

## **Final Report**

# **Rootstock and Training System to Optimize Stone Fruit Bearing and Growth**

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**Delivery partner:**

Department of Economic Development, Jobs, Transport & Resources

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Rootstock and Training System to Optimize Stone Fruit Bearing and Growth – SF13001

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## Summary

Summerfruit is a major horticultural industry in Australia; however sales growth is impeded by low consumer satisfaction with fruit quality. This can lead to low prices and static consumption, threatening the survival of many producers. Agriculture Victoria Research (AVR) undertook to investigate orchard management practices that will dramatically increase productivity and grower returns through improved eating quality and consumer satisfaction. During tree establishment, orchards are known to have variability in fruit quality and composition, partially due to uneven flowering and tree growth. The effect of rootstock, crop load and light interception, during this early establishment period is virtually unknown. The aim was to generate knowledge of the effect of these factors on the tree and fruit development. In association with SF12003, partnerships were developed with the Agriculture Services (Horticulture) team to inform growers and other industry stakeholders of project findings and updates on research activities. The project conducted numerous industry engagements, including regional roadshows, orchard tours, presentations, YouTube videos and factsheets, as well publishing scientific manuscripts and presenting results at international conferences and hosting international postgraduate students.

Experiments were designed and conducted in the stone fruit experimental orchard in Tatura (established by project SF12003) to investigate the dynamics of plant and fruit development within the different canopy systems, particularly fruit development and reserves as wood starch content. Fruit sensors were utilized to non-destructively monitor fruit composition and dry matter (by Near Infra-Red spectroscopy: NIR) and fruit physiological maturity using a chlorophyll content index (Index of Absorbance Difference:  $I_{AD}$ ) correlated with ethylene production. The determination of physiological maturity is key to improving industry outcomes with regards to profitability, and positive consumer experiences in both domestic and export markets.

Fruiting levels (crop load) affected a series of physiological factors in the trees (i.e. reducing shoot growth, quantity of pruning wood and fruit size) and generally delayed fruit maturity, but it did not affect wood starch reserves in any of the canopy systems or rootstocks investigated. In new planted orchards, drastic reduction or full removal of fruit in the first year allowed for increased starch accumulation and improved tree uniformity.

Overall, adjustments to cropping levels to optimize fruit size and quality should help in maximizing gross returns on a per hectare basis. Also, the use of non-destructive tools to determine physiological fruit maturity and composition, such as the DA-meter and NIR respectively, are invaluable to assist industry in determining harvest times, fruit quality and farm logistics. This will improve the number of acceptable fruit in the market place, resulting in higher customer satisfaction, repeat purchase and positive recommendations.

The Summerfruit experimental orchard at Tatura provided the platform to conduct research into fruit and tree physiology as well as providing a resource for informing and training growers, students and service providers of modern high-density orchard systems, IPM and irrigation and fertigation management. There is an excellent opportunity to continue utilizing the experimental orchard to better understand tree and fruit physiology, validate sensing and automation technologies, (including robotics) and improve agronomic practices.

## Keywords

Peach; nectarine; experimental orchard; agronomic management practices; crop load; canopy architecture; fruit maturity; non-structural carbohydrates; starch; DA-Meter.

## Introduction

Summerfruit production in Australia is worth over \$380 million, with Victorian production accounting for over 80% (HIA 2017). Sales growth of summerfruit is impeded by low consumer satisfaction with fruit quality, leading to low prices and static consumption which is threatening the survival of many producers. Agriculture Victoria Research (AVR) undertook to investigate management practices that will dramatically increase productivity and grower returns through improved eating quality and consumer satisfaction. The objectives of this project aligned with the Australian Summerfruit Industry Strategic Investment Plan 2015-2020 and Victorian Government Initiatives (Growing Food & Fibre, Food to Asia Action Plan) by developing knowledge that results in new management practices that dramatically increase productivity, fruit quality and grower returns.

In the early stages of development, orchards are known to have high variability in fruit quality and maturity. This is partly due to uneven flowering and tree growth but the effect of rootstock, crop load and light interception, on the early tree physiological processes is virtually unknown. Understanding these factors will provide growers with earlier, more consistent fruit than is achieved now. The Summerfruit experimental orchard provides controlled conditions to investigate the factors that affect long term tree establishment, fruit yield, consistency and quality.

In temperate fruit trees, early spring shoot growth depends on carbohydrate reserves accumulated in the previous season. Vigorous rootstocks can accumulate more reserves, which contribute to a higher initial flush of shoot growth and different tree growth characteristics (Weibel et al, 2011). There is limited knowledge on the effects of crop load on dry matter allocation in peach as influenced by vigour of the rootstock and length of the fruit development period, which could alter sink activities of early and late ripening peach fruit (DeJong et al. 1987). In addition, according to Radice et al, (2004), rootstock could influence fruit set, production and floral morphology in peaches.

Understanding the effects of major orchard management systems on tree growth is fundamental to determining best management practices for rootstock selection, canopy management and crop load to boost early bearing and to ensure optimal tree growth and subsequent consistent fruit size and quality from the early years of production.

There is currently no objective information available to summerfruit growers on the performance of rootstocks in Australia and their impact on fruit size, composition and quality. Without knowledge of how rootstocks and their interaction with crop load, affects the physiology of fruit development and fruit composition, it is impossible to develop models and protocols to optimise fruit production, quality, minimise variability and produce fruit that meet consumer expectations.

