Horticulture Innovation Australia

Final Report

Research Speed Updating program

Angus Crawford
Apple & Pear Australia Limited (APAL)

Project Number: AP14003

AP14003

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Summary

Research Speed Updating is APAL's innovative approach in capturing the research, development and extension activities around Australia. It is an intensive single day seminar with a technical focus intended to extend mostly HIA funded projects as well as non-HIA projects where possible to industry.

Speed Updating was held on Thursday 25 June 2015 and had over 150 participants who saw 24 presentations from leading scientists, in short 10 minute timeframes. The time was very well managed giving plenty of opportunity for questions, interaction, feedback and researchers to present their ideas on their topic.

The main outcome of this project is growers and industry are updated and engaged with the latest information in research and development. Three broader outcomes were that the apple and pear industry successfully:

1) Captured for the apple and pear industry exactly what is happening in R&D (current projects, completed projects and projects about to commence);

2) Identified gaps in research;

3) Identified duplication of research.

Following favorable evaluation the apple and pear industry see that this is the model of how they want their R&D projects presented. Participants generally thought that "short and to the point" was the better approach. However, some evaluations as well as direct in person feedback showed there is also a view that 10 minutes is insufficient time to give adequate details and most presenters found the lack of time a challenge. Even so, evaluations showed that growers got a lot from listening to the researchers as their projects are happening.

The issues raised was related to the size of the venue, which was too small for such a large crowd.

While some changes will need to be implemented, it was felt that the program should continue in the current format.

Introduction

Research Speed Updating is APAL's innovative approach in capturing apple and pear R&D activities around Australia. It is an intensive single day seminar put together to provide levy payers and the supply chain an opportunity to hear from researchers about the status of their research. It has a technical focus intended to showcase mostly HIA funded projects, though some non-HIA projects are included where relevant.

This Speed Updating event detailed in this report was held in the Gold Coast in line with the National Horticultural Convention (APAL/AusVeg conference) on 25 June 2015. In 2013 a similar event was held as a 'pilot' funded by HIA under project AP12033. Prior to this there was no national review process for research in the apple and pear industry in Australia.

Overall the 2015 Speed Updating seminar was very successful. It provided growers and agronomists information about the intended outcomes of research being funded by the levy; the problem or issue the research targets, the methodology used to better understand the problem or develop solutions, the timelines and progress of the research. It also provided researchers the opportunity to identify linkages with their own research.

This final report outlines the methodologies, outputs, outcomes, evaluations as well as recommendation to ensure future iterations are also successful.

Methodology

The apple and pear industry Technical Manager as the project leader was responsible for the planning, implementation, delivery, facilitation, reporting and evaluation of Speed Updating.

Planning:

The main aspect of planning was the selection of topics and organisation of 22 individuals with 24 presentation topics. Topics chosen were at the discretion of the Technical Manager and were grouped into similar themes to ensure continuity and flow. The process used to select topics included listing all of the HIA R&D program currently contracted as well as projects just completed. Other non-HIA projects which the Technical Manager had been aware of in the industry were also included.

Within each project a presenter was selected and invited to speak, mostly by email correspondence. Other aspects of planning were more logistical such as organisation of facilities ensuring catering, audio, visual and other necessary presentation facilities were made available on the day.

Once agreement was made on who would speak and the topic, each presenter was asked to supply their presentations, photos, contact details as well as 200-800 word summary notes on their topic discussing insights, relevance of their topic, their learnings or observations or recommendations, what follow up research do they think is needed? Background about the issue, what's happening in Australia, what's happening in other countries and how it is helping growers/industry.

Several communication outputs were also developed including a dedicated webpage (http://apal.org.au/research-development-extension/projects/research-reviews/) which provides a link to each presentation. A booklet with detailed information about the speaker, notes on their topic and a copy of slides

was handed out at the event. These communication outputs ensured attendees could take home all the information to reinforce the messages and increase likelihood of adoption. Being online ensures the information generated by the project could reach the wider industry community, particularly for those who did not attend.

Originally USB's were planned to be distributed to participants after the event. However, the Technical Manager believed this was insufficient given the amount of good information being delivered from the day. A 125 page booklet was put together which can be seen in attachment 2 of this report or by following the link. http://apal.org.au/wp-content/uploads/2013/11/Speed-Updating-booklet-final.pdf

Implementation and Delivery

On the day a total of 24 presentations were held with individual presenters travelling interstate and from overseas to participate in Speed Updating.

Researchers are not contractually obliged to participate in Speed Updating so in order to attract speakers to the event a number of methods were employed.

Speed Updating was held in conjunction with the annual conference which was viewed to compliment attendances of both events. Speakers were offered $350 to offset their travel costs, and were invited to an industry dinner held on the evening before the event. Where necessary, international speakers were paid for full travel costs as their projects do not cover attendance to these events. Two international participants from Plant and Food Research New Zealand travelled to report on their PIPS (Productivity Irrigation Pest and Soils) projects.

German researcher, Professor Jens Wünsche, was unable to travel but presented via a Weblink using www.gotomeeting.com.au which ran very well with no glitches due to the level of planning and separate high speed internet WIFI port made available. This presentation was well received but participants prefer as much as possible that presenters are physically present on the day, so web links should be avoided.

The evening prior to Speed Updating researchers were invited to a dinner with key advisory panel growers, HIA representatives and others invited.

Growers who were known to assist HIA on the vital apple and pear industry advisory panels were encouraged to attend and where necessary their travel costs and accommodation were met by the project.

Facilitation

The Technical Manager facilitated the event throughout the day controlling the agenda, preparing and introducing upcoming speakers and providing questions for presenters to stimulate general discussion.

Reporting and Evaluation

Speed Updating was evaluated mainly using a feedback form distributed at afternoon tea which was a time that most of the presentations for the day had been seen. The feedback form contained questions which captured the respondents views on how the event performed and other questions were designed to capture the opinions on many things like opportunities for future research.

Outputs

The specific outputs of AP14003 Research Speed Updating Program are listed as follows:

- Speed Updating event completed in 2015;
- Evaluations of the event have been completed and compiled;
- Content generated from the project has been uploaded to website and YouTube;
- Booklet prepared and printed and distributed to attendees;
- Magazine article published in Australian Fruit Grower;
- Learnings and recommendations supplied to HIA and APAL management.

Outcomes

The primary goal of the Speed Updating event was to improve grower and supply chain knowledge about the latest research and innovations from the R&D program. Speed Updating effectively aligns with the apple and pear industry strategic plan *New Horizons 2015* which the third priority objective states: "*ensure industry has resources and capability by improved motivation, communication, and knowledge transfer of individual growers and the consequent development of leadership and skill competency.*"

The Speed Updating event reinforces other knowledge transfer pathways which include the Future Orchards®, Australian Fruit Grower magazine articles as well as other technical information throughout the APAL website. Based on evaluations and other personal communications we showed that Speed Updating was a success.

Specific outcomes of the project are as follows:

- Researchers and growers engaged with good harnessed relationships between these parties helping adoption of new innovations and provides a link on how industry problems may be solved through current and new future research;

- Industry networking providing opportunities for new potential researcher to researcher collaboration;

- Video posted online has enabled this information to be more widely shared for those not in attendance;

- The identification of potential duplication;

- The identification of potential gaps and collaborative opportunities in R&D;

- The identification of grower R&D priorities;

- Latest apple and pear industry research communicated to growers, agronomists, and supply chain decision makers on topics including:

1. Future Orchards®, presented by Angus Crawford, Apple and Pear Australia Limited
2. Apple and pear industry data project, presented by Jesse Reader, AgFirst Australia
3. Bridging the knowledge gap to breed high-value, flavonoid-rich apples, presented by Dr. Catherine Bondonno, The University of Western Australia
4. Autonomous information systems for horticulture and tree crops, presented by Dr. James Underwood, The Australian Centre for Field Robotics, The University of Sydney

5. Biochar as a soil amendment, presented by Dr. Marcus Hardie, Tasmanian Institute of Agriculture
6. PIPS soil carbon, presented by Dr. Roberta Gentile, The New Zealand Institute for Plant & Food Research Limited
7. Profitable Pears: maximising productivity and quality of new pear varieties (PIPS), presented by Dr. Ian Goodwin, Department of Economic Development, Jobs, Transport and Resources
8. Tree structure, crop load management and orchard light interception (PIPS), presented by Dr. Ben van Hooijdonk, The New Zealand Institute for Plant & Food Research Limited
9. Lenswood young tree growth project – Aztec Fuji, presented by Paul James, Lenswood Apples, Lenswood Co-op
10. Fruit set and crop load management of Australian-bred scab resistant apples, presented by Dr. Osi Tabing, Department of Agriculture and Fisheries (Qld)
11. Developing thinning programs for European pears, presented by Dr Sally Bound, Tasmanian Institute of Agriculture
12. Brevis. A new thinner for Australian apple orchards? presented by Stephen Tancred, Orchard Services
13. Precision fertigation for improved apple orchard productivity (PIPS), presented by Dr Nigel Swarts, Tasmanian Institute of Agriculture
14. Estimating tree water use (PIPS), presented by Dr. Ian Goodwin, Department of Economic Development, Jobs, Transport and Resources
15. Netting the benefits of climate change, presented Susie Murphy White, Department of Agriculture and Food Western Australia, Manjimup
16. A hazy shade of winter (chill), presented by Dr. Rebecca Darbyshire, The University of Melbourne
17. Towards an understanding of bud burst and flowering in a changing climate, presented by Dr. Heidi Parkes, Department of Agriculture and Fisheries
18. Do dormancy breakers have a role in fruit production? Presented by Dr. Sally Bound, Tasmanian Institute of Agriculture
19. Physiological, metabolic and molecular basis of biennial bearing in apples, presented by Prof. Jen Wünsche, University of Hohenheim
20. Improved management of apple and pear scab primary infection, presented by Dr. Oscar Villalta, Department of Economic Development, Jobs, Transport and Resources
21. Codling moth biocontrol and mass-trapping, presented by Dr Mofakhar Hossain, Department of Economic Development, Jobs, Transport and Resources
22. Fruit fly research national overview, presented by Dr Peter Whittle, Horticulture Innovation Australia
23. APFIP and pear variety evaluation and certification update, presented by Mark Hankin, Australian Pome Fruit Improvement Program® Ltd
24. The importance of maturity at harvest in pears, presented by Dr. Dario Stefanelli, Department of Economic Development, Jobs, Transport and Resources

Evaluation and Discussion

Speed Updating was evaluated mainly using a feedback form distributed at afternoon tea which was a time that most of the presentations for the day had been seen. The last six sessions gave participants ample time to fill

in these forms and were handed back at the end of the day. A copy of the form is located in Attachment 1.

Out of the +150 attendees we received 34 feedback forms. This number is most likely reflective of the lower attendances observed in the later part of the day who were not interested in seeing the last few presentations scheduled. The results from these forms are below which show overall the feedback was nearly 100 per cent positive, demonstrating clearly that participants got value out of the event and were satisfied with nearly all aspects of the day (except the venue.)

The negative feedback was all around the venue which was already identified as a serious problem. These problems stemmed from inflexible arrangements with AusVeg during the newly formed APAL/AusVeg conference. Measures are in place to prevent a reoccurrence.

While some topics may have similar themes there was no clear duplication in research projects that caused concern.

