on yield, tree productivity and fruit characteristics at the harvest moment and consumption maturity, are detailed. The highest cumulative yield was obtained by the most cultivars grafted on Farold 40, followed by quince and self-rooted trees, while Euras grafted on CTS 212 quince rootstock, produced higher values. No significant correlation was found between rootstocks and fruit weight, but some influence on fruit shape index was noticed at Euras and Tudor cultivars. Fruit dry matter and total soluble sugars content were influenced both by cultivar and rootstock. The studied cultivars and hybrid selections are interesting to be extended on large scale orchard for their field resistance to main pear diseases, high productivity and fruit characteristics. The use of Parallel U and Trident canopies for the studied pear cultivars, hybrids and rootstocks offered a good frame to express their qualities.

Wednesday 28<sup>th</sup> July 2021

## ROOTSTOCKS SESSION 1

**ROSA: 109**

**PRESENTER: Fazio, Gennaro(K5)**

**TITLE: Imagine rootstocks**

### ABSTRACT:

For centuries rootstocks were considered just a means to propagate delectable fruit. In the 20th century they were used to dwarf plants, increase per hectare productivity, enable high density production systems, resist some very important disease and insects and tolerate some abiotic stresses. As our understanding about root-shoot relationships increases, we are developing more opportunities to utilize the breeding efficiencies generated by separating root (rootstock) trait selection from scion trait selection to include traits that were not envisioned possible. Combined with the increased ability to dissect traits into their DNA components (and derived gene expression) we can imagine being able to use rootstocks to modulate more than the “traditional” traits. For example, we have recently discovered that apple rootstocks are able to modulate the scion’s gene expression, hormone flux, nutrient concentration and metabolite production and concentration. In the near future we may be able to leverage rootstocks to plant orchards that have increased fruit quality, have reduced fruit storage disorders, are more mechanization compatible, or that deliver therapeutic molecules to scions to resist more disease pressures. With increasing diversity in the development of new scion varieties it will become more important to precisely match rootstock and scion genotype to with the climate, soil and management system to optimize orchard productivity and efficiency hence the term “designer rootstock” is meant to describe a unique rootstock that is compatible with a specific scion, soil, climate and management parameters which enables higher efficiencies in the production of high-quality fruit and nuts. This evolution can be imagined and achieved for many of the tree crops that currently lack a designer rootstock component leading to enormous benefits from such systems. The development and application of rootstock systems with novel traits is poised to provide the world with more diverse, affordable, environmentally sustainable horticultural tree crops.

## ROOTSTOCKS SESSION 1

**ROSA: 62**

**PRESENTER: Vercammen, Jef (SP35)**

**TITLE: Search for a dwarfing rootstock for 'Jonagold'**

### ABSTRACT:

For most fruit growers the ideal tree is a tree that does not grow too vigorously, demands little labour and yields yearly high quality and consistent production. In order to achieve this, our varieties are grafted or inoculated on a rootstock. For the Belgian apple culture this is mostly M9, a rootstock with moderate vigour. Though this rootstock satisfies in most cases, we need a rootstock with more vigour like in soils suffering from replant disease. In 2014 'Daliryan', a dark clone of 'Jonagold' was planted on Pajam 1, CG11, CG41 and AR295-6. In this trial we have assessed the growth, the yield, the colouring of the fruits and the fruit quality. After 5 years we have observed that the growth on CG11 is comparable to Pajam 1 and that AR295-6 and especially CG41 are more vigorous than Pajam 1. Yield was higher on all three rootstocks compared to Pajam 1. Colouring and fruit quality were similar. Fruit size, however, was much bigger on CG41, which is an important disadvantage for 'Jonagold'. In 2015 a second trial was planted with 'Novajo', a bright red clone of 'Jonagold' on M9 and CG41 in a parcel with replant problems. In this trial several commercial products containing Mycorrhiza-strains were added in the planting hole. In contrast with the first trial, the trees on CG41 were very weak. They had little side branches and a small root system. As a result, they hardly had any growth in the first year. In the second year they had a strong vigour: the trunk circumference increased a lot, but tree volume remained small. Production on CG41 remained behind in the first years, but in 2018 production was higher. Also, in this trial fruit size of 'Jonagold' was too big, which leaves us to the conclusion that CG41 is unsuitable for triploid varieties under Belgian conditions.

## ROOTSTOCKS SESSION 1

**ROSA: 5**

**PRESENTER: Kviklys, Darius (SP36)**

**TITLE: EUFRIN Apple Rootstock Trials: First Results Across the Europe**

### ABSTRACT:

In 2017 two multi-location apple rootstock trials were established at 16 sites in 13 European countries. The evaluations are performed by members of the EUFRIN (European Fruit Research Institute Network) Apple & Pear Variety & Footstock Testing Working Group. Two separate trials were arranged grouping rootstocks into dwarf and semi-dwarf rootstocks according to the expected vigor. Cv. 'Galaval' was used as scion cultivar. The trial of dwarf rootstocks includes G.11 and G.41 (US), AR 295-6, AR 486-1, AR 628-2, AR 680 2 and AR 835-11 (UK), B10<sup>®</sup> Mich 62396 (Russia), P 67 (Poland), Selections 4, 5 and 7 (New Zealand) and Pajam<sup>®2</sup> Cepiland as control. The trial of semi-dwarf rootstocks includes G.202 and G.935 (US), Selections 1 and 3 (New Zealand), AR 10 3 9 (UK) and G.11 as control for both trials. Part of the rootstocks (both from dwarf and semi-dwarf rootstock trials) were planted in replant conditions in order to test their tolerance to apple replant disease. Based on preliminary results averaged over the sites, dwarf rootstocks can be ranked in terms of vigour in the following order: AR 628-2 < AR 486-1, AR 680 2 < B10<sup>®</sup> Mich 62396, AR 295-6, P 67 < G.11, G.41 < AR 835-11, Selection 4, Pajam<sup>®2</sup> Cepiland < Selection 5. On average, semi-dwarf rootstocks can be ranked in terms of vigour in the following order: G11 < G.935, G.202 < Selection 1, Selection 3 < AR 10 3 9. The highest cumulative yield in the young orchard was registered on trees on G.11, Pajam<sup>®2</sup> Cepiland and AR 295-6, while the lowest production came from trees on AR 628-2. In the group of semi-dwarf rootstocks the highest yield was on Selection 3 and G.11 (control), followed by G.935 and G.202. The rootstocks also have significant effect on fruit weight and fruit quality parameters. Results from the young orchard revealed interactions between sites and rootstock. This fact could lead to site-specific rootstock choice based on the combination of rootstock, soil conditions and climate.

## ROOTSTOCKS SESSION 1

**ROSA: 200**

**PRESENTER: Palai, Giacomo (SP37)**

**TITLE: Rootstock and irrigation induced different response in berry aromatic characteristics in `Merlot` and `Sangiovese` grapevines**

### ABSTRACT:

Rootstock characteristics can modify scion response to water stress improving grapevine physiological response at different level. However, little is known about the combined effect of rootstock and deficit irrigation on berry quality. An experiment was performed on 5-year-old potted grapevines (*Vitis vinifera* L. cvs. Merlot and Sangiovese) plants to compare the effect of two rootstocks (SO4 and 1103P) and three irrigation regimes (Full Irrigation, FI; Regulated Deficit Irrigation 1, RDI 1; Regulated Deficit Irrigation 2, RDI 2) on fruit quality and their aromatic characteristics. Cultivar and rootstock combinations were subjected to water stress from fruit set through veraison and from veraison through harvest in RDI 1 and RDI 2 vines respectively, whereas they were fully irrigated for the rest of the irrigation period. Control grapevines (FI) were fully irrigated throughout the entire season. The total aromatic compounds were affected by cultivar-rootstock-irrigation combination and showed values between 3 to 8  $\mu\text{g/g}$  and 2 to 5  $\mu\text{g/g}$  of berry, in Merlot and Sangiovese, respectively. In both cultivars monoterpenes was higher in RDI 1 plants, particularly in SO4 (+10% than 1103P), but in cv. Sangiovese the RDI 2 treatment negatively affected monoterpenes concentrations (-25% respect to control plants). Benzenoids and norisoprenoids were enhanced by RDI 1 treatment in both cultivars, but while the firsts showed greater values in SO4 rootstock, norisoprenoids were higher in 1103P, especially in Merlot. Similarly, in Sangiovese vanillins and phenols were accumulated when water deficit was applied before veraison and in SO4 plants they increased greatly than in 1103P (+45%, average between the two aromatic classes). Deficit irrigation strategies represent a useful tool to enhance aromatic characteristics in grapevine, however rootstock can magnify or inhibit this effect even in the same cultivar, modifying plant adaptation to water stress.