Uniform growth, early bearing and optimal fruit size, quality and composition from early harvests will allow the growers to capitalise earlier on their investments, reduce production costs and increase productivity. Improving fruit quality will also increase consumer demand and provide a point of difference for Victorian fruit on both domestic and export markets. Determining how these factors (i.e. canopy systems and their interaction with cropping levels) influence fruit composition has not been done before. This will provide Australian stone fruit growers with a significant and unique market advantage and point of difference by supplying consistent quality fruit that consumers want. An independent cost benefit analysis by Horticulture Australia Limited estimated that this project will provide a benefit (NVP) of approximately \$5.7 million, 10 years after the start of the project with a cost benefit ratio of 6.64 despite having used the lowest value for farm gate price (\$ 2000/ton).

## Methodology

This project used the stonefruit field laboratory to investigate tree training, rootstock and their interaction with cropping levels to optimize young tree production and growth of peach and nectarine cultivars. The stonefruit field laboratory is located at Agriculture Victoria Tatura (36.44° S, 145.27° E; 114 m APSL) in the Goulburn Valley region of Victoria, Australia. The soil is a red-brown earth or Red Sodosol (Isbell 2002) known locally as Shepparton fine sandy loam (Skene and Poutsma 1962). The region has a temperate climate with average annual rainfall of approximately 480 mm. Annual average reference crop evapotranspiration  $E_{To}$  is approximately 1190 mm (22-year mean, [www.longpaddock.qld.gov.au/silo](http://www.longpaddock.qld.gov.au/silo)). Trees were planted in winter 2013 in north-south orientated rows at 4.5 m row spacing.

The research pre-schedule developed in 2014 (see Appendix 3) details objectives and aims, research questions, experimental design, methods and equipment to undertake the physiological and chemical studies to determine starch accumulation and dynamics in peach and nectarine wood. Appendix 4 summarises field experiments at the experimental orchard including: cultivar, experimental treatments, orchard design, planting density, planting date, tree architecture and tree training. For this project, two production seasons of experimental data on young trees were collected in the experimental research orchard from the crop load x rootstock experiments and three years for the canopy x crop load experiment for peach and nectarine. Data on starch accumulation dynamics as affected by crop load x canopy system and rootstock were collected over four and three years, respectively, to include non-bearing young trees.

The Stonefruit Field Laboratory advisory committee (established in 2013 for project SF12003) was utilized to assist in experimental decisions and agronomic advice. The committee was fundamental in selecting cultivars, rootstocks/scion combinations, tree density, trellis systems, irrigation systems and steered decisions on experimental factors: agronomic management practices (canopy architecture, irrigation strategies, crop load management) and tree management (nutrition, tree training, pest/disease/weed management). Advisory committee meetings were held for both SF12003 and SF13001 bi-annually to update on project progress, discuss future research and communication directions and seek feedback on findings from the field research program. Appendix 1 outlines the advisory committee terms of reference and membership.

As part of the project, an analysis of the benefits and costs of the fruit thinning treatments in the canopy crop-load experiments was undertaken. The objective of this analysis was to determine whether the fruit thinning treatments in the canopy crop-load experiments being undertaken in the stone fruit field laboratory at Tatura: (a) increased crop value on a per hectare basis, net of thinning and harvesting expenses, and (b) improved the timeliness of operations and hence the value of shelf-life at harvest. The weighted average unit price (\$/t) for each crop-load treatment was calculated from the observed fruit-weight distribution and a hypothetical premium and discount schedule. Gross returns on a per hectare basis (\$/ha) were then calculated by multiplying the average unit price by the experimental yield. Net returns (\$/ha) were then estimated by subtracting hypothetical thinning and harvesting costs, these being the costs that vary with crop load. Inspired by Hummels (2007), this analysis proposes a method to value 'timeliness cost' using the DA-meter.  $I_{AD}$  at harvest was expressed in dollar terms by multiplying the average orchard-gate price by the shelf-life of the harvested fruit (in days) and the ad valorem (percentage) value of a day in the supply chain. Shelf-life at harvest for each crop-load treatment was determined from the  $I_{AD}$  decay function. A more detailed explanation of the cost analysis methods and results is reported in Appendix 5.

The project delivered updates and research findings to industry via presentations, industry articles and publications such as grower magazine articles, fact sheets, newsletters, website content (Horticulture Industry Network, HIN: [www.hin.com.au](http://www.hin.com.au)) and YouTube videos. Numerous industry adoption activities were conducted during the 2013 – 2018 period including: orchard walks/tours, workshops and industry (local and regional) roadshow events.

## Outputs

The project produced a diverse series of outputs including scientific manuscripts, research presentations, posters, industry magazine articles, industry presentations, fact sheets, newsletters, website content and videos (See Appendix 6 for list and electronic copies). In addition, a series of orchard walks/tours, workshops and industry roadshow events were produced as industry adoption activities (see appendix 7 for full list) in common with the linked project SF12003.

### Conference papers and posters

Two oral and one poster papers presented at the 29<sup>th</sup> International Horticultural Congress in Brisbane, 17 – 22 August 2014.

One invited lecture presented at the Master of International Horticultural Science, University of Bologna, Italy, 2013

Five oral papers presented at various national scientific forums (i.e. AgriBio and Tatura seminar series, DEDJTR Innovation Forum, etc).

One poster paper presented at the 11<sup>th</sup> Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems, Bologna, Italy, 28 August – 2 September 2016

One abstract submitted to the 30<sup>th</sup> International Horticultural Congress in Istanbul, Turkey, 14 – 18 August 2018

### Scientific manuscripts

Four scientific manuscripts submitted to Acta Horticulturae, three published and one accepted for publication.

### Industry articles

5 articles published in Australian Stonefruit Grower magazine and 2 articles published in Tree Crop magazine, describing experimental results and protocols relevant to industry.

### Fact sheets

3 fact sheets describing optimal harvest conditions for the nectarine cultivars ‘Autumn Bright’ and ‘Rose Bright’ and the peach cultivar ‘August Flame’. Fact sheets are currently under QA and will be uploaded on the HIN web page.