In the evaluation forms the first eight questions were tick the box style then the last three asked more specific questions requiring a written response. Other comments were there to see what other general things respondents had to say.

The results from the 34 feedback forms were as follows:

1. Presentations				
Please tick the appropriate boxes to record your view of today's event				
	Valuable	Of some value	Of little value	Of no value
Number	31	2	1	0
Percent	91%	6%	3%	0%

2. Organisation				
What rating would you give to the organisational aspects of the event including promotion, the location, the facilities and your opportunity to participate and interact with researchers?				
	Excellent	Good	Fair	Poor
Number	18	11	5	0
Percent	53%	32%	15%	0%

3. Value		
a. Did you learn anything today that you could apply?		
	Yes	No
Number	34	0
Percent	100	0

b. Did you learn anything today that you will definitely pass on to growers and peers alike?		
	Yes	No

Number	33	1
Percent	97	3

c. Do you think you would attend the research review if it were held again?		
	Yes	No
Number	34	0
Percent	100	0

d. Do you think there is value in reviewing Australian apple and pear industry research every two years?		
	Yes	No
Number	34	0
Percent	100	0

e. Do you have a more comprehensive understanding of the R&D being conducted?		
	Yes	No
Number	31	3
Percent	91	9

Written responses

Respondents were asked to write a written response. Given that these participants had just seen a full comprehensive overview of Australian R&D these response were aimed at capturing their impressions and points of view. Not all respondents provided written answers.

When asked (3f) *What are the key benefits (if any) from attending today's Speed Updating event?* All of these answers showed that there is a clear benefit in running a seminar of this type on a regular basis. The answer which captures the general answers was from one respondent writing "Knowing what's going on, understanding better, networking, interacting discussion, discussing questions with specialists."

When respondents were asked (3g) *What areas of research do you think should be continued or started in our industry?* Asking this question has provided some very useful points and while participants had many views on areas of research these answers are summarised as:

- Organic dormancy breakers, organic thinning *(presumably with organic chemicals)*;
- New rootstocks and varieties and management of new varieties (e.g. growing, crop loads etc.);
- Soils, nutrition, soil carbon, soil health;
- Proper engineering for orchard trellis to adequately handle higher yields;
- Autonomous automation, robotics;
- IPM and lowering chemical use;
- Climate change (and no climate change!);

- Plant growth regulators, tree physiology, biennial bearing;
- Light optimisation;
- Managing heat stress;

The next question participants were asked to write (3h) *What aspects could be changed to improve Speed Updating?* While nearly all answers were complaining about the venue the answer which best captures the responses was “Better room - theatrette would be better. Very squashy but what a great turn out by growers and the other people in the supply chain.”

An area to improve many felt the day was too intensive and any future event should have fewer presentations and finish earlier. While every effort was made to keep up the energy of the room, many participants were fatigued simply from the amount of content being presented.

Some additional feedback which was not captured by the evaluation was about presenting more details on the specific apple and pear industries marketing activities which occur. While Speed Updating aimed to focus on apple and pear R&D only, some consideration on this point will be made for future events.

Recommendations

All who filled the feedback forms said they would attend the APAL Research Review (Speed Updating) if it were held again. From this project the following recommendations and learnings have been identified to make future iterations of the project a success.

- Researchers should be given more time to present their research. While 10 minutes suits some attendees, it is unreasonable to expect sufficient detail of complex projects will be provided by presenters in 10 minutes. More flexibility should be given and allow more time for presenters;
- Less presentations selected and a shorter day. Many felt the agenda running from 8:30 – 5:00pm was too long and should have finished at 3:30pm;
- Look to include marketing activities as part of future events;
- The booklet was a good inclusion to the 2015 event. For such as important seminar the booklet is a more effective way to provide presentation information compared to USB. The addition of slides and how presenters where asked to write and provide notes to support their presentation was well received;
- Keep the dinner as part of the day. It provides an invaluable networking platform for industry and researchers;
- As much as possible avoid using Weblink and maximum of one Weblink per event;
- Venue selected must be large, have a stage, be comfortable, and be audible with more screens to ensure all of those present can see easily. Full catering is a must for any event. Apples and pears must be provided always.

Acknowledgements

The project leader would like to acknowledge the following people who provided input to the various planning and delivery aspects of the day. These people from APAL are Sophie Clayton, Nikki K. Wood, Richelle Zealley, Annie Farrow and John Dollisson.

Also, the event would not be possible without the participation of our researchers. We thank them for their efforts as well as their supervisors who granted them permission to travel.

Attachments

Attachment 1: Speed Updating event evaluation form

Attachment 2: Speed Updating event booklet, printed and handed to attendees

Attachment 3: Australian Fruit Grower article August 2015

Attachment 4: Statement of receipt and expenditures

Attachment 1: Speed Updating event evaluation form

Horticulture Innovation Australia

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Speed Updating event evaluation form June 2015

Please tick the appropriate boxes to record your view of today's event;

1. Presentations

	Valuable	Of some value	Of little value	Of no value
Presentations	☐	☐	☐	☐

2. Organisation

What rating would you give to the organisational aspects of the event including promotion, the location, the facilities and your opportunity to participate and interact with researchers?

Excellent ☐ Good ☐ Fair ☐ Poor ☐

3. Value

a. Did you learn anything today that you could apply?
Yes ☐ No ☐

b. Did you learn anything today that you will definitely pass on to growers and peers alike?
Yes ☐ No ☐

c. Do you think you would attend the research review if it was held again?
Yes ☐ No ☐

d. Do you think there is value in reviewing Australian apple and pear research every two years?
Yes ☐ No ☐

e. Do you now have a more comprehensive understanding of the R&D being conducted?
Yes ☐ No ☐

f. What are the key benefits (if any) from attending today's Speed Updating event?

_____

_____

g. What areas of research do you think should be continued or started for our industry?

_____

_____

h. What aspects could be changed to improve Speed Updating?

_____

_____

Horticulture Innovation Australia

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Speed Updating event evaluation form June 2015

Please tick the appropriate boxes to record your view of today's event;

1. Presentations

	Valuable	Of some value	Of little value	Of no value
Presentations	☐	☐	☐	☐

2. Organisation

What rating would you give to the organisational aspects of the event including promotion, the location, the facilities and your opportunity to participate and interact with researchers?

Excellent ☐ Good ☐ Fair ☐ Poor ☐

3. Value

a. Did you learn anything today that you could apply?
Yes ☐ No ☐

b. Did you learn anything today that you will definitely pass on to growers and peers alike?
Yes ☐ No ☐

c. Do you think you would attend the research review if it was held again?
Yes ☐ No ☐

d. Do you think there is value in reviewing Australian apple and pear research every two years?
Yes ☐ No ☐

e. Do you now have a more comprehensive understanding of the R&D being conducted?
Yes ☐ No ☐

f. What are the key benefits (if any) from attending today's Speed Updating event?

_____

_____

g. What areas of research do you think should be continued or started for our industry?

_____

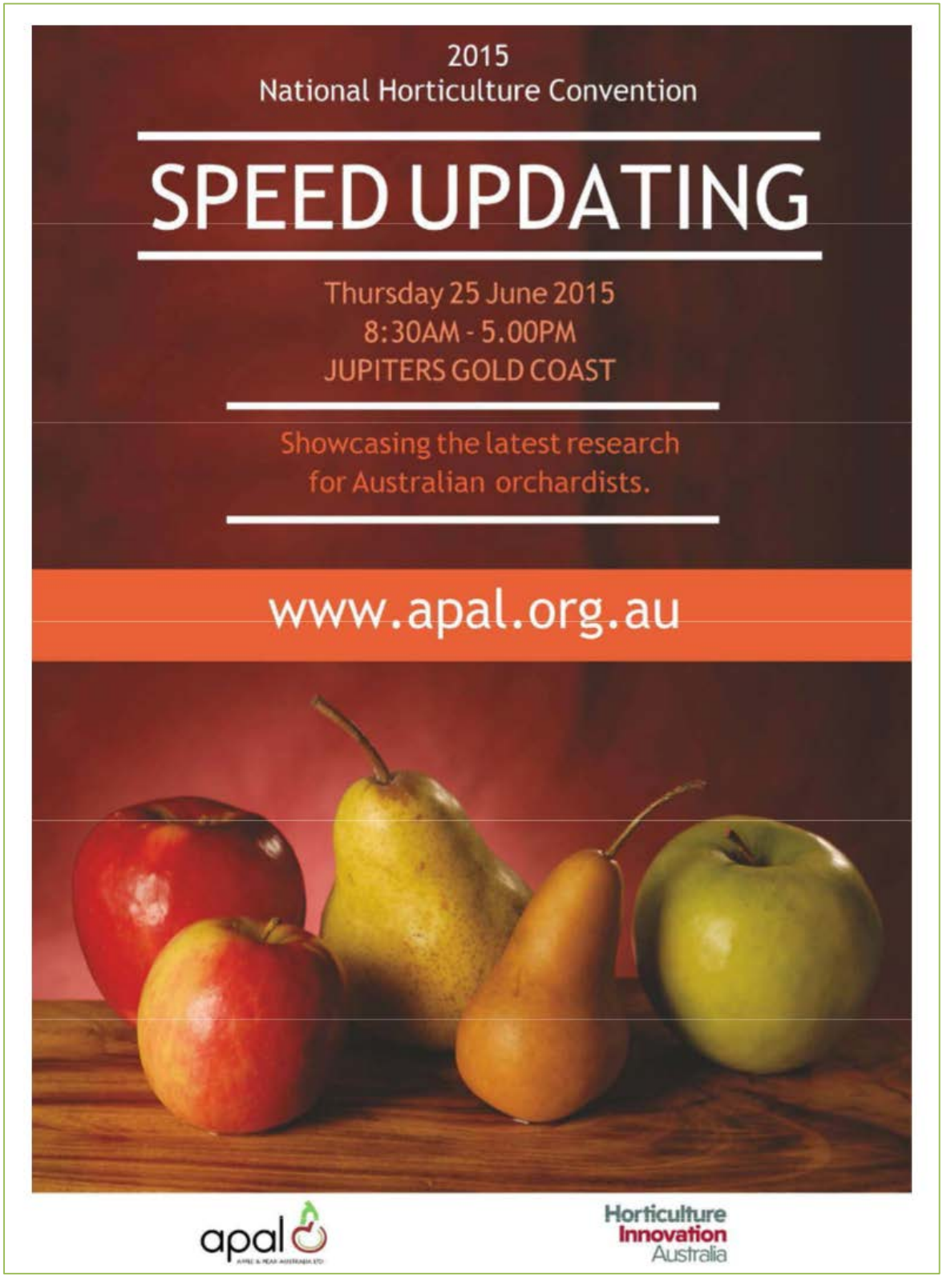
_____

h. What aspects could be changed to improve Speed Updating?

_____

_____

Attachment 2: Speed Updating event booklet, printed and handed to attendees



Speed Updating

APAL's Speed Updating brings together leading local and international scientists to share their research with Australian apple and pear growers. Scientists are given ten minutes to showcase their work for the industry and how they can help orchardists.

The 2015 Speed Updating event was held as part of the National Horticulture Convention jointly presented by APAL and AUSVEG.

Speed Updating is funded by Horticulture Innovation Australia Ltd using the apple and pear industry levy funds from growers and funds from the Australian Government.