## ROOTSTOCKS SESSION 1

**ROSA: 150**

**PRESENTER: Siboz Xolani, Irvin (SP38)**

**TITLE: Horticultural performance of 'Fuji' apple trees on the Cornell-Geneva® apple rootstocks in South Africa**

### ABSTRACT:

The benefits of apple (*Malus × domestica* Borkh.) rootstocks on protecting scions against biotic and abiotic stresses, and influencing scion vigour, precocity, nutritional status, and fruit quality are well known. The introduction of Cornell-Geneva® rootstocks to the South African industry has also increased the demand for these rootstocks that may outperform the commercial standard rootstocks including M.7 EMLA, M.793 and MM.109, which may no longer offer all these required horticultural benefits. The objective of this study was to evaluate rootstocks from the Geneva® range (G.778, G.228, and G.202), against the South African industry-standard rootstocks (MM.109, M.793, and M.7 EMLA). During the 2013 season, identical apple rootstock trails with 'Fuji' scions were established at three localities (Oak Valley Estate, Breëvlei and Helderwater) in South Africa. At each locality, a "more vigorous site" was established with M.7 EMLA, G.202, M.793, G.228, MM.109 and G.778 in 10 blocks of 3 trees per rootstock. The trials were established on fumigated sites previously planted to apple and were managed differently, but according to standard commercial practice. The trees at Oak Valley Estate and Helderwater were planted at 4 m x 1.5 m, while those at Breëvlei were planted at 3.5 m x 1.5 m. All trees from all the three farms were assessed for vegetative and reproductive performance. The G.778, G.228 and G.202 rootstocks produced the greatest cumulative yields at Oak Valley Estate. At Helderwater, the greatest cumulative yields were achieved with trees on G.778 and G.228 followed by those on MM.109, G.202 and M.7 EMLA while the lowest cumulative yields were with trees on M.793 rootstocks. The trees on G.202, G.228 and G.778 rootstocks were more productive than the trees on M.7 EMLA, M.793 and MM.109 rootstocks at Breëvlei. At all three farms, the trees on G.778, G.228 and G.202 rootstocks were consistently productive with the greatest cumulative yields while the trees on MM.109, M.793 and M.7 EMLA were consistently less productive with the lowest cumulative yields. Therefore, the G.778, G.228 and G.202 rootstocks have the potential to replace the commercial South African apple rootstocks, MM.109, M.793 and M.7 EMLA and transition orchard systems in the country.

## ROOTSTOCKS SESSION 1

**ROSA: 209**

**PRESENTER: Winer, Leo (SP39)**

**TITLE: Performance of a tetraploid avocado rootstock VC-320**

### ABSTRACT:

In 2008 a commercial group developed an avocado rootstock colchicine-induced autotetraploid. In this paper we present systematic data collected over seven years from Hass avocado trees grafted onto this tetraploid rootstock as compared with four other common rootstocks in Israel. Hass trees grafted onto the tetraploid rootstock Canacado VC-320 are significantly more productive than the other vegetative clone rootstocks included in the present study. The cumulative yield of Hass avocado grafted on Canacado VC-320 rootstock over 5 consecutive seasons was 65.8 tons per hectare and the range of yield of the other vegetative clones over the same period was 37.6 to 52.9 tons per hectare. The tetraploid rootstock was also more productive than Hass avocados grafted onto the seedling rootstock Degania 117. The tetraploid rootstock Canacado VC-320 also showed less sensitivity than other rootstock/scion combinations to branch dieback related to botryosphaeria infection.

Wednesday 28<sup>th</sup> July 2021

## ROOTSTOCKS SESSION 2

**ROSA: 113**

**PRESENTER: DeJong, Ted (K6)**

**TITLE: How do dwarfing rootstocks control fruit tree vigor? (Is it about hormones, nutrients, carbohydrates or water?)**

**ABSTRACT:**

Most commercial temperate fruit trees are compound trees made up of two different genotypes; a scion and a rootstock. Increasingly, rootstock genotypes are chosen for their ability to reduce or control the growth of the scion. Although modern fruit production is becoming increasingly dependent on “size-controlling” rootstocks there is still not unanimous agreement or clear understanding of the mechanisms involved in the size-controlling effects that specific rootstocks have on scion growth. There are several theories about the mechanisms involved in causing the size-controlling behavior of scions on dwarfing rootstocks and the objective of this talk will be to review these theories and provide some clarity about which theories appear to be most likely to be involved. The most common theories fall into the following categories: semi-incompatibility, water relations, nutritional, hormone/signaling, carbohydrate storage/mobilization/transport and competition/architecture. Most of these theories are not mutually exclusive and several mechanisms may be active in a given rootstock/scion combination to a greater or lesser extent. The nutritional theory appears a bit weak because, if it is in play, it should be able to be overcome by increasing the supply of nutrients preferentially to either the rootstock or the scion to overcome the relative dwarfing effect. Although the hormone/signaling theory is probably the most widely accepted among horticulturists it is fairly weak because most evidence for it comes from associative experiments in which hormone or growth regulator concentrations are associated with growth activity. However, it is not known whether the hormone concentrations cause the observed growth effects or are a result of them. A theory that has substantial empirical evidence to support it is based on differences in xylem anatomy that affect tree water relations.

## ROOTSTOCKS SESSION 2

**ROSA: 99**

**PRESENTER: Rufato, Leo (SP40)**

**TITLE: Changing the perspective of apple culture in Brazil with the Geneva series rootstocks**

### ABSTRACT:

Among the rootstock improvement programs for apple trees in the world, Geneva® is the most active in the world, producing several rootstocks that vary in vigor, precocity and resistance to diseases, but which have never been tested for warmer regions, like Brazil. Since 2011 Udesc has been evaluating several experiments with G series rootstocks, such as the G814, G210, G757, G41, G202, G935, G969, G213, always comparing with the M9. The G213 rootstock, originally created in Geneva, never continued planting in the USA, however, in Brazil it has shown very promising results in terms of productivity, reaching 102 t/ha, with Gala, more than the M9 in six years of production in a replanting area. During this period the rootstocks G213, G202, G757 and G814 were tested, comparing them with the traditional ones used, such as 'M9' and 'Marubakaido' with M9 inter-graft (Maruba / M9), in virgin soil and in an area replanting, in Maxi Gala and Fuji Suprema cultivars. The G213 produces 43% more with Fuji in replant compared to the M9 and 34% more at the Gala. The levels of hormones present in plants were evaluated with G series rootstocks, G213 has higher levels of Zeatin and trans Zeatin-Ribose, and lower ABA indexes, which demonstrates the effect of better sprouting of G213, around 70% at the top of the plant, against 23% at M9, for the cultivar Gala under low winter cold conditions. The rootstocks G814 and G213 provided the highest accumulated production values for 'Gala'. In 2016, the rootstocks G41, G210, G935 and G969 were introduced in the experiments, with a slightly different behavior under Brazilian conditions in relation to the vigor proposed for them in the USA. With the introduction of Geneva®, there was a change in the method of how apple plants are being produced in Brazil, Agromillora is making rootstocks available in grafting caliber for nurseries, providing better quality in the plants produced, reaching More than 2 million Geneva® plants are grafted, 800 thousand of which are G213. Geneva® rootstocks are good options for Brazilian fruit growers, due to their adaptability to replanting soils in Brazil's climate and production stability, with more constant and less alternating production.

## ROOTSTOCKS SESSION 2

**ROSA: 215**

**PRESENTER: Milliron, Luke (SP41)**

**TITLE: Clonal paradox rootstock comparison on 'Howard' walnut in in the Northern Sacramento Valley of California**

**ABSTRACT:**

'Paradox hybrid seedling' (*Juglans hindsii* x *Juglans regia*) is the most widely grown walnut rootstock in Northern California due to high vigor, adaptability to marginal soils, and improved resistance to *Phytophthora* root and crown rot; however, it remains susceptible to disease from soil-borne pathogens. Micropropagation technology has resulted in commercial availability of three clonal 'Paradox' walnut rootstocks, 'RX1', 'VX211', and 'Vlach'. Clonal rootstocks have less genetic variability than open-pollinated rootstocks, resulting in more uniform growth, and the ability to select for specific pathogen resistance. A replicated and randomized trial in California's Northern Sacramento Valley (Los Molinos) planted as bareroot rootstock in March of 2009 as part of a commercial 'Howard' walnut orchard, compares the clonal rootstocks 'RX1', 'VX211', and 'Vlach' to 'Paradox seedling' and the grower control, nursery June budded 'Vlach'. Field grafting was a tremendous challenge at this site, and the nursery June budded 'Vlach' trees had a 'Howard' growth advantage of as much as 26 months compared to the field grafted treatments. To evaluate these treatments, scion circumference (cm), photosynthetically active radiation (PAR), dry in shell yield per plot and tree (kg), as well as the percentage edible yield, jumbo walnuts, light kernels and mold were determined. Due to the substantial scion growth head start, June budded 'Vlach' exhibited significantly larger scion circumference than grafted rootstocks. Among grafted rootstocks, there were few significant differences in growth, although RX1 showed the lowest relative scion circumference and PAR. Field grafted rootstocks showed no overall significant differences in yield or nut quality. The soil-borne disease tolerances and resistances touted with clonal 'Paradox' rootstocks may take more time to result in higher tree survival and therefore greater yield versus 'seedling'.