### Industry presentations

Two presentations at SAL-AGM meeting in Swan Hill (2014), one presentation at the South Australia AGM meeting, Renmark (2014), 2 presentations at the Stonefruit Roadshows in Renmark, Swan Hill and Cobram (2016 and 2017), reporting on the various experimental results, and one workshop for SPC Ardmona on the practical usage of the DA-Meter in the field.

### Field days

Orchard tours commenced in the first season of the project (2013) (See appendix 7 for full list). Project updates and orchard walks were conducted for each advisory committee meeting (twice yearly). Informal grower, consultant, Hort Innovation and Fruit Growers Victoria visits, international delegations, and visits by students, scientists, DEDJTR staff and the Victorian Minister for Agriculture have been documented in the annual progress reports and reported in appendix 7.

### Progress reports

Six monthly progress reports were submitted to Hort Innovation by the due date and accepted.

### Intensive stonefruit web site

Agriculture Victoria’s ‘Premium Fruit to Asia’ (PF2A) 2014/15-2017/18 project provided extension of ‘Stonefruit Research’ undertaken by Agriculture Victoria via the Horticulture Industry Networks (HIN) website. The initial PF2A extension focus on marketing, post-harvest management and economic analysis was expanded to include information about the ‘Profitable Stonefruit’ experiments (SF12003, SF13001 and SF15001), practical video demonstrations of pruning and training practices, and links to industry articles. The HIN ‘Stonefruit Research’ site provides an easily accessible and comprehensive resource for growers. (<http://www.hin.com.au/networks/profitable-stonefruit-research>).



## Videos

A series of YouTube videos were also produced to facilitate industry adoption toward reduction of variability and improve orchard management. Videos were published on Horticulture Industry Network website (HIN - [www.hin.com.au](http://www.hin.com.au)) depicting the following themes:

- Description of orchard and canopy managements (training stone fruit for mechanization and summer pruning)
- Fact sheets on optimal harvest characteristics for the varieties in the study (to be uploaded shortly).
- Protocols on fruit maturity monitoring using non-destructive technology divided in various subjects:
  - Concept and protocols for using the  $I_{AD}$  index (produced by the DA-Meter) to monitor fruit maturity in the field and to harvest at optimal time.
  - Detailed explanations on the usage, data downloading and troubleshooting of the DA-Meter
  - Importance of continuous monitoring and how to interpret data and graphs generated from the DA-Meter.
  - A series of lectures on the Importance of fruit maturity through innovation technology and pre and postharvest management of fruit maturity for market access.

## Outcomes

The key research findings are summarized below.

### **Starch accumulation and dynamics as affected by rootstock, canopy system and crop load:**

- 1) Starch accumulation was highest in the winter wood followed by spring and summer woods, independently of canopy system or rootstock.
- 2) With tree aging, starch in winter wood increased while it decreased in the summer wood, independently of canopy system or rootstock.
- 3) Rootstocks with lower vigour accumulated less starch in wood.
- 4) Crop load did not affect starch accumulation and was independent of canopy system or rootstock.
- 5) Reducing irrigation level (deficit irrigation) reduced starch accumulation in the wood which could later affect bud quality and numbers.
- 6) Different scions accumulated different starch concentrations in wood independently of rootstock and canopy system, suggesting possible different responses to various stresses.

### **Orchard management and fruit quality:**

- 1) Usage of non-destructive equipment (DA-meter) to monitor fruit maturity is important to identify optimal harvest timing and to plan farm logistics.
- 2) Increasing fruiting level (higher crop load) delayed time of ripening, independently of canopy system or rootstock.
- 3) Increasing fruiting level (higher crop load) reduced fruit size, shoot growth and amount of pruning wood, independently of canopy system or rootstock.
- 4) With increasing tree age, the variability in fruit maturity between top and bottom of the canopy was more evident and exacerbated by higher crop loads.
- 5) In young vase trees (2<sup>nd</sup> production), minimal fruit maturity variability within the canopy was detected irrespective of the rootstock or crop load level.
- 6) Rootstocks did not influence fruit maturity up to the 2<sup>nd</sup> year of production.

As part of the project, an analysis of the benefits and costs of the fruit thinning treatments in the canopy and rootstocks crop-load experiments was undertaken. Predicted unit values, gross crop values and net crop values were calculated for all species/cultivars and fruit thinning treatments in the canopy crop-load experiments for the seasons 2016/17 and 2017/18. Fruit thinning increased fruit size and unit values according to the market price structure. However, increased average fruit size came with large yield penalties. To maximize gross returns on a per hectare basis, considering fruit bigger size and consequent higher premium, the additional reduction of crop level from the standard grower practice (mid-crop load treatment in our experiments) should be applied but not higher than 10%. There was little variation in the timeliness of operations, and hence the value of shelf-life, between crop-load treatments (See Appendix 5 for detailed report).

The project identified cultivar maturity classes based on chlorophyll content correlated with ethylene production for the peach and nectarine cultivars involved in the project. Growers can access maturity class indices, from the HIN website, to enable more accurate harvest timing for improved farm and pack shed logistics and delivery of fruit with higher quality to the market. Benefits to the summerfruit industry are predicted to be: improved production practices and reduced costs, increased exports, higher prices received from fruit sales and sustainable industry growth and profitability. The project has worked with Summerfruit Australia to introduce the DA-meter in Australia, therefore enabling adoption of the innovative technology by growers. Several growers in different fruit growing districts across Australia are already using the DA-meter to assess fruit maturity to deliver better quality fruit to consumers (i.e. Zest group).