For more information:

www.apal.org.au

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Agenda

8:30	**Introduction**		
8:45	Angus Crawford	Apple and Pear Australia Limited	Future Orchards®
9:00	Jesse Reader	AgFirst Australia	Apple and pear industry data project
9:15	Dr. Catherine Bondonno	The University of Western Australia	Bridging the knowledge gap to breed high-value, flavonoid-rich apples
9:30	Dr. James Underwood	The Australian Centre for Field Robotics, The University of Sydney	Autonomous information systems for horticulture and tree crops
9:45	Dr. Marcus Hardie	Tasmanian Institute of Agriculture	Biochar as a soil amendment
10:00	Dr. Roberta Gentile	The New Zealand Institute for Plant & Food Research Limited	PIPS soil carbon
10:15	Panel discussion		
10:30	**Morning tea**		
10:45	Dr. Ian Goodwin	Department of Economic Development, Jobs, Transport and Resources	Profitable Pears: maximising productivity and quality of new pear varieties (PIPS)
11:00	Dr. Ben van Hooijdonk	The New Zealand Institute for Plant & Food Research Limited	Tree structure, crop load management and orchard light interception (PIPS)
11:15	Paul James	Lenswood Apples, Lenswood Co-op	Lenswood young tree growth project – Aztec Fuji
11:30	Dr. Osi Tabing	Department of Agriculture and Fisheries	Fruit set and crop load management of Australian-bred scab resistant apples
11:45	Dr. Sally Bound	Tasmanian Institute of Agriculture	Developing thinning programs for European pears
12:00	Stephen Tancred	Orchard Services	Brevis. A new thinner for Australian apple orchards?
12:15	Panel discussion		
12:30	**Lunch**		
1:30	Dr. Nigel Swarts	Tasmanian Institute of Agriculture	Precision fertigation for improved apple orchard productivity (PIPS)

1:45	Dr. Ian Goodwin	Department of Economic Development, Jobs, Transport and Resources	Estimating tree water use (PIPS)
2:00	Susie Murphy White	Department of Agriculture and Food Western Australia, Manjimup	Netting the benefits of climate change
2:15	Dr. Rebecca Darbyshire	The University of Melbourne	A hazy shade of winter (chill)
2:30	Dr. Heidi Parkes	Department of Agriculture and Fisheries	Towards an understanding of bud burst and flowering in a changing climate: approaches to research and extension
2:45	Dr. Sally Bound	Tasmanian Institute of Agriculture	Do dormancy breakers have a role in fruit production?
3:00	Panel discussion		
3:15	**Afternoon tea**		
3:30	Prof. Jens Wünsche	University of Hohenheim	Physiological, metabolic and molecular basis of biennial bearing in apples
3:45	Dr. Oscar Villalta	Department of Economic Development, Jobs, Transport and Resources	Improved management of apple and pear scab primary infection
4:00	Dr. Mofakhar Hossain	Department of Economic Development, Jobs, Transport and Resources	Codling moth biocontrol and mass-trapping
4:15	Peter Whittle	Horticulture Innovation Australia	Fruit fly research national overview
4:30	Mark Hankin	Australian Pome Fruit Improvement Program® Ltd	APFIP and pear variety evaluation and certification update
4:45	Dr. Dario Stefanelli	Department of Economic Development, Jobs, Transport and Resources	The importance of maturity at harvest in pears

Future Orchards®

Angus Crawford
Technical Manager
Apple and Pear Australia Limited (APAL)
acrawford@apal.org.au

Future Orchards® is an apple and pear industry extension project bringing technology transfer activities to eight regions around Australia. The centrepiece of Future Orchards are the regular orchard walks, however, this presentation will show the project is far more multi-faceted with an extensive number of activities. These activities have led the apple and pear industry to be more world competitive by assisting growers in improving yield, improved pack-outs and achieving better returns at the farm gate.

The improvements Future Orchards has delivered have been measurable by direct activities like the Orchard Business Analysis which is generated each year and gives a financial snapshot of the economic performance of the apple and pear industry businesses.

Another direct measure is completed by OrchardNet® which is freely available to apple and pear growers. The program captures specific production data and holds this information for record keeping and benchmarking for the user. OrchardNet data can be used to graph regional and national yield information by variety. In addition to the measurable changes seen by the project there are documented behavioural changes and real life examples of success as a result of regular involvement in the program.


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Outline
1. Activities
2. Outputs
3. Outcomes
4. Evaluation
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Activities
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National Activities
Data gathering, recording and analysis
Magazine articles
Webinars
Regional Activities
Focus orchards
Orchard walks
Horticulture Innovation Australia
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The Project – AP11017
apal
Future Orchards® 3
Horticulture Innovation Australia
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Key Outputs

- 8 Webinars
- Future Orchards Library
- Orchard Business Analysis' completed
- 43 Magazine Articles
- Focus Orchards
- Regional Orchard Walks
- OrchardNet

The International Guests

- Alberto Dorigoni
- Mark Goodwin
- Terrance Robinson
- Steve McCartney
- Karen Lewis
- Jan Peters
- Stuart Tustin
- Ben Van Hooijdonk
- John Palmer
- Martin Thomman
- Juergen Christanell
- David Manktelow

Attendances

Summary of attendee	Result
Number of attendees	240
Average per region	30
Percent region represented	54%
Percent production represented	53%

OrchardNet

Use of OrchardNet	Total
Number of Companies	128
Number of Blocks	1010
Area (hectares)	3045

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Outcomes

Year	Revenue / Ha ($)
2008	30,805
2010	44,334
2011	50,853
2012	38,035
2013	59,471
2014	62,604

Revenue per Hectare ($)

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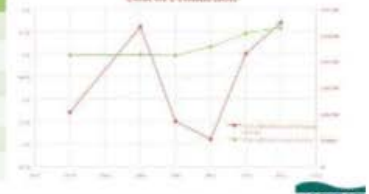
Outcomes

Year	Cost/ha	Cost/kg
2008	42,309	1.17
2010	42,460	1.16
2011	56,468	1.15
2012	45,316	1.11
2013	37,700	1.1
2014	52,798	1.27

Cost of Production



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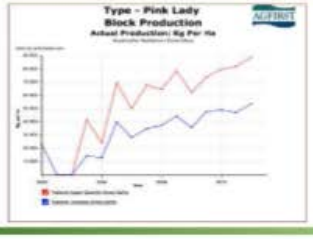
Pink Lady 38 t/ha to 55 t/ha (83% increase)



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Royal Gala 20t/ha to 35 t/ha (75% increase)

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7

Behavioural Change

- Survey results
  - 100% found presentations valuable
  - 99% found orchard walks valuable
  - 95% have implemented something from Future Orchards
- Examples of Success
  - Newton Brothers (WA) aimed for 50 t/ha by 2015. Result was an earlier 58 t/ha achieved in 2013.
  - Flavell (SA) increase overall yield 31 t/ha to 41 t/ha
  - Oakleigh Orchards achieving 108 t/ha (90% Class1 and 170 g/fruit
  - Plus many, many more

Independent Review 2013

- *"an excellent extension project",*
- *"highly regarded"*
- *"delivering significant economic returns to the industry"*
- *"very strong support for the continuation of the program"*
- *"quite possible that Future Orchards is delivering far greater benefit than existing evaluation processes indicate"*

Apple and pear industry data project

Jesse Reader
General Manager
AgFirst Australia
jesse.reader@agfirstaustralia.com.au

Data is the new oil – we need to find it, mine it and refine it…

Everyone has heard the saying 'information is power'. This is true for any industry that needs to renew strategic and operational plans on an annual basis and ensure the best possible outcomes are achieved for all those involved. Knowing what proportion of Australian orchards are already planted and being planted, the varieties of choice and their respective productivity, will help growers and the industry better plan for the future. Getting a grip on our basic tree data is fundamental to giving us the information we need to make decisions about the industry and take action to ensure its profitability long-term.

In 2014, the Apple and Pear Industry Advisory Council (IAC) decided to prioritise funding for the collection of industry data, resulting in the Pome Fruit Industry Data Collection Project that commenced in September 2014. The project had three main components including the collection of historic national crop data, collection of national tree statistics and the establishment of an effective model to estimate the current seasons' crop.

RESEARCH REVIEW
'Speed Updating'

Apple and Pear Industry Data Project
AP13035

Prepared by: Jesse Reader – AgFirst Australia
jesse.reader@agfirstaustralia.com.au

Data is the new oil – *we need to find it, mine it and refine it…*

In 2014, the IAC decided to prioritise funding for the collection of industry data. The project had three main components including the collection of historic national crop data, collection of national tree statistics and the establishment of an effective model to estimate the current seasons' crop.

The apple and pear industry data project was commissioned by Apple and Pear Australia Ltd and contracted to AgFirst in September 2014 using R&D levy funds matched by the commonwealth government.

Why undertake such a project?

"Getting a grip on our basic tree data is fundamental to giving us the information we need to make informed decisions about the industry and take action to ensure its profitability long term". – *John Dollisson – APAL CEO*

There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. These are things we don't know we don't know…

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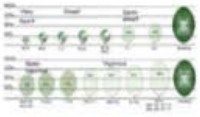
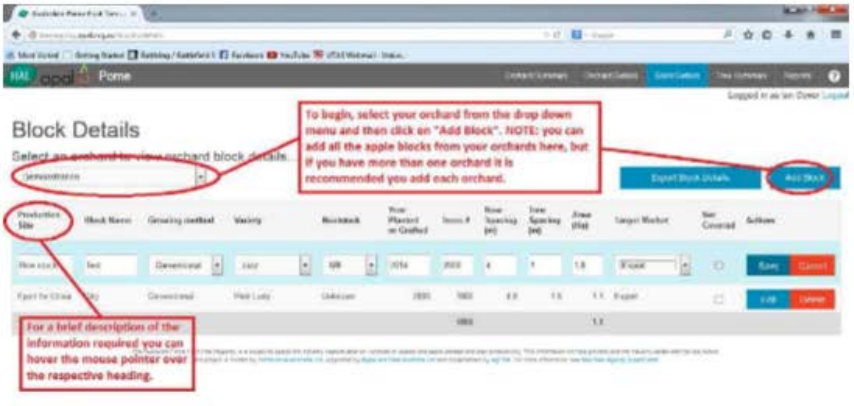
So what did we do?