## ROOTSTOCKS SESSION 2

**ROSA: 102**

**PRESENTER: Westphal, Andreas (SP42)**

**TITLE: Identifying walnut (*Juglans* spp.) rootstocks with resistance and tolerance to plant-parasitic nematodes**

**ABSTRACT:**

Walnut is an important tree crop in California. About 85% of California walnut orchards are reported to be infested with root lesion nematode, *Pratylenchus vulnus*. The commonly used rootstocks, *Juglans hindsii* x *Juglans regia* hybrids known as Paradox, are susceptible to this soil dwelling parasite, particularly at planting. For decades, *P. vulnus* was managed by pre-plant soil fumigation using methyl bromide or other nematicidal compounds. Environmental and human health concerns call for alternative management options. Host plant resistance and tolerance is an effective way to mitigate plant disease problems but identifying and utilizing resistant or tolerant individuals in walnut seedling populations has been challenging. Using clonal propagation and in vitro embryo rescue it has now become possible to propagate clonal walnut plants from interspecific crosses. In this project, the response of *P. vulnus* to interspecific crosses of heterozygous parents of different *Juglans* species was tested. Identifying walnut genotypes resistant and tolerant to *P. vulnus* required measuring nematode populations for multiple years under field conditions. A step-wise selection strategy identified genotypes superior to existing commercial rootstocks. These elite selections were planted in regional rootstock trials and grafted to a common scion. In these trials, the rootstock selections are exposed to field level soil-borne problems in non-treated and preplant fumigated plots. Important horticultural traits and the durability of nematode resistance or tolerance are monitored and compared to the industry standard clonal rootstocks. Multi-year testing is expected to validate rootstock benefits that growers can use as additional pest management tools.

## ROOTSTOCKS SESSION 2

**ROSA: 144**

**PRESENTER: Bujdosó, Geza (SP43)**

**TITLE: Evaluation of growth and cropping of early ripening sweet cherry cultivars on different rootstocks among Central Hungarian climate conditions during the past 10 bearing years**

**ABSTRACT:**

Evaluation of 4 clonal Mahaleb ('Bogdány', 'Egervár', 'Magyar', 'SL 64'), 3 Mahaleb seedlings ('Cemany', 'Érdi V', 'Korponay'), *P. avium* seedling 'C.2493', and 'GiSelA6', rootstocks combined with early ripening sweet cherry cultivars ('Petrus', 'Vera', 'Carmen') have been studied among non-irrigated conditions in Central Hungary. The trial was set up on Experimental Fields of National Agricultural Research and Innovation Centre at Research Station of Érd-Elvira. Aim of our study was to find suitable rootstocks for novel bred Hungarian sweet cherry varieties trained to Hungarian Cherry Spindle. It can be stated after 14 years investigation that 'Petrus' is the most vigorous variety, 'Vera' and 'Carmen' are moderate vigorous. Although 'Carmen' is less productive but the big fruit size compensates this character reaching highest gross crop value. 'Petrus' produced the largest cumulated yield but least fruit size among observed cherry varieties. 'GiSelA6' rootstock showed low vigor, 'SL64' was the most vigorous one among clonal mahalebs. Mahaleb seedlings 'Érdi V', 'Korponay', and 'Cemany' induced high vigor, while 'Egervár' with all varieties, and 'Magyar' for 'Petrus' showed moderate vigor, 82 and 74% compared to the 'SL 64', respectively. Cumulated yield of varieties was different by rootstocks, highest yield produced 'Vera' trees on 'Egervár', 'Carmen' trees on 'Cemany', 'Petrus' on 'Magyar' rootstocks but the highest yield efficiency related to trunk cross-sectional area showed 'GiSelA 6'. The least fruit weight and fruit rate of 26 mm < we measured on 'GiSelA 6'. Although highest yield efficiency and gross crop value efficiency produced trees on 'GiSelA 6' root even under non-irrigated conditions, the risk of significant smaller fruit size gives causa for concerns. Among Hungarian clonal mahaleb rootstocks 'Egervár' was most efficient with 'Vera' and 'Carmen' varieties considering the gross crop value. This research was partially supported by GD008 project of the National Agricultural Research and Innovation Centre Research Institute for Fruit growing and Ornamentals.

Thursday 29<sup>th</sup> July 2021

## ORCHARD MANAGEMENT SESSION 2

**ROSA: 179**

**PRESENTER: Arnoldussen, Brent (SP44)**

**TITLE: Plant Based Dispersions: Novel sprayable frost protectants for tree fruit**

**[Reducing cold damage with cellulose nanocrystal dispersions]**

**ABSTRACT:**

Cold damage to reproductive buds or flowers is a perennial concern to tree fruit producers. Indeed, cold damage has caused more economic losses to crops in the US than any other weather hazard. The potential losses (yield reductions to complete crop failure) from cold damage are predicted to increase with variable weather patterns resulting from climate change. Cellulose nanocrystals (CNC) represents a new generation of renewable nano-biomaterials, with many unique physical and chemical properties, including their low thermal conductivity. Our team has developed a process for creating CNC dispersions that can be sprayed onto trees, forming a thin (ca. 25µm-40µm) and durable insulating film around the surface of the buds. Thermal image analyses revealed that apple (*Malus domestica* Borkh) and sweet cherry (*Prunus avium* L.) flower buds treated with 3% CNC dispersions lose 16.5% less thermal energy into the environment in cold conditions than untreated buds. Analyses of internal freezing events in apple with digital scanning calorimetry showed that buds coated in 3% CNC exhibited lethal freezing at a temperature 3.2°C and 5.5°C lower than the untreated control 1 and 3 days after application, respectively. Large-scale field trials using commercially available electrostatic sprayers showed that CNC-treated (2.5%) reproductive buds were hardier by ca. 5.8°C, a level of protection that lasted up to 7 days post application. The results of this work suggest that CNC dispersions can effectively protect reproductive buds from cold damage and may represent a novel means for fruit growers worldwide to reduce losses.

## ORCHARD MANAGEMENT SESSION 2

ROSA: 73

**PRESENTER: Bird, George (SP45)**

**TITLE: Impact of Cover Crops, Compost and Mulch on Cherry Tree Development and Yield**

ABSTRACT:

In cherry orchard replant situations in Michigan, *Pratylenchus penetrans* (Penetrans root-lesion) and *Xiphinema americanum* (American dagger) nematodes, can be key limiting factors. During the past 60 years, soil fumigants and cover crops have been used to reduce risk to these plant-parasitic nematodes. In 2009, research was initiated at the MSU, NWHRC to identify cover crop systems designed to eliminate the need for soil fumigation. Six cover crop systems were maintained in 2010 and 2011 for analysis of Benton sweet cherry tree growth and development in 2013 through 2018 and machine-harvested yield in 2019. The cover crop systems included: 1) conventional system: rye in 2010 followed by oats and rye in 2011, 2) nematode non-host system: buckwheat followed by winter peas in 2010 and pearl millet followed by Essex rape in 2011, 3) two-year bio-fumigation system: Oats and peas followed by oilseed radish in 2010 and oats and peas followed by Ida and Pacific Gold mustard in 2011, 4) second-year bio-fumigation system: oats followed by winter pears in 2010 and Ida mustard followed by Pacific Gold mustard in 2011, 5) compaction buster system: oilseed radish in 2010 and oats and peas followed by oilseed radish in 2011 and 6) legume system: oats and red clover in 2010 and red clover in 2011. Each system was replicated four times in a randomized block design of four trees per plot. The original intent was to fumigate the conventional system in the fall of 2011. Unfortunately, the entire block was fumigated. The orchard was planted in the spring of 2012 to 84 Benton sweet cherry trees and maintained through the first mechanical harvest in 2019. Tree growth measurements: trunk cross section area (TCSA), limb growth and canopy volume were made on an annual basis. In 2015, TCSA, limb growth and canopy volumes were greatest for the trees planted following the nematode non-host cover site development system and lowest following the legume system. The same was true for limb growth and canopy volume. In 2019, cherry yields associated with the nematode non-host system were significantly ( $P = 0.05$ ) greater than those associated with the legume system. TCSA was the best indicator of future yield. The research consisted of the following five at-planting in 2014 treatments. A second five-treatment trial was established to evaluate the impact of compost and mulch on tree development and yield. The treatments consisted of a: 1) non-treated control, 2) compost and mulch applied on the orchard floor surface at planting, 3) starter compost applied in the tree planting hole plus surface compost, 4) starter compost applied in the tree planting hole plus surface mulch and 5) starter compost applied in the tree planting hole plus surface compost and mulch. Each treatment was replicated four times. Three growth measurements were made at the end of each growing season, beginning in 2014: trunk cross section area, limb growth and canopy volume. The greatest TCSA in 2014-2016 were from trees where the starter compost had been used in the planting hole. The lowest trunk cross section area was associated with the non-treated control. Trees with intermediate TCSA were those where only surface compost and mulch were applied. The 2019 cherry yields were greatest where the starter compost was applied in the planting hole, intermediate where only surface applied mulch or compost was used and lowest in the non-treated control. A third orchard has been established to identify potential of cover crops, compost, mulch and non-fumigant nematicides systems as replacements for soil fumigation.