## Monitoring and evaluation

During the course of the project there was regular engagement and communication with summerfruit industry which has been made aware of any information pertinent to make more informed decisions. Regular feedback was sought from industry through the advisory committee meetings held as part of SF12003 project as well as through a series of industry adoption activities (presentations at grower meetings and conferences, roadshows, orchard walks and tours).

The strategies for adoption of project information included collaboration with Summerfruit Australia and DEDJTRs Agriculture Services (Horticulture) team to establish an extension program within the Victorian Government's Food to Asia program. Through it, a series of communication activities were undertaken including roadshows, orchard tours and industry articles. A series of YouTube videos, project research updates and newsletters were also made available through the Horticulture Industry Network (HIN) website ([www.hin.com.au](http://www.hin.com.au)).

Project visibility was increased by participating in international conferences (29<sup>th</sup> International Horticultural Congress, IHC2014, Brisbane; 11<sup>th</sup> International Symposium on Integrating Canopy, Rootstock and Environmental Physiology in Orchard Systems, Bologna, Italy) and visiting international research institutes. As a result, from a visit to Bologna University in 2013, a Master student (Mr A. Ceccarelli) visited Australia for 6 months to conduct experiments on the effects of crop load on fruit quality at harvest in nectarine, and postharvest performance based on fruit maturity at harvest. Similarly, a visit to the University of Palermo in 2017, provided the opportunity for a PhD student (Mr A. Scalisi) to study the effects of irrigation scheduling to wood starch storage, fruit quality and maturity on nectarine in the experimental orchard over a 9-month period. The project also hosted several undergraduate students from University of Melbourne and RMIT as part of their practical training science program. These research collaborations and subsequent scientific presentations and publications represent unintended project outcomes during the 2013 – 2018 period.

The project established techniques enabling the non-destructive monitoring of stone fruit maturity. These techniques include the protocol for accurate sampling in the field to monitor on tree fruit ripening and canopy variability. These techniques have begun to be adopted by industry as demonstrated by Project leader Dr Dario Stefanelli that was asked to supervise the scientific aspect of an industry project from SPC Ardmona (confidential) aimed to create protocols for harvesting and postharvest monitoring of fruit maturity using the DA-meter, further increasing technology adoption. The project was approved by the Victorian government in the new technology industry adoption program as part of the Horticulture Innovation Fund.

The overall reception and feedback of the project from growers and industry, either verbal, by email or survey (roadshows), has been very positive as shown by the surveys summaries in Appendix 8. The project greatly benefited by being linked to SF12003 through which a series of orchard walks and tours were delivered, increasing visibility and acceptance of the research program as shown by the repeat visits and tours by delegations to the experimental orchard during the course of the project (see Appendix 7). International visibility and interest in the research program was also great as shown by the collaboration established with foreign research institutions culminated in the hosting of Master and PhD students (see above). Furthermore, the project team was awarded with DEDJTRs Farm Services and Agriculture Research Award 2015/16 for Science in November 2016.

## Recommendations

This project supports the stone fruit sector to become more globally competitive by improved orchard management practices geared to producing consistent high fruit quality.

Key recommendation from the project:

- 1) Usage of non-destructive equipment (DA-meter) to monitor fruit maturity (minimum of 60 fruit starting 4 to 6 weeks prior to harvest, as also suggested by Bonora et al. (2014)), is important to identify optimal harvest timing and to improve farm logistics.
- 2) In cases where tree canopies have uneven light distribution, monitoring of fruit maturity should be performed in different canopy positions to better time the various pickings while maintaining high fruit quality and further improving farm logistics (i.e. rotation of picker crews, volumes to be stored and packed).
- 3) For new planted orchards, drastically reducing or fully removing the fruit in the first year of production allows for increased starch accumulation reserves and improved tree uniformity.
- 4) Adjusting cropping levels as suggested in SF12003 (thin at the target cropping level of 1 fruit per 12 – 15 cm of fruiting lateral and when fruit are < 15 mm diameter) should maximise gross returns on a per hectare basis.

Additional areas of research and innovation identified during the project:

- a) Non-destructive sensing of fruit quality in the orchard and along the value chain (i.e. maturity, soluble solids, chemical composition) to improve fruit quality, traceability and logistics.
- b) Understand relationship between light interception and row orientation with structural and nonstructural carbohydrates production, accumulation and distribution in relation to short and long-term orchard sustainability.
- c) Investigate the relationship between rootstock, crop load, canopy system and irrigation on wood starch accumulation to better understand the role in mature trees toward better crop sustainability.
- d) Utilise image analysis to correlate flower density to optimal crop load for flower thinning management.

Overall for the rootstock experiments only two years of production data were available and one of them (2017/18) was strongly affected by frost reducing the effects of the crop load treatments, therefore, making it difficult to deliver secure recommendations.

The stone fruit experimental orchard at Tatura is recognized nationally and internationally as demonstrated by the level of interest from Australian growers as well as the number of international collaborations linked to it. Continued investment to operate the stone fruit experimental orchard will enhance these collaborations and provide a world-class research and training facility to test many aspects of whole-of-supply chain RD&E for temperate fruit industries incorporating pre- and post-harvest, crop physiology and agronomy, consumer preference, marketing and IPM disciplines.

## Refereed scientific publications

### Journal article

Stefanelli, D., Jaeger, J, Haberfield, D, O’Connell M., 2018. The effects of canopy architecture and crop load on non-structural carbohydrate in young stonefruit trees. Accepted for publication by *Acta Horticulturae* on 19/04/2018.

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## **Intellectual property, commercialisation and confidentiality**

'No project IP, project outputs, commercialisation or confidentiality issues to report'

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## Appendices

### Appendix 1 Stonefruit Advisory Committee in common with SF12003 - Terms of Reference



Terms of Reference -  
Advisory Committee.