1. Online Tree Registry
2. National Crop Estimate
3. National Packhouse Survey
4. Developed a national team of skilled individuals to provide local support and deliver on the regional specific tasks

1. Online Tree Registry

- Tree numbers by variety and by state
- Area planted
- Tree density
- Tree age
- Rootstock



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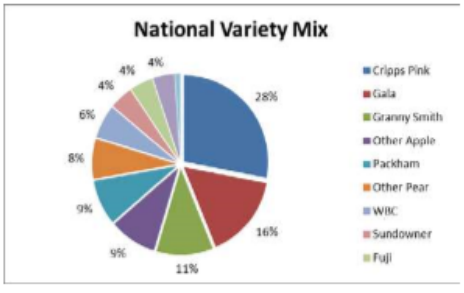
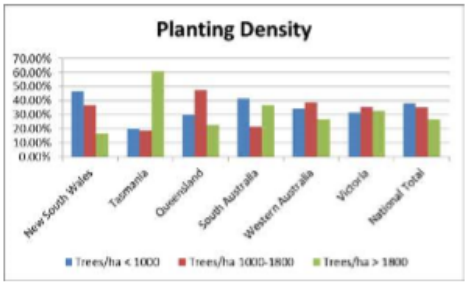
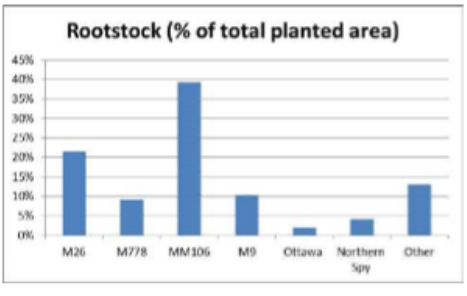
Apples	Estimated Production (% of total)	Estimated Planted Area (Ha)
QLD	12%	1,100
VIC	42%	3,800
NSW	15%	1,650
WA	11%	1,000
SA	10%	1,100
TAS	10%	800
Total		9,450

Pears	Estimated Production (% of total)	Estimated Planted Area (Ha)
QLD*		
VIC	89%	3,040
NSW*		
WA	5%	171
SA	5%	170
TAS	1%	34
Total		3,415







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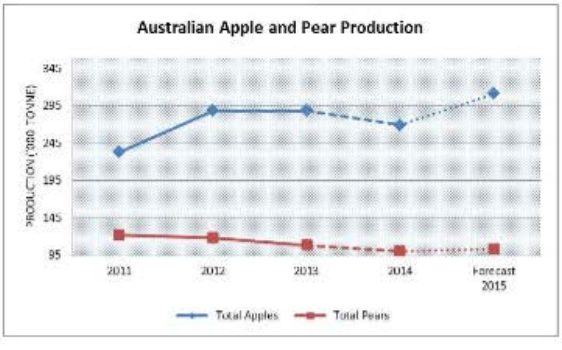
2. National Crop Estimate

- Crop/grower survey
- Physical fruit size monitoring
- Production of a national crop forecast report

3. National Packhouse Survey

- Verification of the actual crop picked in 2014 to confirm the forecast
- Grower survey based on fruit packed and actual sales of the 2014 crop
- Only recently completed



Gross Production	2013	2014	Forecast 2015	Change 2013-2014	Change 2014-2015
	(TONNE)	(TONNE)	(TONNE)		
Total Apple	288,866	270,405	311,758	-6.8%	15.3%
Total Pear	109,204	100,520	104,367	-8.0%	3.8%
Total Pome Fruit	398,071	370,925	416,126	-6.8%	12.2%

GROSS YIELD (Kg/HA)	2013	2014	Forecast 2015	Change 2013-2014	Change 2014-2015
Royal Gala	23,563	21,625	26,244	-1.3%	21.4%
Cripps Pink	34,295	33,844	38,445	-1.2%	13.6%
Granny Smith	43,658	43,149	47,807	-20.2%	10.8%
Red Delicious	44,443	36,976	48,105	-3.6%	30.1%
Fuji	26,595	25,660	30,634	-8.7%	19.4%
Sundowner	31,122	28,639	34,562	-8.5%	20.7%
Golden Delicious	39,405	36,308	43,098	-10.4%	18.7%
Other Apple	11,819	10,708	13,512	-3.0%	26.2%
Total Apple	**31,862**	**29,614**	**35,301**	**-7.6%**	**19.2%**
Packham	34,861	33,854	35,826	0.1%	5.8%
WBC	34,958	33,037	36,092	-9.6%	9.2%
Pears Other	24,237	22,118	23,738	-7.1%	7.3%
Total Pear	**31,352**	**29,670**	**31,885**	**-2.8%**	**7.5%**
Total Pomefruit	**31,559**	**29,334**	**33,009**	**-6.7%**	**12.5%**

Concluding Comments

The ongoing success of this project will depend on the cooperation of industry and the supply of accurate information.

All information is entirely confidential for the sole purpose of the project and only aggregate data is reported.

The development of an accurate crop forecasting model, along with the development of a robust tree statistics database represent a significant step towards improving the quality of pome fruit statistics in Australia.

Bridging the knowledge gap to breed high-value, flavonoid-rich apples

Dr. Catherine Bondonno
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University of Western Australia
catherine.bondonno@uwa.edu.au

Worldwide, cardiovascular disease is the leading noncommunicable disease, accounting for 30% (17.3 million) deaths annually. Findings from epidemiological studies that increased fruit and vegetable intake can reduce the incidence of cardiovascular disease have sparked wide scale research to determine which phytochemicals and which mechanisms are responsible. Polyphenols are among the phytochemicals being actively studied as potential candidates for the cardioprotective effect of fruits and vegetables. Polyphenols are produced as secondary plant metabolites and are found in great abundance in the human diet.

They are characterised by the presence of one or more phenolic rings and can be classed as flavonoid and nonflavonoid compounds. A rich source of polyphenols is apples. Being among the top 20 agricultural commodities by value and volume worldwide, they are a major contributor to total flavonoid intake in both developed and developing countries. Apple flavonoids, predominantly found in the skin, include quercetin, (-)-epicatechin and chlorogenic acid. Evidence for the health benefits of these flavonoids is steadily growing.

The overarching objective of our research is to identify, develop and release Australian-bred apples with superior nutritional qualities. This is because we believe that health is an important driver of food choices. Also, if in addition to having other desirable attributes (taste, texture, colour, keeping quality, yield etc.), an apple can be marketed based on specific nutritional health attributes, this would add significant value to the apple and the industry. The aim of our research is twofold: firstly, to screen apple selections for flavonoid composition, to characterise the polyphenols present and to identify apple selections with elite polyphenol levels; secondly, to demonstrate in human volunteers that consumption of apples with elite flavonoid levels results in effects on cardiovascular disease risk factors consistent with health benefits.

Aim 1: To date we have quantified four important polyphenols (quercetin, (-)-epicatechin, chlorogenic acid and phloridzin) in 21 Australian apple identities. Seasonal variation over 3 years has also been assessed in 7 apple breeds. Quercetin and chlorogenic acid were the predominant polyphenols. Quercetin, (-)-epicatechin and phloridzin were concentrated in the skin while chlorogenic acid was found predominantly in the flesh. Our research has demonstrated that apples (with skin) can provide a large contribution to dietary polyphenol intake. There is

a large genetic influence on polyphenol content; however seasonal variation is less marked.

Aim 2: There is mounting evidence that specific dietary flavonoids can enhance vascular health. Quercetin and (-)-epicatechin, flavonoids present in high concentrations in the skin of apples, can augment nitric oxide status. Nitric oxide is a molecule critical to vascular health. Apples can be an important contributor to quercetin, (-)-epicatechin and total flavonoid intake, but their effects on nitric oxide status and endothelial function are unclear.

We aimed to investigate the acute effects of flavonoid-rich apple on nitric oxide status and endothelial function in healthy men and women. Participants (n=30) were recruited to a randomised, controlled, cross-over trial. The acute effects of flavonoid-rich apple (skin + flesh) were compared to energy-matched low-flavonoid apple (flesh only). Primary outcomes included plasma nitric oxide status and endothelial function, measured as peak and 4-minute post-ischemia flow mediated dilatation of the brachial artery. Relative to control, apple resulted in higher plasma nitric oxide status and higher peak flow mediated dilatation and higher 4-minute post-ischemia flow mediated dilatation. Flavonoid-rich apples can, therefore, augment nitric oxide status and enhance endothelial function, outcomes which may benefit cardiovascular health. This may translate into a natural and low cost approach to reducing the cardiovascular risk profile of the general population.

Our objective to identify, develop and release Australian-bred apples with superior nutritional qualities is ongoing. We are continuing to characterise the flavonoid composition of current and potential new apple varieties. We are currently exploring the stability of quercetin during storage of major Australian apple varieties. Clinical trials are underway to establish the importance of quercetin content of apples for health benefit in humans and to determine whether regular consumption of a high quercetin apple results in a sustained health benefit.

We would like to acknowledge the support of HIA.

Acknowledgements

- This is a multicentre collaboration between School of Medicine and Pharmacology (Jonathan Hodgson, Kevin Croft, Catherine Bondonno.); School of Plant Biology (Mick Considine) and the Department of Agriculture and Food WA (Steele Jacob, John Sutton, Kevin Lacey and Diana Fisher)

Acknowledgements

This work involves in kind and cash support from a number of groups including:

- Current:
  - HIA
  - Pomewest
- Previous:
  - Australian National Apple Breeding Program
  - Apple and Pear Australia Ltd
  - ARC

Overarching objective

To identify, develop and release Australian-bred apple(s) with superior nutritional qualities.

Why?

- We believe that health is an important driver of food choices
- If, in addition to having other desirable attributes (taste / texture / colour / keeping quality / yield / etc), an apple can be marketed based on specific nutritional health attributes, this could add significant value to the apple and the industry

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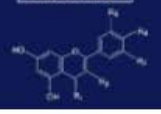
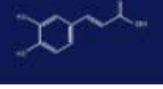
Polyphenols

- Secondary plant metabolites
- Phenol group, multiple hydroxyl groups
- Many thousands: diverse range of functions
- 2 main classes:

flavonoids | phenolic acids





Dietary sources of flavonoids

Background

- Apples are rich in polyphenols ("antioxidants")
- Apples are often a major contributor to total flavonoid intake
- There is increasing evidence that polyphenol-rich foods and beverages can reduce the risk of heart disease and stroke
- There is evidence that an important mechanism is via increased nitric oxide, improved blood vessel function and lower blood pressure

Aims

- To screen apple selections for flavonoid composition, to characterise the polyphenols present, and to identify selections with elite polyphenol levels; and
- To demonstrate in human volunteers that consumption of apples with elite flavonoid levels results in effects on cardiovascular disease risk factors consistent with health benefits.