## ORCHARD MANAGEMENT SESSION 2

**ROSA: 90**

**PRESENTER: Mahdavi, Shahla (SP46)**

**TITLE: Branch Induction in Newly Planted Un-feathered 'Aztec Fuji' Apple Trees Using Cambium Cuts, Promalin, Nitrogen, and Tip Removal**

### ABSTRACT:

The use of well-feathered nursery trees on dwarfing rootstocks is crucial for establishing high-density apple orchards to ensure early production. Also, training trees to develop a tall spindle canopy architecture has gained popularity in high-density orchards during the past decade. However, commercially produced nursery trees often lack feathers or are unevenly branched, making initial training decisions difficult and delaying precocious fruiting. In this project, we studied the vegetative meristem activation response to partial scoring or partial girdling of the bark cambium above the bud, with and without application of 500 ppm Promalin (gibberellins 4 and 7 plus the cytokinin 6-benzyladenine), tip removal of the tree leader at the green tip stage on April 23, 2019, promaline spray at 500 ppm at post-bloom stage on May 7, 2019, and nitrogen as UAN-32 (32% N) application at five levels (0, 20, 40, 60 or 80 g N/tree in addition to the previously applied N by the grower) on June 20, 2019 in newly planted un-feathered or unevenly branched 'Aztec Fuji' trees on Malling 9 Nic 29 rootstock in southwest Idaho, USA. Control trees received a heading cut to the leader at 60 cm above the ground, resulting in the emergence of 5-6 strong branches near the heading cut. These trees had larger trunk cross-sectional areas than scored or girdled trees. Scoring or girdling, with or without Promalin, significantly improved branching by increasing the number of branches and bourse shoots. In many cases, the effects of partial scoring, with or without Promalin, were similar to those of bark girdling which is a more risky and time-consuming process. Branches induced by scoring and girdling had sharper crotch angles relative to the vertical leader. Spraying promalin on May 7, 2019 at 500 ppm was not as effective as scoring or girdling to initiate branches. Additional nitrogen rates or tip removal from the tree leader did not significantly impact branch induction.

Thursday 29<sup>th</sup> July 2021

## ROOTSTOCKS SESSION 3

**ROSA: 101**

**PRESENTER: Reighard, Gregory L. (SP47)**

**TITLE: Thirty-three years evaluating rootstocks for peach in the NC-140: What have we learned**

**ABSTRACT:**

The NC-140 multi-state project currently titled “Improving Economic and Environmental Sustainability in Tree Fruit Production Through Changes in Rootstock Use” evaluated fruit tree rootstocks for more than 40 years. Coordinated peach rootstock testing began in 1984, and six long-term trials have been implemented with 5 completed. The first trial included 16 states and 19 cooperators. Nine rootstocks included 4 industry standards (*Prunus persica* seedlings), a plum hybrid, own-rooted, and 3 *Prunus* hybrid introductions from France. Peach seedling rootstocks had the best survival and yields except for ‘GF677’. The 1994 trial was planted in 18 states/provinces and 32 cooperators with 18 rootstocks of which all but 3 were peach. High yielding rootstocks included the standards -- Lovell and Guardian® peach seedlings. Plum hybrid rootstocks affected bloom and maturity dates compared to the peach stocks. Cumulative yields were significantly affected by rootstock and location with no rootstock better than Lovell. Ranking of rootstock performance did not change between years 5 and 8. An associated multi-state bud hardiness study showed trees on Lovell or ‘TaTao5’ interstem on Lovell were most cold hardy in mid-winter. Trials planted in 2001 and 2002 at 17 sites in North America included 15 clonally propagated *Prunus* spp. and hybrid rootstocks and the peach seedlings Lovell, Bailey and Guardian® as controls. Both trials were ended prematurely after 5 or 6 years due to virus concerns. These 2 trials showed the potential for semi-dwarfing rootstocks in peach but also the shortcomings of slow growth, poor anchorage, suckering, delayed incompatibility, small fruit size and increased tree death in many but not all of the vegetative propagated rootstock cultivars. The last completed trial was planted in 2009 at 16 locations with 18 rootstocks that included interspecific hybrids from Spain, Italy, Russia and the U.S. Significant differences were observed among rootstocks and locations for most horticultural traits. Overall, peach and peach hybrid rootstocks were the most vigorous and productive, while the Controller™ series and plum rootstocks were the most yield efficient. Bacterial canker in the southeastern United States and high pH soils in the Intermountain West were important factors affecting tree survival. A summary of results showed that in the southeastern US Guardian® was the best rootstock due to its tolerance to the Peach Tree Short Life syndrome. In the northeastern US, the clonal peach stocks Controller™ 7 and 8 have shown superior performance to the traditional peach seedling rootstocks. In the Intermountain West where high soil pH is a problem for peach rootstocks, the *Prunus* hybrid rootstock Krymsk® 86 has shown superior performance. Overall, 26 states/provinces in the U.S., Canada, and Mexico with 71 cooperators (co-authors) have evaluated 53 rootstock selections and cultivars. Peach seedling rootstocks have almost always been the best performers, but NC-140 field trials of non-seedling propagated cultivars have been promising, which has encouraged increased planting of clonal rootstocks for peach in North America.

## ROOTSTOCKS SESSION 3

**ROSA: 167**

**PRESENTER: Lang, Gregory (SP48)**

**TITLE: Ten-year conclusions from the NC-140 sweet cherry canopy architecture x rootstock trials in North America**

**ABSTRACT:**

Under the initiative of the NC-140 Regional Rootstock Research Project, high density sweet cherry orchard system trials were coordinated and planted at 13 sites across North America in 2010. Four distinct canopy architectures were combined with three precocious rootstocks of varying vigor levels: Gisela 3 (Gi3, dwarfing), Gisela 5 (Gi5, semi-dwarfing), and Gisela 6 (Gi6, semi-vigorous). The developmental objectives for the orchard systems included a) filling of the allotted orchard "footprint" by the end of third year, b) a maximum tree height to facilitate most pruning and harvest without ladders, and c) simplified, minimal permanent canopy structure with periodic renewal of fruit-bearing structures. Two canopy architectures were "three-dimensional": 1) TSA (Tall Spindle Axe), a single leader with 15 to 20+ lateral fruiting branches comprising a conical canopy, and 2) KGB (Kym Green Bush), a multiple leader bushy canopy with 8 to 15 upright fruiting leaders. The other two canopy architectures were "two-dimensional" or "planar": 3) SSA (Super Slender Axe), a single leader with 20 to 30+ short lateral fruiting shoots, planted at twice the density of the other systems, pruned severely, and aligned to form a narrow fruiting wall canopy, and 4) UFO (Upright Fruiting Offshoots), an oblique cordon-like horizontal leader with 8 to 12 upright fruiting leaders aligned in a narrow fruiting wall canopy. Five sites maintained the trial for the full 10 years: Clarksville, Michigan (cv. Benton); Geneva and New Paltz, New York (both cv. Regina); and Summerland, British Columbia and Kentville, Nova Scotia (both cv. Skeena). Tree vigor was influenced more by site and rootstock than by canopy architecture, with the exception of SSA due to the greater root competition. Yields per tree and yields per allotted orchard area were strongly influenced by site-scion combination (highest total yields by far in British Columbia), by rootstock (lowest yields per orchard area for Gisela 6), by year (high annual variability), and by canopy architecture (high annual variability). Given the interactions between different canopy architectures and rootstock-imparted vigor levels, the caveats for projecting and comparing yields per tree, yields per orchard area, cumulative orchard yields, and yield efficiencies among canopy-rootstock combinations will be discussed.

## ROOTSTOCKS SESSION 3

**ROSA: 190**

**PRESENTER: Minas, Ioannis (SP49)**

**TITLE: Establishment performance of the 2017 NC-140 semi-dwarf peach rootstock trial across 10 sites in North America**

**ABSTRACT:**

Eight semi-dwarf and standard vigor Prunus rootstocks budded with 'Cresthaven' peach were planted at 10 locations in North America (nine in U.S. and one in Canada) in 2017. During the first three years of establishment, significant differences among rootstocks and sites were found for survival, root suckers, tree growth, yield, fruit size and yield efficiency. Tree survival was high (>96%) in the states SC, PA, MI, AL, CO and UT and low (<75%) in NY, NC and GA. Rootpac®40 had the lowest overall survival (72%) followed by Controller™7, Rootpac®20 and MP-29. Rootstock suckering was excessive on Rootpac®20 Prunus interspecific hybrid with Lovell a distant second. The largest trees were in AL followed by NY, SC and UT while the smallest trees were in CO a short growing season site with calcareous soils and high soil pH. Largest trees were on Guardian®, followed by Lovell, Rootpac®20 and Controller™6 (76, 72 and 60% of Guardian®, respectively) whereas smallest trees were on Rootpac®40, MP-29 (41% of Guardian®). Full bloom varied 77 days, whereas maturation 55 days across the sites in 2019 the first year that trees cropped. However, no differences in bloom or harvest time observed across rootstocks. Yield (10-11 kg/tree) was highest in UT and AL and lowest (1-3 kg/tree) in NC, CO and GA. The highest yields were on the most vigorous rootstocks such as Guardian®, Lovell and Rootpac®20, while lowest yield was on Rootpac®40. Rootstocks with the highest yield efficiency was MP-29 while the lowest was Rootpac®40. Fruit size was large (227-298 g) in UT, SC, AL, moderate (195-213 g) in NC, PA, CO and NY and small (127 g) in GA. Controller™6 produced the largest fruits (249 g) and Guardian® with MP-29 the smallest (210 g).