### Appendix 2: Experimental Pre-schedule in common with the Stonefruit Field Laboratory (SF12003)



Preschedule -  
Stonefruit.pdf

### Appendix 3: Experimental Pre-schedule addition specifically for aspects of this project (SF13001).



SF13001  
preschedule\_additic

### Appendix 4: Summary of field experiments in the Stonefruit Field Laboratory, Tatura



Summary of field  
experiments.pdf

### Appendix 5: Benefit/cost analysis for the crop load experiments

















Crop load  
economic analysis.p

### Appendix 6: Project activities and publications, in addition to SF12003

Activity/Event	Title	Publication
Invited lecture at Bologna University, 2013	Modern Horticulture: A Journey Through Quality?	Quality in Hort at Bologna.pdf
Abstract submitted to 29 <sup>th</sup> IHC congress, Brisbane 2014	Influence of crop load and canopy position on fruit maturity and quality in nectarine	IHC2014_Abstract_cropload.pdf
Research Addition to SF12003 (CMI104603) Pre-schedule, 2013	Wood starch and sugars measurement methods submitted to DEDJTR statistician and endorsed	Starch_protocol_Approved.pdf

Oral presentation at the AgriBio seminar series, 2013	Influence of crop load and canopy position on fruit maturity and quality in nectarine	 Semina_AgriBio_Ros eBright_Feb14.pdf
Thesis for the “International Master in Horticultural Science”, Bologna, Italy, 2013	Methods for controlling fruit load to affect yield and fruit quality in peach and nectarine	 Alessandro Ceccarelli Master Thesis-2014.p
Industry article in Australian Stonefruit Grower, August 2013,3/13:18-20	Current direction of international peach and nectarine research – Is the Australian summerfruit industry up to speed?	 Lopresti-ASG-August-2013.pdf
Industry article published on Australian StoneFruit Grower May 2014	Usefulness of the I <sub>AD</sub> Index in the field: characterization of the Tatura Trellis training system on fruit maturity and quality in nectarine	 DA_Tatura_published.pdf
Oral presentation at the DEPI, R&D forum, 2014	Fruit ripening along the Supply chain – Revolution of the I <sub>AD</sub> Index	 Stefanelli_DAMeter_2014.pdf
Oral presentation at 29 <sup>th</sup> International Horticultural Congress, Brisbane, Qld, Aust., 20th August 2014	Fruit maturity and quality in nectarine as affected by crop load and canopy position	 presentation Brisbane GC-DS.pdf
Oral presentation 29 <sup>th</sup> International Horticultural Congress, Brisbane, 2014	Understanding the factors affecting within-tree variation in SSC in peaches and nectarines	 IHC 2014 presentation John Loj
Poster at 29 <sup>th</sup> International Horticultural Congress, Brisbane, 2014	Stone Fruit Value Chain: A Systems Approach for Improved Consumer Satisfaction	 DStef_valuechain_BrisbaneV2.pdf
Scientific manuscript published in Acta Horticulturae, 2016	Stone Fruit Value Chain: A Systems Approach for Improved Consumer Satisfaction	 Acta Horticulturae_1120_
Scientific manuscript published in Acta Horticulturae, 2016	Influence of Crop Load and Canopy Position on Fruit Maturity and Quality in Nectarine.	 Acta Horticulturae_1119_
Scientific manuscript published in Acta Horticulturae, 2016	Understanding the factors affecting within-tree variation in soluble solids concentration in peaches and nectarines	 Acta Horticulturae_1130_
Industry article published in Australian Stonefruit Grower August 2014, 3/14:29-34	How does crop load and fruit position influence variability in Rose Bright nectarine quality?	 How does crop load and fruit position influ
Oral presentation at grower meeting in Renmark, SA, 2014	Effect of crop load and tree position on fruit quality variation in Rose Bright nectarine	 Renmark Crop load Rose Bright JL July 20
Oral Presentation at SAL - AGM Swann Hill, 2014	Influence of crop load and canopy position on fruit maturity and quality in early nectarine	 Seminar Rose Bright Swann Hill-Aug 2014.
Oral Presentation at SAL - AGM Swann Hill, 2014	Reducing variability in summer fruit quality through improved tree management	 Stone fruit sugar-quality 2014 Fi
Industry article published in Australian Stonefruit Grower August, 2015	Life and growth of the stone fruit canopy trial – the first two years	 Australian-Stonefruit-Grower_August2015