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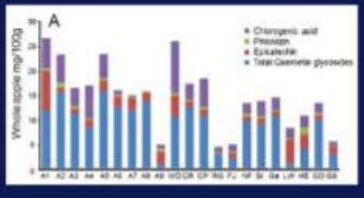
Aims

- To screen apple selections for flavonoid composition, to characterise the polyphenols present, and to identify selections with elite polyphenol levels

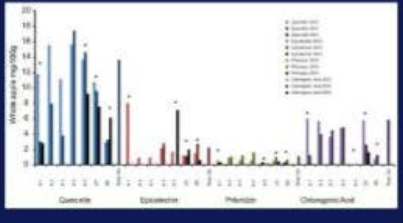
Polyphenol content of apple selections



Polyphenol content of apple selections

Flavonoid	Evidence	Apple levels
Quercetin	• > 33 mg/day associated with decreased risk of CV disease; • effects on blood pressure and endothelial function	2.5 mg – 21.5 mg
Epicatechin	• inverse relationship between consumption and risk of CV disease • 70 mg acute benefit on endothelial function	2.5 mg - 11 mg
Chlorogenic acid	• Evidence from coffee consumption suggest benefits on blood pressure and endothelial function	0 – 14.5 mg

Polyphenol content of apple selections



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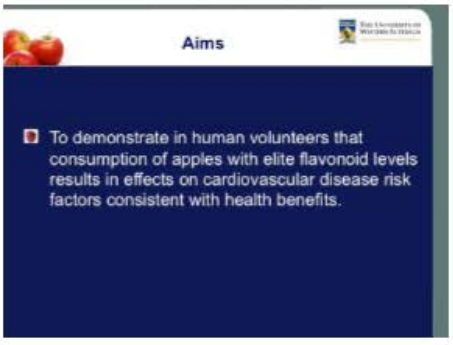
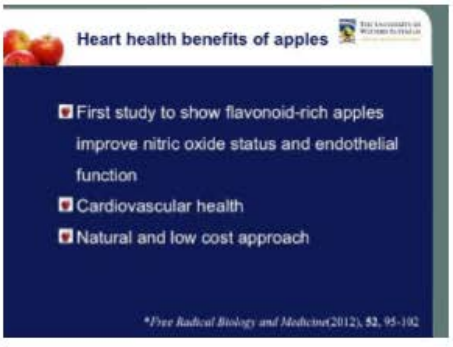
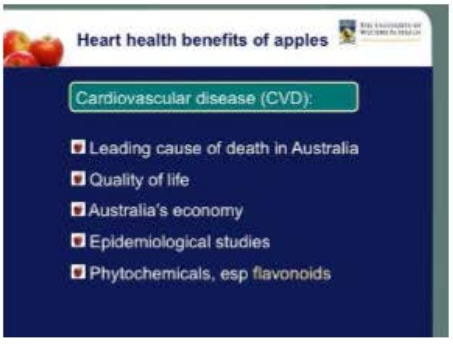
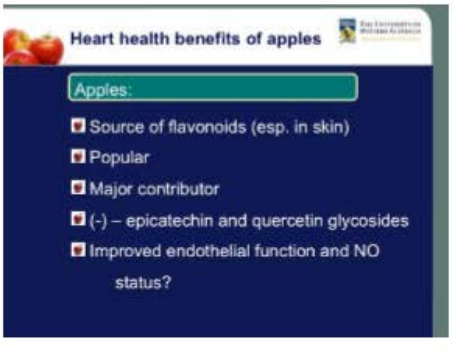

Aims
To demonstrate in human volunteers that consumption of apples with elite flavonoid levels results in effects on cardiovascular disease risk factors consistent with health benefits.


Heart health benefits of apples
First study to show flavonoid-rich apples improve nitric oxide status and endothelial function
Cardiovascular health
Natural and low cost approach
*Free Radical Biology and Medicine(2012), 52, 95-102


Heart health benefits of apples
Cardiovascular disease (CVD):
Leading cause of death in Australia
Quality of life
Australia's economy
Epidemiological studies
Phytochemicals, esp flavonoids


Heart health benefits of apples
Apples:
Source of flavonoids (esp. in skin)
Popular
Major contributor
(-) – epicatechin and quercetin glycosides
Improved endothelial function and NO status?

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Heart health benefits of apples

Aim:

to investigate the acute effect of flavonoid-rich apples on endothelial function and NO status in healthy men and women

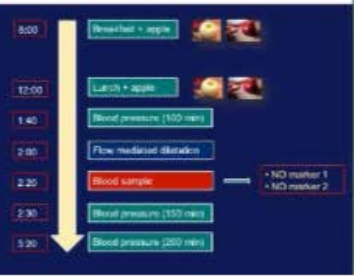
Study design

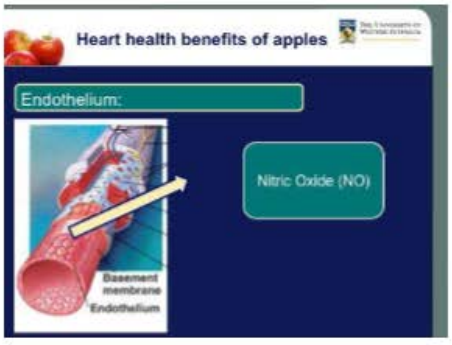
Randomised, controlled, cross-over trial

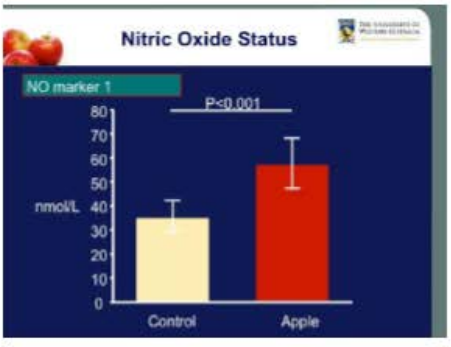
Flavonoid composition of apple

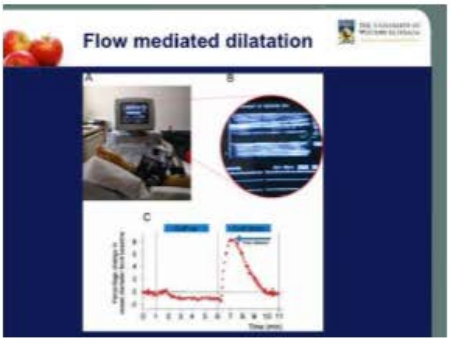
Polyphenol	Apple control (apple flesh) mg/dose (500 kJ)	Apple active (apple flesh+skin) mg/dose (500 kJ)
Quercetin glycosides	2	180
Free Quercetin	<0.1	4
Total Quercetin	2	184
(-)-Epicatechin	2	180
Chlorogenic acid	44	44

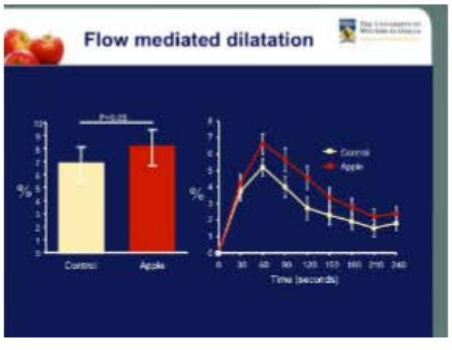
Study day plan



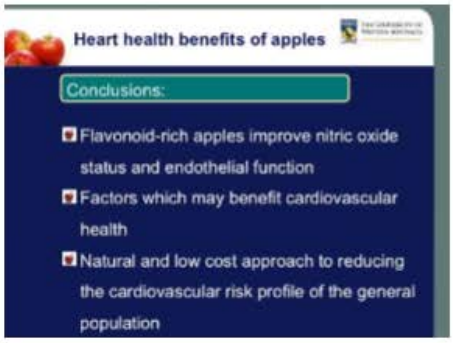

Heart health benefits of apples
Endothelium:
Nitric Oxide (NO)
Basement membrane
Endothelium

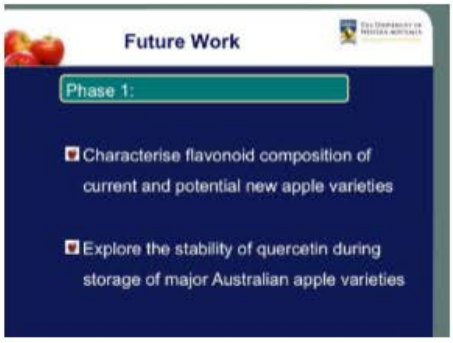

Nitric Oxide Status
NO marker 1
P<0.001
nmol/L
80
70
60
50
40
30
20
10
0
Control
Apple

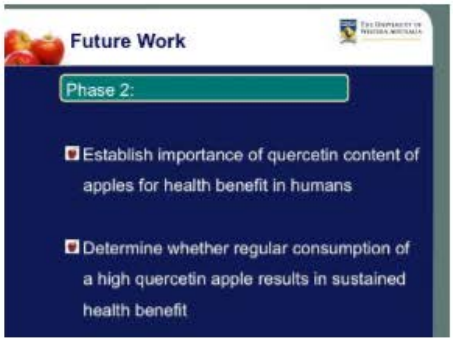

Flow mediated dilatation
A
B
C


Flow mediated dilatation
%
Control
Apple
Time (seconds)

22


Heart health benefits of apples
Conclusions:
Flavonoid-rich apples improve nitric oxide status and endothelial function
Factors which may benefit cardiovascular health
Natural and low cost approach to reducing the cardiovascular risk profile of the general population


Future Work
Phase 1:
Characterise flavonoid composition of current and potential new apple varieties
Explore the stability of quercetin during storage of major Australian apple varieties


Future Work
Phase 2:
Establish importance of quercetin content of apples for health benefit in humans
Determine whether regular consumption of a high quercetin apple results in sustained health benefit

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Autonomous information systems for horticulture and tree crops

Dr. James Patrick Underwood
Senior Research Fellow
The Australian Centre for field Robotics (ACFR), The University of Sydney

Dr. James Patrick Underwood is a senior research fellow at the Australian Centre for Field Robotics (ACFR) at The University of Sydney. James is an expert in the area of perception systems for field robotics – the study of how outdoor robots working in complex, unstructured environments can make sense of their world using science and technology in multi-modal sensing, data fusion and mapping. James has applied his research to a number of industry applications including mining, defence and agriculture, with a focus on research and development of robotics and sensing technology for the horticulture industry.

Commercial tree cropping operations are highly labour intensive and compared to broad-acre agriculture, there is a comparative lack of commercial off-the-shelf technology for mechanisation and automation. Broad-acre applications are typically wide, open, relatively homogeneous fields, whereas the tight and highly variable operating environments in orchards pose multiple challenges for automation. Similarly, the variation between orchards across the industry is challenging for low-cost one-size-fits-all solutions. Nevertheless, robotics and autonomous systems have an important role. Information systems, such as for the estimation of yield and health, as well as the detection of weeds, pests and diseases, can help to increase agricultural output and to build new practices that ensure long-term sustainability.

We have investigated the use of autonomous ground vehicle robots to map and model orchards, instantaneously and over time, to provide detailed information about every individual tree, while covering entire orchard blocks. The vehicle autonomously drives along the centre of each row, building an orchard model from an array of on-board sensors. Lidar sensors provide a detailed three dimensional model of each tree, which is augmented with the visual information from the cameras. Automated image processing software is used to detect flowers and fruit within the images and to calculate the densities per tree. The data are spatially mapped and used to estimate and predict the distribution of yield. This can be used as a decision making tool and to diagnose potential problems where individual trees or regions of the orchard do not perform as expected.

During a two year study, we evaluated the system in a commercial almond orchard in Mildura and a commercial apple orchard in the Yarra Valley, demonstrating a strong relationship ($R^2 \sim 0.8$) between the orchard models and the yield for

individual trees and whole rows. This demonstrated the potential for intelligent, autonomous, ground-based information systems for tree crops. Further work will be required to validate the performance over a wider variety of conditions, including different orchard configurations and for a wider range of fruits.

A key finding was that the regularity and simplicity of the orchard structure and canopy design has a strong impact on the reliability and simplicity of autonomous systems and software. Two-dimensional trellises provided for the most simplicity, both for autonomous motion along rows and for streamlined processing of images for yield estimation. In the future, it is envisaged that optimal orchard design will need to consider autonomous and mechanised systems in addition to biological constraints such as optimal light capture and pollination.