## ROOTSTOCKS SESSION 3

**ROSA: 39**

**PRESENTER: Casagrande Biasuz, Erica (SP50)**

**TITLE: Rootstock-induced scion vigor is associate with changes in plant water status in the scion**

### ABSTRACT:

In apple, dwarfing rootstocks are used to control tree vigor allowing for increased densities that increase apple production. Although there is considerable variation among rootstocks in dwarfing capacity, the mechanisms by which rootstocks affect vigor in apple scions remains unclear. Here, Honeycrisp apple on 10 rootstocks (N=3) and WA-38 on 9 rootstocks (N=3) was grown in Washington, USA. Trees were acquired from a commercial nursery and planted in 2017. In 2018 and 2019, scion physiological, isotopic and morphological traits were measured to better understand the link between rootstock-driven vigor and physiological traits. Rootstock affected scion shoot growth ( $P < 0.001$ ), stomatal conductance ( $P < 0.01$ ) and stem water potential ( $P < 0.001$ ). Rootstocks with low vegetative vigor like Budagovsky-9 also had lower stomatal conductance and enriched leaf  $\delta^{13}C$  and  $\delta^{18}O$  isotope composition. Plant growth was positively correlated with stomatal conductance ( $r = 0.38$ ;  $P < 0.01$ ) and stem water potential ( $r^2 = 0.55$ ;  $P < 0.001$ ). Rootstocks affected plant water status and net gas exchange. Here, we report an association rootstock-induced vigor and scion physiological traits such as gas exchange, stem water potential, and leaf carbon and oxygen isotope composition. This research has implications for the understanding of the mechanisms of dwarfing by rootstocks in apple.

Thursday 29<sup>th</sup> July 2021

## CROP LOAD AND THINNING

**ROSA: 63**

**PRESENTER: Vercammen, Jef (SP51)**

**TITLE: Chemical thinning of 'Nicoter'**

### ABSTRACT:

The acreage of apples in Belgium has decreased steadily over the past 20 years and since 2008 it is lower than the acreage of pears. In 2018 231 million kg of apples, of which 64 % 'Jonagold', has been produced on 5.985 ha. In recent years the share of 'Jonagold' has been decreased. Instead new varieties like 'Nicoter', 'Belgica', Kizuri, ... are planted. But unlike 'Jonagold' they are diploid and require a strong (chemical) thinning. The size of the apples is an increasingly important factor for the determination of the price. To obtain a higher average fruit weight in diploid varieties, the number of fruits per tree has to be optimized, for which the new options will be discussed. In Belgium the following chemical thinning agents are authorized: 1-Naphtaleneacetamide (NAD -Amid-thin W), naphtalene acetic acid (NAA – Fixor), 6-benzyladenine (6-BA – Globaryl 100, Exilis and MaxCel) and met amitron (Brevis). Besides, also ammonium thiosulfate (ATS) is used as a foliar nutrition to thin apples. The result of the chemical thinning depends on temperature, tree vigour, pollination (the number of seeds), the difference in fruit size and the light intensity 14 to 30 days after full bloom. Mostly the thinning effect of 6-BA on 'Nicoter' is too weak and 'overthinning' rarely occurs. Adding NAA to 6-BA can improve the thinning efficiency. On the contrary, met amitron (Brevis) can give an excessive thinning, especially with high night temperatures and in combination with low light levels. Therefore, our advice is to use NAD or 6-BA (+/- NAA) when only a mild thinning is intended. On trees with an abundant number of flower buds and ideal weather during bloom 1 treatment with 1.1 to 1.5 kg/ha Brevis (met amitron) is recommended. The optimal time for the application of met amitron is at an average fruitlet diameter of 8 to 12 mm on the 2-year-old-wood. A later application is possible, but the gain on average fruit weight is yet compromised and results are more inconsistent. An earlier application than the recommended timing is less effective.

## CROP LOAD AND THINNING

**ROSA: 82**

**PRESENTER: Reginato, Gabino (SP52)**

**TITLE: Effect of auxin sprays on 'French' plum fruit size and yield efficiency under different source/sink ratio**

**ABSTRACT:**

In Chile, *P. domestica* 'French' has usually been grown for prunes, but in recent years, the fresh fruit Chinese market has meant greater profitability for the growers, which results in an increased demand for larger fruits. Synthetic auxin sprays has been reported as effective to increase fruit size in different fruit trees, but it has not been validated in this cultivar. The objective of this study was to determine the effect of synthetic auxins on fruit size and yield efficiency of 'French' plum and its interaction with the vegetative growth of the trees. The study was carried out in the 2018-2019 season, in an orchard located in Graneros, O'Higgins Region, Chile (34.10 S; 70.84 W), in 15-year-old 'French'/Marianna 2624 trees. Each treatment was applied on 8 trees with differentiated pruning, 4 trees light pruned and high crop load and 4 trees heavy pruned and lower crop load, to deduct, a posteriori, the effect of crop load on yield efficiency and the mean fruit size. The treatments were: (T1) Control, not sprayed; (T2) 2,4DP at 75 mg a.i./L (2,4-dichlorophenoxy propionic acid) in white bud; (T3) naphthalene acetic acid (NAA) at 16 mg a.i./L in jacket fall and repeated 12 days later; (T4) 2,4DP at 75 mg i.a./L and (T5) 3,5,6 TPA at 20 mg i.a./L, both sprayed at the beginning of pit hardening. At harvest, the leaf area of spurs and twigs was determined and the elements of one branch per tree counted to estimate the leaf area of each tree. The yield efficiency and the crop load were expressed as kg and fruits per ha that intercepts 70% PAR (Photosynthetically active intercepted radiation) respectively. The PAR<sub>i</sub> was significantly reduced by auxin sprays, being greater the effect in T3 and T5. T4, T5 and T3 showed a significant increase in the average fruit weight respect to the Control (20%, 14% and 7%, respectively), while T2 did not differ from it. Considering the export prices for fresh plum (2017-2018 season) and the production of the Control, the crop value is maximized with 1.5 to 2 million fruits per hectare that intercepts 70% PAR, with an average fruit weight between 23.0 to 21.3 g; 0% of non-exportable fruit and between 8 to 14% of "Large" category (27 – 30 mm in diameter). The results suggest that at least ~200 cm<sup>2</sup> of leaf area per fruit is needed for an effective response of the fruit size to the auxin spray.

## CROP LOAD AND THINNING

**ROSA: 146**

**PRESENTER: Rufato, Leo (SP53)**

**TITLE: Different chemical thinning strategies and their effect on apple production in Southern Brazil**

### ABSTRACT:

Currently, in Southern Brazil, one of the main obstacles in apple productive sector is the shortage and high cost of labour, especially for harvest, pruning and thinning, which accounts for about 60% of production costs. In addition to high cost, the hand thinning is slow and, when finished late, it is less effective to increase fruit size and improve return bloom; however, this practice is still widely used in Brazilian orchards. The objective of the work was to evaluate different chemical thinning strategies and their effect on apple production. The work was carried out in São Joaquim/Santa Catarina State, in orchards of Epagri – São Joaquim Experimental Station (28°16'30"S, 49°56'09"W, altitude 1,400m). The orchard was implanted in 2006, with the cv. Maxi Gala, grafted on M.9, with 1 x 4 m spacing. Three chemical thinning strategies were tested: Naphthalene Acetic Acid (7.5g/100L, full bloom) + 6-Benzyladenine (Maxcel®, 200mL/100L, 5-8 mm) + Ethephon (Ethrel®, 100mL/100L, 15 mm) + hand thinning (20 mm). 6-Benzyladenine (Maxcel®, 200mL/100L, 5-8 mm) + hand thinning (20 mm). Ethephon (Ethrel®, 100mL/100L, 15 mm) + hand thinning (20 mm). The control was hand thinning when fruits reached 20 mm. During hand thinning execution, number of thinned fruits and time for thinning 1 hectare was determined. At harvest, number of fruits per tree, production per tree and hectare were evaluated; also the fruits were classified in size classes. The time spent to perform the hand thinning was on average 44% less in trees submitted to chemical thinning. Trees that received NAA + BA + Ethephon + hand thinning showed a reduction in productivity of 24% compared to control. But in compensation, 34% of the fruits produced were classified between caliber of 80 and 100, while the control produced only 6% of the fruits in this size category.

## CROP LOAD AND THINNING

**ROSA: 145**

**PRESENTER: Rufato, Leo (SP54)**

**TITLE: New strategy using retain to increase fruit set on apples in mild climatic region in southern Brazil**

### ABSTRACT:

The use of plant growth regulators are tools for growers. In mild climatic grower regions condition as Southern Brazil, PGR's could be the key for successful orchard. The aim of this two experiments were evaluate the effect of PGR's sprayed twice, early in the season, during full bloom and petal fall on: fruit set, yield, fruit size, fruit number per tree, fruit quality parameters and ethylene production (E2). The experiments had been conducted during 2018/19 growing season on two different orchards at Correia Pinto, Santa Catarina State, Brazil. Treatments that have been used on both trials were control, 5 treatments using Retain® (15% a.i. AVG) with growing rates ranging from 103,75 mg L-1 to 622,5 mg L-1 and experiment 1(E1) has received two treatments more than experiment 2 (E2), were them: TDZ 20 mg L-1 and the other one the combination (Stimulate®2 ml L-1+ Hold®2 ml L-1). Both trials were on 'Gala' apple trees arranged in a randomized block design. On E1 TDZ and Retain®, the two higher doses, got the best results for fruit set, 130% more than control, and fruit number per tree, 98% more fruits than control. TDZ had the biggest yield, 60 Mg ha-1, followed by the two higher doses of Retain®, 42 Mg ha-1. All doses of Retain® had negative influence on unitary fruit weight, fruit height and diameter. On E2, Retain® 622,5 mg L-1 had the best result for all productive parameters, yield was 18 Mg ha-1 more and fruit set 65% bigger than control. Ethylene rate is bigger on control treatment in the first day after spray one. Ethylene production was not reduced after the second spray on treatments with 103,75 mg L-1 and 207,5 mg L-1 of Retain®. On E1 TDZ has a prominent result, doing better than Retain® in all doses. Both trials had showed that Retain® had significant positive influence on fruit set and yield, increasing results with higher doses. E2 show that Retain® has effect on ethylene production suppression on flowers and fruitlets.