Oral presentation at the AgriBio seminar series, 2015	Capitalising on the importance of fruit maturity through innovative technology	 AgriBio seminar .pptx.pdf
Workshop seminar delivered to train SPC Ardmona personnel, 2016	Difference of Absorbance technology - Application of the I <sub>AD</sub> Index in pome and stone fruit	 Stefanelli_DAMeter-workshop_2015.pdf
Industry article published in Australian Stonefruit Grower May 2016:18-20	Ripe for the enterprise	 Grower-News-May-2016-Low-Res---Sur
Industry article published in Tree Crop August/September issue: 26-29, 2017	Preliminary results from rootstock study	 TC_AugSept_2017.pdf
Abstract submitted to the 11 <sup>th</sup> international Symposium Bologna, Italy, 28/08-02/09/2016	Non-Structural Carbohydrate in young stone fruit as affected by canopy training: preliminary results	 Abstract poster Bologna 2016.pdf
Poster presented at the 11 <sup>th</sup> international Symposium Bologna, Italy, 28/08-02/09/2016	The effects of canopy architecture and crop load on non-structural carbohydrate in young stone fruit trees: preliminary results	 Stefanelli_Poster-st arch2016 v2.pdf
Oral presentation at the Innovation Forum in Tatura, 2016	Pre and post-harvest management of fruit maturity and quality for market access	 Pre and post harvest quality_Tat21
Oral presentation at Regional Roadshows in Renmark, Swan Hill and Cobram, 2016	Ethylene Sampling Protocols to calibrate for fruit maturity using the DA meter. <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-grower-events">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-grower-events</a>	 Stefanelli_workshop_tour_2016.pdf
Oral presentation at Regional Roadshows in Renmark, Swan Hill and Cobram, 2017	DA-Meter protocols in the field, Observations and Results. <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-grower-events">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-grower-events</a>	 Stefanelli_workshop_tour_2017.pdf
Industry article submitted to “Tree Crop” magazine, May 2018	Non-destructive orchard determination of sugars and dry matter in ‘September Bright’ nectarines subjected to different irrigation practices	Under publication
Oral presentation at the Tatura seminar series, 2018	In-field automatable tools for the determination of plant physiological responses and fruit quality parameters in ‘September Bright’ nectarines subjected to deficit irrigation strategies	 Presentation Australia - Alessio2.1
Abstract submitted to 30 <sup>th</sup> IHC congress, Istanbul, Turkey, 2018	Continuous detection of plant water status in high density ‘September Bright’ nectarines	 Abstract IHC-S33 final.pdf
Scientific manuscript accepted for publication by Acta Horticulturae on April 2018	The effects of canopy architecture and crop load on non-structural carbohydrate in young stonefruit trees.	Under publication
YouTube video	Description of orchard and canopy managements (training stone fruit for mechanization) <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-novel-canopy-systems-for-mechanisation">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-novel-canopy-systems-for-mechanisation</a>	
YouTube video	Description of orchard and canopy managements (summer pruning) <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/some-stonefruit-pruning-techniques">http://www.hin.com.au/networks/profitable-stonefruit-research/some-stonefruit-pruning-techniques</a>	
YouTube video	Concept and protocols for using the IAD index (produced by the DA-Meter) to monitor fruit maturity in the field and to harvest at optimal time. <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality</a>	

YouTube video	Detailed explanations on the usage, data downloading and troubleshooting of the DA-Meter <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/how-to-use-the-da-meter">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/how-to-use-the-da-meter</a>	
YouTube video	Importance of continuous monitoring and how to interpret data and graphs generated from the DA-Meter. <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/understanding-da-meter-data-using-graphs">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/understanding-da-meter-data-using-graphs</a>	
YouTube video	Lecture on the Importance of fruit maturity through innovation technology <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/capitalising-on-the-importance-of-fruit-maturity-through-innovation">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/capitalising-on-the-importance-of-fruit-maturity-through-innovation</a>	
YouTube video	Lecture on pre and postharvest management of fruit maturity for market access. <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/pre-and-post-harvest-management-of-fruit-maturity-and-quality-for-market-access-of-stonefruit">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-maturity-and-fruit-quality/pre-and-post-harvest-management-of-fruit-maturity-and-quality-for-market-access-of-stonefruit</a>	
YouTube videos and web page, 2018	Continuous detection of plant water status in high density 'September Bright' nectarines - <a href="http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-irrigation-trials/continuous-detection-of-plant-water-status-in-high-density-september-bright-nectarines">http://www.hin.com.au/networks/profitable-stonefruit-research/stonefruit-irrigation-trials/continuous-detection-of-plant-water-status-in-high-density-september-bright-nectarines</a>	
Media article, 2018	Plant-based probing could transform orchard irrigation by saving water and cutting costs. - <a href="http://www.abc.net.au/news/rural/2018-06-04/plant-based-probing-could-lead-to-water-savings/9824838">http://www.abc.net.au/news/rural/2018-06-04/plant-based-probing-could-lead-to-water-savings/9824838</a>	
Fact Sheet draft, to be uploaded on HIN webpage	Harvest Fact Sheet for cv 'Autumn Bright'	 Harvest Fact Sheet for AutB.pdf
Fact Sheet draft, to be uploaded on HIN webpage	Harvest and storage Fact Sheet for cv 'August Flame'	 Harvest and Storage Fact Sheet f
Fact Sheet draft, to be uploaded on HIN webpage	Harvest and storageFact Sheet for cv 'Rose Bright'	 Harvest and Storage Fact Sheet f

**Appendix 7 Project activities in common with SF12003:**

Activity	Audience	Attendance
Presentation: Overview of Stonefruit Field Laboratory, 23 November 2012, Melbourne.	Growing Food & fibre Update (Ron Prestidge, Director - Agriculture Research) delegation.	10
Stonefruit orchard (Murray Valley) tour: Stonefruit Field Laboratory experiment objectives, orchard tour and inspection of fruit grading facility, 25-26 January 2013, Cobram	Adrian Conti, Prof Ted de Jong (University of California), Russell Fox (IK Caldwell)	5
Site tour: Stonefruit Field Laboratory - experiment objectives, 12 March 2013, Tatura.	Research Director - AgriFood (Chris Korte)	1
Presentation: Stonefruit Field Laboratory, 20 March 2013, Knoxfield.	Kaiteki Institute delegation	8
Presentation: Stonefruit Field Laboratory, 11 April 2013, Tatura	Saudi Arabia delegation	10
Site tour: Stonefruit Field Laboratory - experiment objectives, 9 May 2013, Tatura.	KPM-Horticulture (Martin Bluml), Mark Imhof, Dave Monks	4