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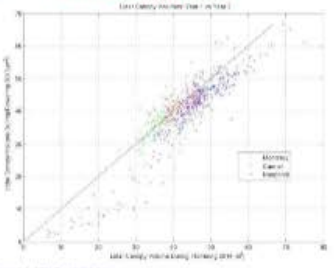
Tree Segmentation

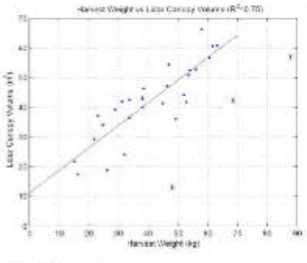
Tree Geometry

Canopy volume, rate of growth, tree structure

Lidar Canopy Volume



Yield Estimation



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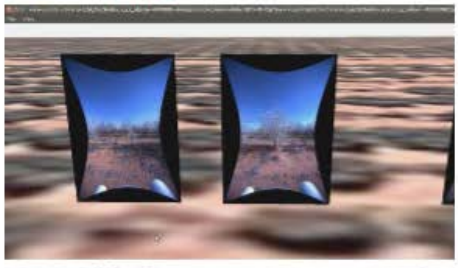
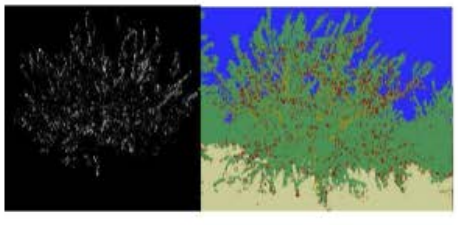
Images

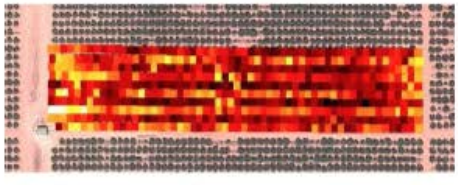


Seasonal / Historical Comparisons

Classification: Flower/Fruit Count

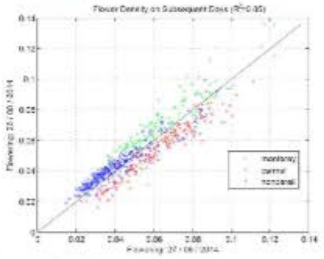


Flower Maps

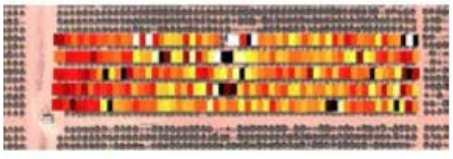


Alternating pattern due to pollinator rows

Flower Dynamics



Yield Maps

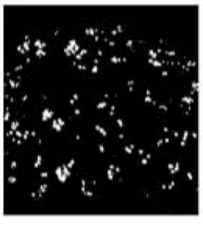


Red=low yield, yellow=high yield
Trees adjacent to access road (left) have lower yield

Applicable to Other Fruits

Mango photo: Kerry Walsh and Alison Payne, Central Queensland University

Applicable to Other Fruits



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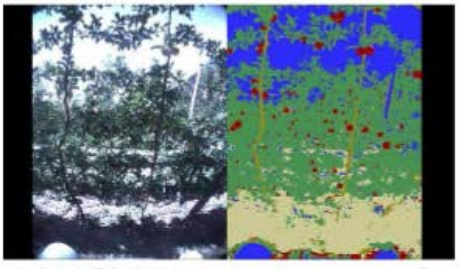
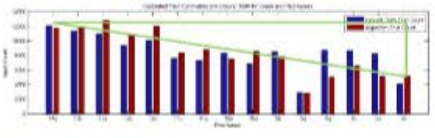
Classification: Fruit Count



Value of Information

- Image based apple counting

- Per-row yield estimates, compared to harvest



Capabilities

Now
- Per-tree measurement with broad coverage
- Seasonal and historical digital records
- Performance tracking and diagnosis

Next
- Per-fruit measurement and tracking
- Per-tree health monitoring
- Per-tree and per-fruit automated treatment

Questions…

Biochar as a soil amendment

Dr. Marcus Hardie
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Declining soil health in perennial fruit tree orchards is a concern due to a long term lack of carbon inputs. Traditionally, orchardists have added carbon-rich amendments, such as composts, mulches or manures to increase soil carbon however, these amendments are expensive to apply and breakdown within 12-18 months.

In contrast biochar, created by heating organic matter under reduced oxygen conditions, has a residence time of hundreds to thousands of years in soils. We investigated the effects of applying 47 t ha^{-1} of *Acacia* whole-tree green waste biochar which had undergone pyrolysis at temperatures up to 550 °C, and commercially available compost on soil structure, water limits, stability, carbon, acidity, and microbial diversity. And their effects on tree growth, photosynthesis, water uptake, yield and fruit quality in an intensively managed young commercial apple orchard in the Tasmanian Huon Valley. The soil amendment treatments included incorporation of a low-temperature-derived green-waste biochar at 47 T/ha prior to planting, compost application at 10 T/ha after planting, biochar plus compost application, and control.

Thirty months after incorporation, we found that biochar application had no significant effect on a number of important soil parameters including soil moisture content, drainable porosity, field capacity, plant available water capacity, aggregate stability, nor the permanent wilting point. However, biochar amended soil had significantly higher near saturated hydraulic conductivity, soil water content at -0.1 kPa, and significantly lower bulk density than the unamended control. These differences were attributed to the formation of large macropores (>1200 µm) resulting from greater earthworm burrowing in the biochar amended soil.

Biochar application significantly increased phosphorous concentration in the leachate, whilst having no significant effect on nitrate or potassium concentration. The volume of rainfall and irrigation moving through the topsoil was significantly higher in the biochar treatment (due to earthworm burrowing) which resulted in significantly higher amounts of potassium and phosphorous being leached from

the biochar treatment than the control. Biochar application had no significant effect on either the concentration or the amount of nitrate leached from the topsoil. Leaching accounted for loss of between 53 % to 78 % of the applied nitrogen, 5 % to 11 % of the applied phosphate, and 69 % to 112 % of the applied potassium, were leached below the topsoil.

Crop yield and fruit quality parameters were unaffected by the soil amendment treatments. Trunk girth was significantly higher than the control in the biochar plus compost and biochar treatments, in the first year and fourth year, respectively, while compost had no effect in any year. Plant physiology in terms of photosynthetic capacity and leaf nutrient concentration were unaffected by biochar or the compost. Similarly, seasonal daily tree water use was similar between biochar and control treatments. Lack of a significant difference in tree water- and nutrient-relations between treatments was attributed to the site receiving excess nutrients and irrigation such that any potential effects of biochar and compost on increased water and nutrient availability were not realised. The relative abundances of soil bacteria were similar across treatments. The biochar and compost treatments were associated with modest changes in the type and function of microbial communities.

In general, application of *Acacia* biochar at the Huon valley site had no significant effect on fruit quality or yield, little effect on soil structure or soil quality, no effect on soil water holding capacity or nutrient retention, and no effect on tree water use or photosynthetic capacity. In fact biochar application had a deleterious effect on soil acidity (decreased 0.53), and increased leaching of phosphorous and nitrate. The overall lack of response to the application of biochar is thought to be due in part to the abundant use of fertilizer and irrigation at the site such that trees were not exposed to moisture or nutrient stress during the monitoring period. It is possible that other types of biochars, in other soils, at other sites, especially drier less nutrient rich sites, may have resulted in observable effects from biochar application.

Biochar to the Rescue

- Reduce soil acidity
- Increase soil moisture
- Increase water retention
- Improve soil structure
- Increase number of beneficial soil microbes
- Stimulates soil microorganisms
- Increase productivity and crop yields
- Reduced leaching of nitrogen into ground water
- Reduce fertiliser use

Biochar can improve almost any soil.

What is biochar ?

Biochar: charcoal resulting from heating of biomass in an oxygen-limited environment

Trial Description

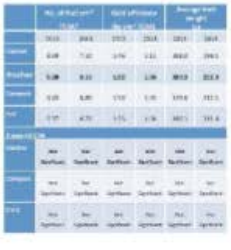
Location: Mountain River, Tasmania
Cultivar: Fuji (Naga-Fu 2)/M26
(with Royal Gala interstem)

Treatments:

i. control (untreated)
ii. biochar 47 t/ha or 5 kg /tree
iii. compost 10 t/ha
iv. biochar + compost

Biochar produced from the wood wastes of *Acacia* sp. produced at 550 °C (sourced from Pacific Pyrolysis, NSW)

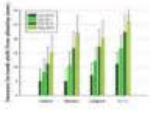
Tree growth



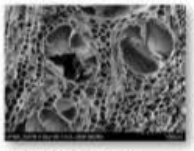
No effect on...

- Yield
- Yield efficiency kg /cm²
- No of fruit
- Fruit weight
- Blossom density

Sig. increase in stem girth



Soil Water and Porosity



SEM of Acacia green waste

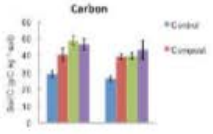
No significant effect on:

- Field capacity
- Permanent wilting point
- Plant available water
- Soil moisture
- Aggregate stability
- Mesoporosity & Microporosity

Significantly:

- Reduced bulk density
- Increased total porosity
- Increased saturated water content.

Soil Carbon and Acidity



- Both organic amendments increased soil C
- Biochar decreased rate of potential N mineralisation

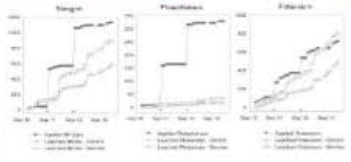
Acidity

- Biochar pH $_{1:5\ H_2O}$ 6.40
- Unusual most are alkaline

After 20 months

- Control pH $_{1:5\ H_2O}$ 6.14
- Biochar pH $_{1:5\ H_2O}$ 5.61

Nutrient Leaching



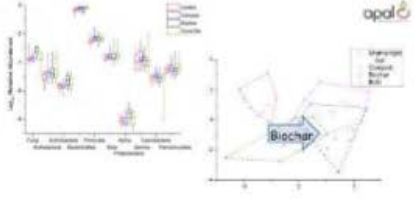
Biochar resulted in significantly more water moving through the soil profile....worms

Biochar significantly increased

- Phosphorous Concentration
- Phosphorous leaching
- Potassium Leaching

(Nitrogen 51% increase – not significant)

Soil Microbial Diversity



Changes in bacterial diversity - not significant or modest

Shift in the type of microbes in each treatment

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Biochar to the Rescue

- Reduce soil acidity
- Increase soil moisture
- Increase water retention
- Improve soil structure
- Increase number of beneficial soil microbes
- Stimulates soil microorganisms
- Increase productivity and crop yields
- Reduced leaching of nitrogen into ground water
- Reduce fertiliser use

Biochar can improve almost any soil.

Biochar to the Rescue

Fail Reduce soil acidity
Fail Increase soil moisture
Fail Increase water retention
Yes Improve soil structure
Fail Increase number of beneficial soil microbes
Yes Stimulates soil microorganisms
Fail Increase productivity and crop yields
Fail Reduced leaching of nitrogen into ground water
Fail Reduce fertiliser use

Biochar can improve almost any soil.

Biochar Not to the Rescue

Fail Reduce soil acidity
Fail Increase soil moisture
Fail Increase water retention
Yes Improve soil structure
Fail Increase number of beneficial soil microbes
Yes Stimulates soil microorganisms
Fail Increase productivity and crop yields
Fail Reduced leaching of nitrogen into ground water
Fail Reduce fertiliser use

Biochar can not improve almost any soil.

Some biochars in some soils probably do work but not this biochar, at this site.....