## CROP LOAD AND THINNING

**ROSA: 148**

**PRESENTER: Sibozza, Xolani Irvin (SP55)**

**TITLE: Evaluation of Dormancy Breaking Agents in Apple Trees Grown in Warm-Winter Regions of South Africa**

### ABSTRACT:

South Africa is a subtropical region associated with insufficient winter chilling for commercial apple (*Malus × domestica* Borkh.) production. Insufficient winter chilling (<1000 Richardson Chilling Units per year) is usually associated with abnormal bud break pattern, delayed foliation and protracted flowering. Commercial apple growers depend on dormancy breaking agents including hydrogen cyanamide (Dormex®) and winter oil to compensate for the insufficient winter chilling. Dormex® is not environmentally friendly and has been banned in many apple producing countries. There is an urgent need for the South African apple industry to reduce the concentration of Dormex® or find alternative dormancy agents that are more environmentally friendly. The aim of this study was to evaluate alternative dormancy breaking agents including promalin® (6- benzyl adenine + gibberellins), potassium nitrate (KNO<sub>3</sub>), sodium nitrite (NaNO<sub>2</sub>), urea and winter oil in apple trees to improve bud break. The field study was conducted in commercial 'Rosy Glow' and 'Fuji' apple orchards from 2016 to 2019. Uniform individual trees were randomly selected and allocated to dormancy breaking agents. The 'Fuji' and 'Rosy Glow' trial sites were conducted according to a randomised complete block design of 10 trees per 6 treatments with single tree per block, 1 guard tree and guard row. Two branches per tree representing one-year- and two-year- old shoots were randomly selected and tagged for the total number of dormant buds before the application of dormancy breaking agents. 3% Dormex® promoted more vegetative buds than reproductive buds because of a phytotoxic effect on floral tissues. All the alternative treatments were as good as the industry standard 0.5% Dormex® + 3% oil. The addition of Promalin® to the industry standard treatment appeared to be the most promising bud break treatment in both cultivars.

Thursday 29<sup>th</sup> July 2021

## FLOWER BIOLOGY SESSION

**ROSA: 178**

**PRESENTER: Hillmann, Laura (SP56)**

**TITLE: GDD, ovary growth and relative water content predict changes in the lethal temperature of 'Montmorency' tart cherry flower buds between dormancy and anthesis**

### ABSTRACT:

Once ecodormancy is satisfied, tart cherry (*Prunus cerasus* L.) 'Montmorency' reproductive buds are killed at progressively higher sub-freezing temperatures. Lethal temperatures have been published for discrete phenology stages of floral buds, however, the physical changes that occur between the early developmental stages 'first swell' and 'green tip' are often indistinguishable. Concomitantly, an approximate 20° loss hardiness occurs during this developmental timeframe. There is a dearth of information on the preanthesis developmental changes of 'Montmorency' floral buds, ovaries and anthers and their relationship with lethal temperature (LT50) of flowers. Our major objective was to determine which of these characteristics could indicate dormancy transitions and predict freeze susceptibility. Floral buds were collected several times per week near the end of ecodormancy until anthesis in the spring of 2017 and 2018. Fresh buds were weighed, imaged and dried to determine the dry matter and relative water content. Entire pistils were extracted from a subset of fresh floral buds and imaged under a stereo-zoom microscope for ovary diameter and volume measures using calibrated image analysis software. Anther squashes were performed to identify the relative timing of the stages of microsporogenesis. Randomly selected floral buds from each sample population were frozen in a programmable temperature chamber at a rate of 1.5°C per hour to determine the LT50 of flowers. Between dormancy and green tip, ovary volume increased nearly three orders of magnitude and RWC increased from ~45% to 70% in both years. The onset of ovary growth was observed by 50 GDD and preceded all other observable changes in development, including microsporogenesis. Approximately 98% of the variability in ovary growth was explained by a simple GDD model with a 2nd order polynomial function. Relative water content of floral buds was also an early indicator, strongly associated with pistil growth and loss of hardiness. Between the onset of ovary growth and anthesis, 95% of the variation in LT50 was explained by GDD accumulation.

## FLOWER BIOLOGY SESSION

**ROSA: 94**

**PRESENTER: Minas, Ioannis (SP57)**

**TITLE: Dissecting peach cold hardiness eco-physiology and metabolism**

### ABSTRACT:

Reduction in fruit production due to cold damage in floral tissues is the major limitation to profitability and ultimately survival of temperate fruit industries of North America, including Colorado. Understanding cold hardiness responses to abiotic conditions is key to improve stone fruit performance and productivity in a changing environment. The critical temperatures of the floral buds for two peach cultivars 'Sierra Rich' and 'Cresthaven' were developed in high resolution during the different phases of dormancy (acclimation, maximum hardiness, deacclimation) with differential thermal analysis (DTA). 'Sierra Rich' was the least hardy and exhibited minimum response to freezing events and deacclimated faster as a response to unseasonal warm temperatures, compared to 'Cresthaven' that was acclimated rapidly in response to freezing events and slowly deacclimated in spring. Biochemical analysis of soluble sugars and starch in floral bud tissue demonstrated that the cold hardy peach cultivar 'Cresthaven' is accumulating higher levels of starch early in the dormancy, which might be responsible for the increased soluble sugar levels towards deacclimation compared to the cold-tender cultivar 'Sierra Rich'. Large scale and non-targeted metabolite profiling (GC-MS) was performed on peach buds from 'Cresthaven' and 'Sierra Rich' at five time points across the three phases of dormancy. Principal component analysis (PCA) of the 232 detected peach bud metabolites indicated distinct metabolite profiles at each of the three distinct dormancy phases. Further, the two cultivars differed at each time point, indicating a genotype x date source of variation in the metabolome which highlights that metabolite shifts during dormancy, and that the dynamics of the response are variable between cultivars with different frost tolerance. This further demonstrates that the active cross talk between the environment and the dormant reproductive organs is regulating metabolic pathways that might contribute to tree adoptability to environmental changes.

## FLOWER BIOLOGY SESSION

**ROSA: 53**

**PRESENTER: Mizani, Anahita (SP58)**

**TITLE: The effect of rootstocks on mango tree vigour, scion architecture and percentage of flowering terminals in juvenile unpruned trees**

### ABSTRACT:

In Australia, commercial tree size management in mango orchards involves annual machine hedging and heavy hand pruning. In tropical growing regions, heavy pruning often stimulates strong vegetative regrowth that is less likely to flower due to insufficient terminal growth unit dormancy required for flowering. A few mango rootstocks have been shown to reduce scion vigour and maintain regular, high yields, however, there is lack of rigorous field-testing of these and other rootstocks under Australian scions growing in Queensland. Apart from some scion vigour control, the effects of mango rootstocks on scion architecture has not been studied in Australia and reports in the international literature are scarce. In this study, ninety genetically diverse rootstocks have been evaluated for their ability to reduce vigour in two Australian mango scion varieties from the National Mango Breeding Program (NMBP); 'NMBP-1243' and 'NMBP-4069'. Tree height, canopy volume and shape, rootstock and scion trunk cross section area were measured in young trees 30 months after planting to evaluate tree growth and vigour. Branch angle, length and diameter, number of growth units, number of leaves, and leaf size were also measured to characterise scion architecture. Ten rootstocks were identified as reducing vigour, while maintaining the percentage of flowering terminals per canopy volume. Four rootstocks were also found to influence scion architecture by altering secondary branch angles to be closer to the horizontal, potentially making them more suited to single leader training used in high-density orchards systems. Canopy architecture parameters measured in this study suggested that rootstocks may be a useful technology for dwarfing and altering the architecture of mango scion canopies to make them more suited to intensive orchard systems.

## FLOWER BIOLOGY SESSION

**ROSA: 26**

**PRESENTER: DeJong, Ted (SP59)**

**TITLE: A Simple Conceptual Model for Explaining How Fruit Trees Work**

### ABSTRACT:

The search for pomological understanding of fruit tree development and growth has been largely dominated by attempts to understand and/or explain responses and processes in trees by studying signaling molecules (hormones or plant growth regulators) that elicit different developmental and/or growth responses of various organs in trees. This approach to understanding fruit tree development and growth has tended to increase the complexity of the subject and largely ignores the fact that studying the presence or concentration of signaling molecules does not really address what controls how the signals are elicited or received. This approach has also tended to reinforce the idea that trees need to be understood as a unified whole, rather than a sum of their parts. It has been hypothesized for decades that plants grow as semi-autonomous, interacting organs that compete for available resources at the whole plant level but that organs have their own genetically modulated controls that provide the basis for their development and growth. This hypothesis provides a simple alternative conceptual model for studying and understanding fruit tree development and growth. Thus, fruit trees can be understood by studying the behavior of individual organs and sub-organs (leaves, shoots, stems, branches, flowers/fruit, buds, roots) and the factors that govern how they function. A major argument for this approach is that one can graft several different fruit tree varieties (or in the case of Prunus, different species) onto one rootstock and the organs on each grafted scion will maintain the behavioral and physical characteristics of each parent genotype. Therefore, it is obvious that major controls for the development of individual organs rests with the organs, not with the tree as a whole. This conceptual model does not negate the importance of signaling molecules in the regulating growth and development but recognizes a level of organ autonomy in developmental and growth processes and downplays the idea that these processes are governed at the whole plant level. Sub-models of development and growth of several types of organs as well as ideas for further studies will be presented.