Presentation: Research pre-schedule, 27 May 2013, Tatura.	Departmental scientists, technical and extension staff	20
Site tour: Stonefruit Field Laboratory - experiment objectives, 28 May 2013, Tatura.	Deputy Secretary (James Flintoft) delegation	10
Site tour: Stonefruit Field Laboratory - experiment objectives, 12 June 2013, Tatura.	Executive Director, Future Farming Systems Research (Ron Prestidge)	1
Presentation: Stonefruit Field Laboratory, 17 July 2013, Sydney.	Summerfruit Industry Conference	33
Site tour: Stonefruit Field Laboratory - experiment objectives, 1 August 2013, Tatura.	DEPI-Hume Region Transition Team delegation	10
Presentation: Stonefruit Field Laboratory - experimental objectives, 28 August 2013, Tatura.	DEPI Senior Executive delegation	35
Site tour: Stonefruit Field Laboratory - experiment objectives, 3 September 2013, Tatura.	HAL Program managers (Kathryn Young, Alok Kumar, Peter Melville, Richard Bennett) delegation	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 4 September 2013, Tatura.	Horticulture Industry Network delegation	10
Site tour: Stonefruit Field Laboratory - experiment objectives, 3 February 2014, Tatura.	Executive Director, Future Farming Systems Research (Ron Prestidge) and Research Manager- Horticulture (Ian Goodwin)	2
Presentation: Crop load experiment, 6 February 2014, Bundoora.	DEPI BRD and AR research staff	15
Presentation: Stonefruit Field Laboratory, 7 February 2014, Tatura.	DEPI Deputy Secretary (James Flintoft) delegation	23
Site tour: Stonefruit Field Laboratory - experiment objectives, 26 February 2014, Tatura.	Dr Erwin Engel (French National Institute for Agricultural Research) and Gavin Rose (DEPI-Chemist)	2
Site tour: Stonefruit Field Laboratory - experiment objectives, 17 March 2014, Tatura.	Prof Todd Einhorn (Colorado State University)	1
Site tour: Stonefruit Field Laboratory - experiment objectives, 7 May 2014, Tatura.	Project Advisory Committee delegation	7
Site tour: Stonefruit Field Laboratory - experiment objectives, 24 July 2014, Tatura.	DEPI (James Flintoft, Gregory Harper) delegation	7
Site tour: Stonefruit Field Laboratory - experiment objectives, 30 July 2014, Tatura.	Horticulture Center of Excellence (Sze Flett, Aimee McCutcheon, Peter Hansford) and Ian Goodwin	4
Site tour: Stonefruit Field Laboratory - experiment objectives, 6 August 2014, Tatura.	DEPI Group Leaders- Horticulture	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 13 August 2014, Tatura.	Katherine Pope (UC Davis), Rebecca Darbyshire (The Uni of Melbourne)	2

Presentation: Stonefruit Field Laboratory, 20 August 2014, Brisbane.	29th International Horticultural Congress: horticultural service providers, scientists	20
Site tour: Stonefruit Field Laboratory - experiment objectives, 27 August 2014, Tatura.	Project Advisory Committee delegation	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 28 August 2014, Tatura.	South African delegation & APAL (Kevin Sanders)	7
Site tour: Stonefruit Field Laboratory - experiment objectives, 2 October 2014, Tatura.	Launch of Horticulture Center of Excellence delegation	35
Site tour: Stonefruit Field Laboratory - experiment objectives, 14 October 2014, Tatura.	Thailand delegation	15
TV interview: Stonefruit Field Laboratory - experiment objectives, 22 October 2014, Tatura.	WINTV Shepparton - News	
Site tour: Stonefruit Field Laboratory - experiment objectives, 22 October 2014, Tatura.	Regional Stone & Pomefruit R&D Forum delegation	30
Site tour: Stonefruit Field Laboratory - experiment objectives, 14 January 2015, Tatura.	German fruit grower delegation	45
Site tour: Stonefruit Field Laboratory - experiment objectives, 4 February 2015, Tatura.	Prof Han Mingyu (Northwest A&F University, China)	1
Site tour: Stonefruit Field Laboratory - experiment objectives, 18 February 2015, Tatura.	Horticultural Group Leader delegation	4
Site tour: Stonefruit Field Laboratory - experiment objectives, 22 February 2015, Tatura.	The University of Melbourne delegation	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 2 March 2015, Tatura.	Bill Montague & Charles Peters (Washington State)	3
Site tour: Stonefruit Field Laboratory - experiment objectives, 4 March 2015, Tatura.	DEDJTR - Rural Development and Transition Policy delegation	27
Site tour: Stonefruit Field Laboratory - experiment objectives, 6 May 2015, Tatura.	Project Advisory Committee delegation	7
Presentation: Stonefruit Field Laboratory - Irrigation experiment, 17 June 2015, Mildura.	Horticulture Water Use Efficiency workshop	35
Presentation: Stonefruit Field Laboratory, 25 July 2015, China.	Chinese delegation	15
Site tour: Stonefruit Field Laboratory - experiment objectives, 28 October 2015, Tatura.	Project Advisory Committee delegation	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 23 November 2015, Tatura.	Italian grower delegation	15