Acknowledgements

Thanks to a great team

Facilitated by funding from Horticulture Australia Ltd to the PIPS (Productivity, Irrigation, Pests and Soils) Orchard Productivity Program

And to Adrian and Scott Stevenson for providing the site and allowing us access at all hours

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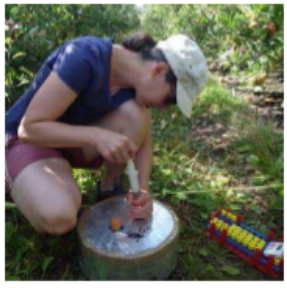
PIPS soil carbon



Dr. Roberta Gentile
The New Zealand Institute for Plant & Food Research Limited
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Soil carbon stocks in orchards are critical to enhance soil, water and nutrient retention and they are a means to reduce greenhouse gas emissions. In the PIPS soils program we conducted a survey of soil carbon and soil health indicators in the main apple orcharding regions of Australia, with the objectives of establishing the soils' current carbon status and determining the relationships between soil carbon and soil functions. Total carbon stocks to 1m depth ranged from 6 to 26 kg C m-2.

We also measured the soil labile carbon contents, that is, the hot-water extractable carbon contents. These were strongly related to soil microbial activity and potential nitrogen release. Labile carbon is a measure of the carbon that is available for soil microorganisms and which is active in nutrient cycling. Lastly, we resampled three orchards after four years to see if there had been a measurable change in soil carbon. We did not find any change in the total soil carbon stocks down to 1m depth. It is important for the sustainability of orchard production that soil carbon stocks be maintained, or better still, enhanced.

Roberta Gentile
R. Simpson, M. Hardie, J. Direen, D. Cornwall, K. Mason, C. van den Dijssel, and B. Clothier

Soil Carbon

- Drives soil functions
  - soil aeration
  - water holding capacity and infiltration
  - nutrient retention and delivery
  - biological habitat
  - climate change mitigation
- PIPS program
  - Aim to increase eco-efficient use of nutrients

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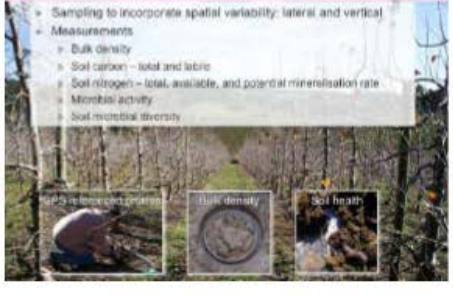
Apple Orchard Survey

- Establish soil carbon status
- Determine the relationships between soil carbon and soil functions

Orchard Sampling

- Sampling to incorporate spatial variability: lateral and vertical
- Measurements
  - Bulk density
  - Soil carbon – total and labile
  - Soil nitrogen – total, available, and potential mineralisation rate
  - Microbial activity
  - Soil microbial diversity



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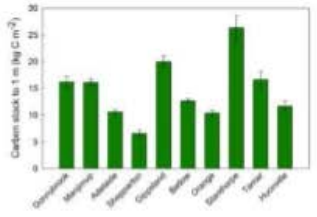
Soil Carbon Stocks

- Carbon stocks to 1 m depth
- Range from 7 to 26 kg C m^{-2}



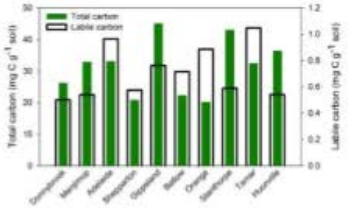
Soil Health

- Strong positive relationships between:
  - Labile carbon, total nitrogen, microbial activity, potential nitrogen mineralisation
- Potential indicators for soil carbon regulation and nutrient supply

	Total C	Labile C	Total N	Available N	Microbial activity
Total C	-				
Labile C	0.24	-			
Total N	0.74	0.58	-		
Available N	-0.02	-0.13	0.21	-	
Microbial activity	0.31	0.71	0.71	0.03	-
N mineralisation	0.41	0.58	0.66	0.01	0.79

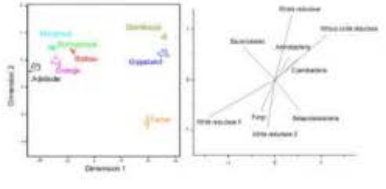
Labile v. Total Carbon

- Labile carbon is more sensitive indicator of microbial activity and nutrient supply



Microbial Community Composition

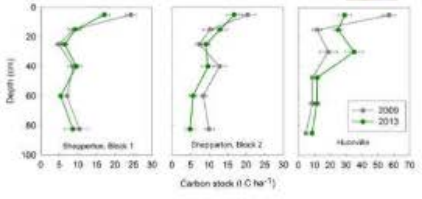
- Orchards differ in their community composition



Change in Soil Carbon

Change in Soil Carbon

- No net change in carbon stock to 1 m



Conclusions

- Established baseline measures of soil carbon stocks
- Quantified soil health metrics
- Labile carbon is a sensitive indicator of potential nutrient supply
- Important to maintain or enhance soil carbon

Plant & Food RESEARCH

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Horticulture Innovation Australia

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Thank you to
Terry Martella, Harvey Gilbert, Michael Stafford, Brad Fankhauser, Maurice Silverstein, Barry McLean, Michael Cunial, Daniel Nicolet, Brad Ashlin and Howard Hansen

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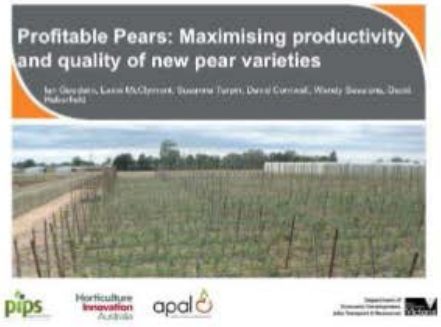
Profitable Pears: maximising productivity and quality of new pear varieties (PIPS)

Dr. Ian Goodwin
Research Manager – Horticulture Production Science,
Agriculture Research Division
Department of Economic Development, Jobs,
Transport and Resources (DEDJTR)
Ian.Goodwin@ecodev.vic.gov.au

Orchard management systems of the new red-blushed pear varieties to maximise productivity and sustain high yields of consistent quality fruit are being investigated in a 4ha "pear field laboratory" at Tatura. Three experiments have been established to examine the effects of different training systems and planting densities; compare drip and microjet irrigation on young tree growth; explore root pruning as a mechanism to stimulate fruit bud development; and investigate the effects of rootstocks on growth, precocity, yield and fruit quality.

Results will be presented on young tree growth from these experiments. In addition, a summary of preliminary investigations of plant growth regulators (PGRs) to promote and control shoot development and aide fruit set will be presented. New proposed studies on nitrogen management of red-blushed pears will also be outlined.


Profitable Pears: Maximising productivity and quality of new pear varieties
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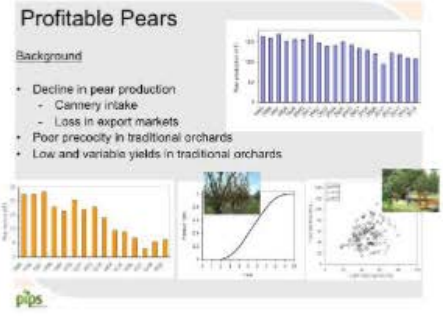
Profitable Pears
Background
• Decline in pear production
- Cannery intake
- Loss in export markets
• Poor precocity in traditional orchards
• Low and variable yields in traditional orchards
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Profitable Pears
Objectives
Investigate sustainable management techniques to increase precocity, fruitfulness and fruit quality of new pear varieties.
1. Rootstock, training system and planting density.
2. Irrigation system and management.
3. Fruit bud type and fruit quality.
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Profitable Pears
Progress
1 Rootstock, training system and planting density.
Established experiments
• Rootstock x Variety
• Training system x Planting density x Rootstock (ANP-0131)
• Gordon (ANP-0534)
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Profitable Pears

Rootstock Experiment

- Rootstock: D6, D6/BM2000, D6/Nijaseiki, BP1, Quince A/Beurre Hardy, Quince C/ Beurre Hardy, D6+virus
- Variety: ANP-0131, ANP-0118, ANP-0534

Variety	Pruning dry weights (g)
ANP-0131	297
ANP-0118	215
ANP-0534	223

Rootstock	Pruning dry weights (g)
D6/BM2000	146
D6/Nij	192
BP1	235
QA/BH	246
QC/BH	263
D6	306

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Profitable Pears

Planting Systems Experiment

- System: Open Tatura leader (multi + single), Vertical leader (multi + single), Central leader, Vase
- Density: 740 – 4444 trees/ha
- Rootstock: D6, BP1, QA/Beurre Hardy

Rootstock	Pruning dry weights (g/ m row)
BP1	27
D6	49
QA	52

System – Tree spacing	Leader number per tree	Pruning dry weights (g/m row)
Vertical – 0.5 m	1	39
Vertical – 1 m	2	28
Central leader – 0.5 m	1	22
Central leader – 1 m	1	15
Open Tatura – 0.5 m	2	69
Open Tatura – 1 m	4	65

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Profitable Pears

Cordon Demonstration

- Upturned or headed cordons
- 40 cm leader spacing
- ANP-0534 on D6

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Profitable Pears

Progress

2. Irrigation system and management

Imposed treatments and continued measurements

- Drip and microjet
- Standard and frequent
- +/- root pruning

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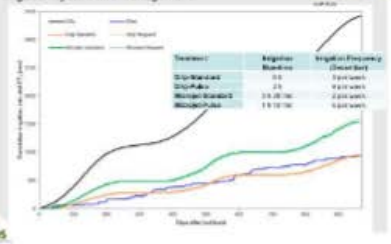
Profitable Pears

Progress

2. Irrigation system and management



Profitable Pears

Progress

2. Irrigation system and management

Profitable Pears

Progress

2. Irrigation system and management

Profitable Pears

Progress

3. Fruit bud type and fruit quality
- Bud types – fruiting behaviour and fruit quality
- Branch angle – bud development
- Plant growth regulators
  - Five experiments conducted to investigate PGR effects on fruit set, development of fruiting buds, side lateral development, and termination of shoot extension

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Profitable Pears

Next steps

- Continue treatments and measurements including flowering and fruiting behaviour
  - Rootstock and planting systems
  - Irrigation and root pruning
- Continue to update the Intensive Pear website and HIN
  - Project summary and results
  - Video footage
- Industry articles
- Irrigation experiment
  - Sub-project report
  - Present at irrigation conference
- Liaison meeting and field day

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Thank you

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Questions

Tree structure, crop load management and orchard light interception (PIPS)

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Crop load management, tree structure and light interception of apple orchards were investigated in order to optimise yield and quality. 'Gala' and 'Cripps Pink' were researched in the Huon Valley in Tasmania, the Goulburn Valley in Victoria and Stanthorpe in Queensland. Generally, fruit size was greatest on terminal buds of short shoots and spurs, and smallest on axillary buds of one-year-old wood. Greater fruit size for spurs and terminal buds was associated with more leaf area to support fruit growth.

Spurs were removed by hand ('Artificial Spur Extinction', ASE) during tree dormancy to enable precise crop load management and this was compared with thinning apples by hand, both in the absence of chemical thinning. ASE reduced flower numbers by ≥ 50%, increased fruit set on terminal and spur buds, and promoted greater fruit size for a given crop load. Commercial productivity was maximised where 5 or 6 floral buds per cm^2 branch cross-sectional area were retained resulting in yields of ≈100 T/ha of high quality fruit. This is equal to the best production globally.