Friday 30<sup>th</sup> July 2021

## PRECISION FARMING SESSION

**ROSA: 100**

**PRESENTER: Khot, Lav (K7)**

**TITLE: Precision orchard management in Digital Agriculture Era: A Review**

### ABSTRACT:

Conventional as well as transitioning orchard systems are in need of the key technological interventions to effectively and economically manage them amidst increasingly dynamic seasonal climate patterns. Besides biotic and abiotic stress as well as localized crop load management challenges, technology savvy consumers demand of high-quality chemical residue free produce has added extra scrutiny on the way specialty tree fruits are produced for the fresh market. Coincidentally, technological landscape is also changing rapidly, allowing development of intervening solutions to address some of the above issues. The aim of this study is to provide overview of pertinent technological solutions being developed and commercialized for managing today's orchard systems. Synopsis includes discussion on advances in ground and aerial remote sensing technologies for monitoring crop physiological changes and key stressors in the orchard environment as well as the direct translation of such data for precision actuation of the orchard system management machines/tools. Discussed will also be some novel crop input(s) management technologies being researched by academia, start-up ventures and pertinent technology progression challenges.

## PRECISION FARMING SESSION

**ROSA: 216**

**PRESENTER: Penzel, Martin (SP60)**

**TITLE: Modelling the tree individual fruit bearing capacity of *Malus x domestica* Borkh. 'Gala'**

### ABSTRACT:

For precise crop load management, a target fruit number per tree is crucial to evaluate the actual number of fruit per tree at any time during the growing season. As the individual tree's growth capacity varies within an orchard, the target fruit number should vary accordingly for an appropriate supply-to-demand balance. The capacity of apple trees to produce fruit of desired diameters, i.e., the fruit bearing capacity (FBC), was investigated considering the inter-tree variability of canopy leaf area (LA). The LA of 996 trees in a commercial 'Gala'/M9 apple orchard was measured with a terrestrial 2D LiDAR laser scanner in two consecutive years. The leaf photochemical light use efficiency (mol CO<sub>2</sub> fixed per mol photons absorbed) and light saturated net CO<sub>2</sub> gas exchange were recorded monthly during fruit development. The FBC was simulated by utilizing the LiDAR scanned LA, fruit growth rates, gas exchange variables of the leaves and the fruit and weather data in a carbon balance model. The variance of FBC was similar in both years, whereas individual trees showed different FBC in both seasons as indicated in spatially resolved data of FBC. Considering a target mean fruit diameter of 65 mm, FBC ranged from 84 to 168 fruit per tree in 2018 and from 55 to 179 fruit per tree in 2019 depending on LA of the trees. The simulated FBC to produce the mean harvest fruit diameter of 65 mm and the actual number of harvested fruit > 65 mm per tree were in good agreement. Summarizing, results demonstrate that high variability in LA per tree and corresponding fruit bearing capacity existed within the orchard. To achieve a targeted harvest fruit diameter, the FBC should be considered in crop load management practices. For this purpose, however, annual spatial monitoring of the tree-individual FBC is required.

## PRECISION FARMING SESSION

**ROSA: 107**

**PRESENTER: Sahni, Ramesh Kumar (SP61)**

**TITLE: Fixed spray delivery systems for efficient crop input applications in deciduous crops**

### ABSTRACT:

Air-assisted sprayers are commonly used for insects and pest infestations control in perennial specialty crops. However, off-target spray drift, human exposure to chemicals and associated adverse environmental impacts, soil compaction and dependency on the ground condition are some of the major reported drawbacks of air-assisted sprayers. Therefore, a fixed spray delivery system, also known as a solid set canopy delivery system (SSCDS), has been envisioned as an alternative technique to overcome above mentioned shortcomings. This study reviews pertinent advances in SSCDS configurations being optimized for effective spray applications in the range of perennial specialty crops. Discussed will be the development and refinement of a hydraulic spray delivery (HSD) and pneumatic spray delivery (PSD) based SSCDS configurations at North American Institutions (Washington State University and Michigan State University) and Europe. Reported will be the results pertinent to various studies on the SSCDS fluid dynamics and emitter configuration optimization for efficient spray deposition, coverage and reduced off-target drift in high-density apple and cherry orchards, and vertical shoot position trained vineyards. The study will also report the progress made on SSCDS automation for ease of operation, reduced human intervention, and large-scale commercial adaptation.

## PRECISION FARMING SESSION

**ROSA: 156**

**PRESENTER: Chandel, Abhilash (SP62)**

**TITLE: High resolution ground and airborne imaging techniques for rapid mapping of orchard systems**

### ABSTRACT:

Technological interventions are needed for rapid assessment of orchard canopy attributes. Such evaluation will help drive decisions related to canopy and crop load management as well as prescriptive application of pesticides, fertilizers and growth regulators. This study is therefore aimed at assessing suitability of high-resolution ground and airborne imaging techniques for effective and rapid mapping of central leader apple canopy attributes. A small unmanned aerial system with a consumer-grade RGB imager was employed to map three-dimensional (3D) canopy attributes at ground sampling distance of 0.85 and 1.80 cm/ pixel. Data was analyzed in a geographic information system to extract zone-wise leaf wall area, porosity, tree row volume and density. Pertinent orchard block (15 random tree samples) was also imaged using an active infrared stereo depth imager. Algorithms are being developed to process above ground imagery. Ground and aerial imagery derived canopy attributes will be correlated with the ground reference leaf area index (LAI) estimated from a line quantum sensor. This study will present pertinent results and discuss suitability of the aerial imagery derived prescriptive maps for site-specific orchard management

## PRECISION FARMING SESSION

**ROSA: 46**

**PRESENTER: Auzmendi, Inigo (SP63)**

**TITLE: Virtual plants for interpreting the effects of planting density in young macadamia orchards**

### ABSTRACT:

Virtual plants are computer simulations of the development and growth of plants in 3D space. These simulations generated by functional-structural plant models are driven by explicit internal mechanisms in response to the environment, replicating tree architecture and physiological functions of individual organs in the canopy. Virtual plants have been employed for integrating several factors to simulate and understand potential growth. These computational models can be used in different ways; one of them is the interpretation of field experiments. Many tropical and subtropical plants, like macadamia, are planted in orchards with a low planting density, and productivity could be significantly increased if planted at higher densities, as has been done in apple orchards. However, testing such systems by replicating field experiments carried out in apple might not be enough, because other species may show a different behaviour. Additionally, plant variability could mask the effects of the treatments, especially in young orchards. Using virtual plants to interpret the field data could improve our understanding of how trees grow, resulting in a more efficient approach than trial and error. We implemented a virtual macadamia tree growing in orchard conditions combining sub-models of light environment, photosynthesis, potential growth of individual organs and inter-organ competition for carbon. Tree canopy architecture measured in the field was employed as the basis to simulate growth during one season. Our simulations showed the effect of planting density on growth and yield of young macadamias at tree and orchard level. It increased our understanding and helped to interpret experimental results measured in the field. Our conclusions can be helpful to improve the design of future macadamia field experiments and young orchards. This work exemplifies one way of using functional-structural plant models for practical applications in horticulture.

Friday 30<sup>th</sup> July 2021

## FRUIT QUALITY SESSION 1

**ROSA:44**

**PRESENTER: Blanke, Michael (SP64)**

**TITLE: Non-invasive detection of russet on pome fruit**

**[Detection of russet on pome fruit using the new spectral russet index (SRI) ]**

**ABSTRACT:**

The objective of the present work was to identify russet on the fruit peel using new non-invasive technology with real-time data processing including colourimetry, spectrometry, 3D profilometry and a luster sensor, on fruit of pear cultivars 'Abate Fetel', 'Conférence', 'Williams Christ', 'Sweet Sensation', 'Vereinsdechants Birne' (Comice), and 'Alexander Lucas'. Russet was identified by a profilometer with the help of true and false colour images at 40x magnification on 'Conférence' pear sections with a larger peel roughness Ra 3.3  $\mu\text{m}$  (SE 0.4) compared with Ra 2.5  $\mu\text{m}$  (SE 0.3) on russet-devoid fruit peel. Russet detection using the luster sensor CZ-H72 failed due a small difference (8 a.u.) in glossiness between russet (54.5 a.u.) and non-russet (62.5 a.u.) 'Conférence' (green) in contrast to 'Sweet Sensation' (red) with a 2.5-fold statistically significant difference between russet (29.3 a.u) and non-russet (61.2 a.u.) surface. For the red pear cultivars 'Williams Christ' and 'Sweet Sensation' (66.8 °hue for russet and 62.4 °hue for russet-devoid peel), non-invasive detection of russet was hampered when using colourimetry. For green pear, however, a statistically significant difference between russet (79.9 °hue or 82.4 °hue) and russet-devoid (94.8 °hue or 99.7 °hue for 'Conférence' or 'Alexander Lucas') pear could be detected. By contrast, russet could be successfully detected for all – red and green - varieties using portable non-invasive spectrometry (190 – 1100 nm). A new spectral russet index was proposed relating the two peaks (550 nm - 600 nm and 775 nm - 785 nm of light reflection) to the trough (667 nm - 685 nm). Russeted pear (e.g. 3.6) exhibited ca. 25 % smaller SRI values than russet-devoid peel (4.8) of both cultivars 'Conférence' (green) and 'Sweet Sensation' (red), irrespective of peel colour. Overall, both non-invasive techniques 3D-profilometer and spectral light reflection with the novel russet index, proved suitable russet detection in pears. In particular, the study has identified colourimetry as a suitable measure for russet detection for green and luster sensor for red pear cultivars. The study has also shown that russet can be identified non-invasively by a range of new affordable mostly portable technologies in real time, which offer new possibilities of russet detection in the field or on a grading line.