Site tour: Stonefruit Field Laboratory - experiment objectives, 4 January 2016, Tatura.	Prof David Connor (The University of Melbourne) and Dr Ines Minguez (University of Madrid)	2
Site tour: Stonefruit Field Laboratory - experiment objectives, 11 March 2016, Tatura.	The University of Third Age delegation	45
Site tour: Stonefruit Field Laboratory - experiment objectives, 23 March 2016, Tatura.	Irawan Budianto (Trade Director, Victorian Government Business Office, Jakarta) and Amelia Fyfield (Manager International Policy and Market Analysis)	2
Presentation: Stonefruit Field Laboratory - experiment objectives, 29 April 2016, Tatura.	DEDJTR Agriculture Services and Biosecurity Operations delegation	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 4 May 2016, Tatura.	Project Advisory Committee delegation	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 18 May 2016, Tatura.	Agricultural delegation from China including Mr Yang (CEO of Xinyangfeng Fertiliser) and Professor Deli Chen (UoM).	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 19 May 2016, Tatura.	University of South Dakota students delegation	25
Site tour: Stonefruit Field Laboratory - experiment objectives, 23 June 2016, Tatura.	Delegation of GO-TAFE Horticultural students	5
Site tour: Stonefruit Field Laboratory - experiment objectives, 5 September 2016, Tatura.	Delegation of GO-TAFE Agricultural and rural students	5
Site tour: Stonefruit Field Laboratory - experiment objectives, 14 September 2016, Tatura.	Delegation of DEDJTR Agriculture Production leadership team	6
Site tour: Stonefruit Field Laboratory - experiment objectives, 28 September 2016, Tatura.	Delegation of summerfruit growers, horticultural industry personnel	7
Site tour: Stonefruit Field Laboratory - experiment objectives, 29 September 2016, Tatura.	Delegation of DEDJTR Agriculture AR-FS joint leadership team	8
Site tour: Stonefruit Field Laboratory - experiment objectives, 4 October 2016, Tatura.	Project Advisory Committee delegation	5
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 15 November 2016, Tatura.	Garry Godwill (Fruit Growers Victoria)	1
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 29 November 2016, Tatura.	Delegation of Chinese fruit research team, including Professor Jiang	10

Site tour: Stonefruit Field Laboratory - inspection of fruit grading facility, 6 December 2016, Tatura.	Deputy Secretary (Prof German Spangenberg) and Director (Dr Greg Harper) Agriculture Research - Department of Economic Development, Jobs, Transport and Resources delegation	4
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 10 January 2017, Tatura.	Prof David Connor (The University of Melbourne) and Dr Ines Minguez (University of Madrid)	2
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 17 January 2017, Tatura.	Horticulture Industry Network IDOs delegation	15
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 24 January 2017, Tatura.	Drs Stuart Tustin, Jason Johnson (New Zealand Plant & Food Research) and Prof Luca Corelli Grappadelli (University of Bologna)	3
Site tour: Stonefruit Field Laboratory - orchard management systems, plums, 9 February 2017, Tatura.	Gaethan Cutri (Grower, Trade Assessment Panel Member - Independent expert at Horticulture Innovation Australia)	1
Site tour: Stonefruit Field Laboratory - orchard management systems, plum fruit guage study, 27 February 2017, Tatura.	Julie Godwill (Fruit Growers Victoria) and Richelle Zealley (Communications and Events Officer, APAL) and Alison Barber (Engagement Officer, APAL) and visiting horticultural scientist (Switzerland)	4
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 7 March 2017, Tatura.	Delegation of Horticulturists from Rotary Vocational Training Team Ontario, New York State, USA	15
Site tour: Stonefruit Field Laboratory - experiment objectives and collabrative UoM water use/stress research (UAV remote sensing) study, 9 March 2017, Tatura.	Delegation of government and university (Sharif University) officials from Iranian (farmers, water managers and engineers) and University of Melbourne (Engineering Faculty)	20
Presentation: Stonefruit Field Laboratory - experiment objectives, 14 March 2017, Tatura.	Deputy Secretary (Agriculture Research - Department of Economic Development, Jobs, Transport and Resources) delegation	20
Site tour: Stonefruit Field Laboratory - experiment objectives, 14 March 2017, Tatura.	Deputy Secretary (Agriculture Research - Department of Economic Development, Jobs, Transport and Resources) delegation	20
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 22 March 2017, Tatura.	Marko Dorić (Montague Orchards)	1



Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 4 April 2017, Tatura.	Noel Ainsworth (Supply Chain Horticulturist, DAF Qld)	1
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 5 May 2017, Tatura.	Dr David Ugalde (Department of Agriculture and Water Resources, ACT)	1
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 31 May 2017, Tatura.	Project Advisory Committee delegation	5
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 9 June 2017, Tatura.	Mallee community delegation	8
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 19 July 2017, Tatura.	Ress Moller (Cornell University, Agricultural Science student)	1
Site tour: Stonefruit Field Laboratory - experiment objectives and inspection of fruit grading facility, 10 August 2017, Tatura.	The University of Melbourne Agricultural Students delegation	39
Presentation: Stonefruit Field Laboratory - experiment objectives, 10 August 2017, Tatura.	The University of Melbourne Agricultural Students delegation	39
Orchard tour: Apricot Grove - Stonefruit Field Laboratory experiment objectives, orchard tour and inspection of fruit grading facility, 29 August 2017, Renmark	Charlie & Hilke Ppiros	2
Orchard tour: Cutri Fruit - Stonefruit Field Laboratory experiment objectives, 2-D orchard tour and inspection of fruit grading facility, 30 August 2017, Wood Wood & Woorinen	Gaethan Cutri (Grower, Trade Assessment Panel Member - Independent expert at Horticulture Innovation Australia), Marc Intervera (Cutri Fruit, Innovation manager)	6
Site tour: Stonefruit Field Laboratory - experiment objectives and discussion on irrigation management strategies, 6 September 2017, Tatura.	Prof Wiehann Steyn (HortGro, South Africa) and Dr Esme Louw (University of Stellenbosh)	2
Presentation: Stonefruit field laboratory – results from irrigation deficit experiments, May 2018, Tatura	Tatura personnel and growers	16

**Appendix 8 Industry feedback from regional roadshows (2016 and 2017)**



Cobram Roadshow Evaluation\_2016.pdf



Renmark Roadshow Evaluation\_2016.pdf



Swan Hill Roadshow Evaluation\_2016.pdf



Cobram Roadshow Evaluation\_2017.pdf



Renmark Roadshow Evaluation\_2017.pdf



Swan Hill Roadshow Evaluation\_2017.pdf