## FRUIT QUALITY SESSION 1

**ROSA: 64**

**PRESENTER: Louw, Esme (SP65)**

**TITLE: The effect of protracted bloom on 'Golden Delicious' fruit quality from two climatically different areas**

**ABSTRACT:**

It is well known that a protracted bloom period leads to mixed fruit maturities in deciduous fruit trees. This does not just impact on the timing of production practices through the growing season but also complicates harvest date projections due to high variability. Warm winter conditions exacerbates protracted bloom and intensifies the outcomes. To quantify the effect of flowering time (early, full bloom and late) on the maturity and quality of 'Golden Delicious' fruit, we followed individual fruit from the first signs of budbreak until commercial harvest and post regular atmosphere storage (12 weeks) in six different orchards in each of two climatically different production areas (high vs low winter chill orchards) in the Western Cape of South Africa. Starch breakdown and flesh firmness were determined and compared over five different flowering periods (early, mid-early, full bloom, mid late and late). Both climatic areas showed protracted bloom with flowering time differences of more than four weeks. The percentage flowers outside of the full bloom window ranged between 27-40% for the early and mid-early period and between 25-27% for the late and mid-late periods across the two areas. Starch breakdown in fruit from buds that received more winter chill did not differ in terms of starch breakdown at harvest but fruit from buds that received lower chill showed higher starch breakdown in the fruit from the early flowering period and lower breakdown in the late flowering period. Flesh firmness at harvest increased as the flower period extended in both areas. Interestingly the flesh firmness after storage (and seven-day shelf life period) did not differ significantly between flowering periods in the area with higher winter chill. The fruit from early flowers in this area seems to maintain a higher level of their initial firmness during storage. Correlations between starch breakdown and firmness levels at harvest and after storage are reported and discussed. The results contribute to the illustration and quantification of the negative effects of protracted bloom on fruit production and speculate about its influence on flower quality and how it shapes fruit quality.

## FRUIT QUALITY SESSION 1

**ROSA: 38**

**PRESENTER: Honaas, Loren (SP66)**

**TITLE: The 'Anjou' Genome: perspectives on winter pear production**

**ABSTRACT:**

Functional genomics is an emerging technological frontier in tree fruit production systems. This is driven in part by the increasing accessibility of genomics resources for specialty crops, which include genomes and transcriptomes. These global-scale technologies are providing insights into Rosaceous tree fruit production systems that will allow researchers and producers to maximize favorable outcomes. Recent work has shown that 'Anjou' pear fruit quality varies as a function of on-tree fruit position, specifically that fruit had distinct fruit quality attributes and metabolite profiles at harvest and throughout the storage period. To discover the genes associated with these differences, we sequenced the transcriptomes of these 'Anjou' pear fruit samples. We also sequenced the 'Anjou' genome to help us understand the impact of cross-cultivar transcriptome data analysis and to discover genes in this winter pear cultivar to enable comparative genomics of European pear.

Friday 30<sup>th</sup> July 2021

## FRUIT QUALITY SESSION 2

**ROSA: 92**

**PRESENTER: Anthony, Brendon (SP67)**

**TITLE: Comprehensive physiological and metabolomic analysis to identify metabolic signatures of the impact of canopy position on peach fruit quality**

**ABSTRACT:**

Fruit developing in different canopy positions are exposed to different light microclimates that can influence their internal quality and maturity. Maturation, a highly regulated process at the genetic level, significantly impacts fruit quality. Previous literature on the effect of various pre-harvest factors on fruit quality is limited due to poor control of maturity among comparisons. An experiment was conducted to assess the impact of canopy position (bottom: 0-1.2m, middle: 1.3-2.1m, and top: 2.2-3.0 m) on peach fruit internal quality. Two peach cultivars: 'Sierra Rich' (low vigor) and 'Cresthaven' (high vigor) were evaluated. The whole lot of fruit from the different canopy positions was assessed at the commercial harvest stage for size, dry matter content (DMC) and physiological maturity (index of absorbance difference, IAD), using non-destructive near-infrared (NIR) spectroscopy. This approach allowed for a comprehensive physiological analysis on fruit of equal maturity levels to assess the true impact of canopy position on peach quality. When evaluating all of the fruit, maturity and DMC increased linearly with the elevated height of canopy in both cultivars. However, when controlling for equal maturity, only fruit coming from the vigorous 'Cresthaven' trees showed a significant  $\Delta$  DMC of 2.1% between extreme canopy positions. Given the lower vigor of 'Sierra Rich', it was hypothesized that light was more evenly distributed throughout the canopy leading to fruit of uniform quality across the different positions. Extensive and non-targeted profiling of primary and secondary metabolites was carried out using gas chromatography mass spectrometry (GC-MS) on the mesocarp and skin of equally mature peach fruit samples. Overall, this combined physiological and metabolomic analysis provides insight into the real impact of canopy position and underscores that distinct light environments may facilitate specific regulations in peach fruit quality development.

## FRUIT QUALITY SESSION 2

**ROSA: 15**

**PRESENTER: van Hooijdonk, Ben (SP68)**

**TITLE: Aminoethoxyvinylglycine maintains fruit red skin colour and delays maturation, improving size and quality of 'PremP009' pear**

**ABSTRACT:**

'PremP009'/Piqua®Boo® is an interspecific pear derived from the *Pyrus* species *P. communis*, *P. pyrifolia* and *P. bretschneideri*. 'PremP009' fruit are pyriform with vibrant red skin and a "ready to eat" harvest texture. Because of its complex pedigree and recent commercialisation, the physiology of 'PremP009' is not well understood. From field observations, fruit sometimes exhibit reduced red skin coverage under high summer temperatures, and harvest fruit-drop in some young orchards necessitates 3-to 4-day select-picking intervals. In pomefruit, fruit development, maturation and abscission are regulated by endogenous hormones including ethylene. We treated 'PremP009' trees with  $\pm$  aminoethoxyvinylglycine (AVG, 0.83 g/L) at three different preharvest timings (mid-December, mid-January, and late January) to elucidate how perturbing ethylene biosynthesis modified fruit development and quality. In February, fruit were harvested seven times over 25 days. A Compac InVision and weight sizer were used to quantify fruit size and colour. Across treatments, mean fruit weight increased markedly from day 1 (116 g) to 25 (197 g) of harvest. These increases in fruit weight were associated with decreasing red skin coverage over the fruit surface (67% to 38% from day 1 to 25). AVG applied in mid-January ( $\approx$ 20 days before harvest) helped maintain red skin colour, but delayed maturation and harvest timing, increasing mean fruit weight by  $\approx$ 20 g. Fruit drop was delayed but not reduced by AVG. We discuss the potential of AVG for managing fruit maturity, marketable yield and postharvest physiology of 'PremP009'.

## FRUIT QUALITY SESSION 2

**ROSA: 198**

**PRESENTER: Whiting, Matthew (SP69)**

**TITLE: Intra-canopy variability in apple and sweet cherry fruit quality**

### ABSTRACT:

Fruit quality is a fundamentally important determinant of crop value, and, combined with yield, largely determines orchard profitability. As such, fruit quality parameters are well-studied among genotypes, within orchard systems, or in response to a myriad of treatments. Irrespective of trial design and objectives, fruit quality data are typically generated from analyses of 'random' subsamples from the population of fruit. In the current study, we evaluated the variability in quality attributes among all fruit in apple (*Malus domestica* Borkh) and sweet cherry (*Prunus avium* L.) trees. As an initial step to developing management strategies for optimizing fruit quality, we sought to better define the existing variability in quality attributes among fruit and identify the sources of that variability. We compared quality of fruit from 7-year-old 'WA38' apple, 3-year-old 'Fuji' apple trees in a high-density commercial orchard and, for reference, a single 'Fuji' tree in a moderate density commercial orchard. Trees were defoliated manually just prior to commercial harvest, and the position of each fruit and major tree limbs were mapped using a Topcon total station laser scanner. Each fruit was evaluated for key quality parameters including weight, soluble solids content, firmness, and exocarp color. There was significant variability in every quality trait among individual fruit, with 2-3 fold range for most attributes. There were no clear relationships between fruit position in the canopy and any quality attribute in the high-density trees. We also conducted fruit quality analyses on individual 'Santina' sweet cherry fruit from trees trained to the UFO system in a commercial block. Across 2100 fruit evaluated, there was a range in fruit weight of ca. 3 g – 13 g, in firmness of ca. 150 – 400 g/mm, and in soluble solids of ca. 9.5 – 22 %. Interestingly there were no strong relationships between exocarp color and any other quality parameter. This work highlights the significant variability in fruit quality among fruit despite their being grown with high management inputs and in modern fruiting wall systems. Our work continues to identify key developmental and/or physiological factors that contribute to this variability.