The most productive orchards always had canopy light interception of ≈60%. However, not all intensively planted blocks on dwarf rootstocks had high yield for various reasons including inadequate trellising, poor tree structure, low pollination under hail net and excessive vigour. One of the greatest limitations to Australian apple orchard productivity remains the conservative decisions of tree spacing and orchard layout, which limits light interception to < 50%, well below the optimum 60% achieved by the best Australian apple orchards.

This presentation provides some practical examples of how to optimise tree structure during winter pruning to maximise fruit yield and quality.

PIPS Tree Structure

APAL Speed Updating Research Review, 2015

PIPS Tree Structure - overall objective:

Increase orchard productivity and efficiency by 'manipulating tree structure to optimise function'.

The 5-year tree structure programme of PIPS1 is now completed. Key are findings presented!

---

1) Understanding genotypic fruiting behaviour: Which floral buds have more potential for fruit size and fruit quality?

Spur	Terminal	Axillary
< 2.5 cm with minimal internode extension	≥ 2.5 cm but ≤ 30 cm with internode extension	Floral buds on one-year-old shoots

---

2) Optimising tree structure:

- Only 6 branches per m of tree height required (often > 9 present)!
- Train branches to 10-15° below horizontal (i.e., slightly pendant).
- Artificial spur extinction applied annually reduces excess floral bud number & induces regular bearing & strong fruit bud development.

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Spur extinction:

Before After

Optimising tree structure & performance: Light interception responses

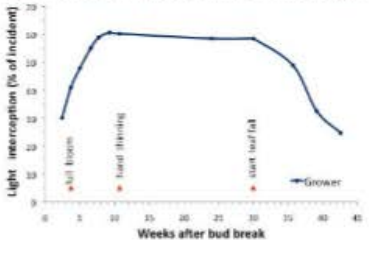
(Ken Breen's PhD studies, NZ, effects of canopy optimisation)

- Commercial 'Royal Gala' block on M.9, planted 2005, 3.4 x 1.25 m, 2352 trees per ha.
- Grower's target yield: 100 tonnes/ha

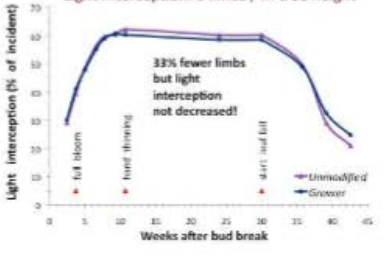
Canopy changes :

- Branch number optimisation for improved light relations - **9 branches per m of tree height reduced to 6!**
- Artificial spur extinction for precision crop loading and enhanced spur quality. **12 floral buds cm² / BCA reduced to 6!**

Light interception, grower, 9 limbs / m tree height



Light interception: 6 limbs / m tree height



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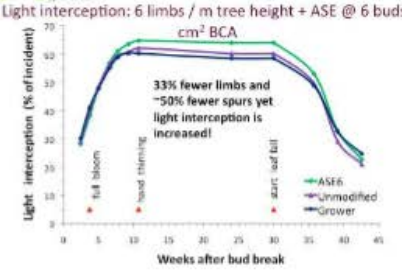
Light interception: 6 limbs / m tree height + ASE @ 6 buds/ cm^2 BCA



Optimising tree structure can increase yield!

Tree type	Limbs per m tree ht (per tree)	Fruit No. per tree	Yield t/ha	Mean fruit weight (g)
Grower management	9.0 (27)	327	117	152
Optimised limb no.	5.9 (18)	325	118	154
Optimised limb no. plus ASE	5.8 (17)	321	120	170

The power of optimisation!

Australian orchards have high productivity potential!

Fruit bud density set per limb	Total BCA per tree	Fruit density after hand thinning	Mean fruit weight (g)	Trees / hectare	Gross Yield (t /ha)
'Rosy Glow' / M.26					
5 buds / cm2 BCA	28.1 cm^2	5.4 fruit / cm^2 BCA	180.5	2222	83.0
6 buds / cm2 BCA	45.5 cm^2	5.7 fruit /cm^2 BCA	174.1	2222	101.0

Trees planted at 4.5m x 1 m, 2222 trees / ha.

- 100 t/ha achievable @ 61% light interception!
- Intensive blocks that were less productive had low light interception because of inadequate trellising & wider than necessary interows.

Further reading:

- Fewer spurs leads to a better and more reliable fruit set. Australian fruitgrower, 2014, 8, 5, p 25-27.
- Spur extinction – a natural process leading to a new crop management technology. Australian fruitgrower, 2018, 8, 5, p 26-29.
- Manipulating apple tree structure to optimise fruit yield and quality. Australian fruitgrower, 2016, 8, 4, p 32-34.
- New directions in crop load management. Australian fruitgrower, 2012, October, p 16-18.
- Are all fruit buds created equal? Australian fruitgrower, 2011, 5, p 10-13.

Thank you for your interest

Lenswood young tree growth project – Aztec Fuji

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The South Australian apple industry is currently undergoing a major and rapid change in production systems and varieties. These "changes" involve integrating netting and new trellis systems into their new intensive orchards and at the same time changing over to new varieties. Two of these varieties are Aztec Fuji and Rockit™. Both of these varieties can be problematical in achieving enough height to appropriately fill the allocated space in these new orchard systems, albeit for different reasons.

The South Australian growers have embraced the important information available to them, primarily from the Future Orchards program and are actively addressing one of the key areas they have identified that they need to change – young orchard performance.

Whilst the PIPS project is providing valuable information on new orchard designs our growers have to focus on maximising their investments on what they are actually planting at the moment. Nursery trees have already been propagated, ground preparations already started and trellises ready to go.

In commercial practice growers use a wide range of techniques to manage and develop their young trees from planting onwards. These techniques are often widely discussed and challenged within the South Australian industry group. One particular practice often discussed routinely used is heading nursery trees. There are numerous research papers suggesting that this should not be undertaken. However it is often used to "improve tree and orchard uniformity". One way to identify the best options for use in our environment was to actually compare the techniques being used.

In 2014 a trial was super imposed on a new commercial planting of Rockit™ and Aztec Fuji. Two identical trials were set up to compare different young tree establishment and development strategies. This presentation will focus on the Aztec Fuji component of the trial. This trial is completely self-funded by the Lenswood Coop and Next Fruit Generation Australia (NFGA).

The trial site is in a replant site that was redeveloped using as many best practice techniques as possible. The land was cleared, prepared and fumigated with Metham sodium. In October 2014 the trees were planted and the trial superimposed on the planting. The trees were commercially purchased, grown on M.26 rootstock and planted at 2857 trees /ha (3.5 x 1 m).

The trial involves 6 treatments, each with 4 randomised replicates with the trees trained routinely in accordance with the "usual" practices for each system. Two treatments will involve changes to the 1st year winter pruning practices usually undertaken. Baseline measurements of the trees indicate that they were all of similar size and quality at the time the trial was superimposed (see slide data). Measurements, photos and grower field days are being routinely undertaken. An important measurement will be the yield performance of the systems up to year 5. Two of the major factors influencing the growth of Fuji trees using conventional training systems are the impact of same age branches on leader growth and the propensity for Fuji leaders to quickly weaken. To optimise the growth of Fuji trees on netting trellis structures we need to minimise these two problems.

The trial treatments include:

1. Control – managing nursery trees as provided by the nursery.
2. Nursery trees – whipped at planting (but not headed).
3. Nursery trees whipped at planting, not headed and all branches (feathers) stubbed back in winter of the first growing season.
4. Nursery trees whipped at planting and headed.
5. Nursery trees whipped and headed at planting and all branches (feathers) stubbed back in the winter of the first growing season.
6. Grower's own preferred system (based on commercial practices being used by the trial site grower).

All of the trees were deflowered at flowering (in preference to fruit removal) and had the same nutritional and pest and disease control program. Additionally all trees have had routine applications of Gibberelic acid applied (by targeted air blast sprayer application) to assist in leader tip growth. The use of other growth regulators to assist in side branch development has not been used because of the trial focus on leader development. In the control treatment any original nursery feathers below 800 mm were removed.

The preliminary results at the end of the first growing season are very interesting. The presentation slides show the actual growth measurements of these trees this season. The grower has produced very good consistent trees.

A comparison of the initial winter growth measurements taken in May 2015 – 8 months after planting has some very interesting observations. A statistical analysis of these results has not yet been undertaken however some of the differences are very self-evident.

In summary the whipped trees have outperformed the whipped and headed trees (to date) they are generally taller, have more branches (feathers) and these feathers are more evenly spaced along the leader.

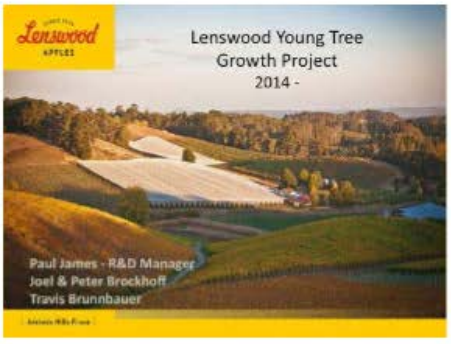
The data shows that the headed trees have fewer feathers per tree on average and that the majority of these are located below the 900 mm heading height. The issue of the feathers being concentrated below the 900 mm heading height exacerbates the problem of low branches impacting on Fuji tree height and leader growth.

A separate evaluation of the control tree performance (data not presented) shows the significant impact of same age feathers on the growth of the young tree leaders. The individual tree performance of control trees with nursery feathers retained at planting had an average growth reduction on leader Trunk Cross sectional Area (as measured at 800 and 1250 mm) of 64.3%. Whereas the control trees with no nursery feathers had and average difference of only 32.2%. Two individual trees had a 50% reduction in actual leader circumference at the same heights – highly constricted. A similar but less dramatic impact was also seen in the tree height where there was a 7.8% difference.

At this stage of the trees development there has been a distinct commercial advantage to whipping the nursery trees in preference to whipping and heading. This finding reinforces a number of studies previously undertaken around the world.

Growers will be advised to avoid heading nursery trees unless there is a specific need to do so. They will also be advised to whip trees in preference to retaining nursery feathers. However this advisory will be contingent on the quality of nursery trees provided.

The continuation of the trial will provide some valuable local data and show the potential impact of stubbing the 1 year old feathers on overall tree performance.



SA Situation

- Moving into netted orchards with integrated trellis systems
- Many different grower approaches to training young trees
- Grower propensity to head trees
- Need to improve young orchard performance (FO)
- Changing varieties - ↑'Controlled ' Varieties
- Need to maximise commercial performance
- Growers improving pre plant preparation and young tree management

How do we get from this to this?

Efficiently
Productively
Quickly
Economically
Uniformly

Full canopies of high quality and annual high yielding crops

10,000 M^3 Canopies
100 t/ha (variety dependent)

2 New Varieties

Aztec Fuji & Rockit

- Both "Vertically Challenged" but for different reasons.
- Lenswood Apples – self funded trial established 2014 – identical set ups and management
- Focus on Aztec Fuji
  - Impact of lower branches (same age "feathers") restricts tree height and performance
  - Need to improve leader dominance

Trial Block

- Commercial – replanted orchard
- Fumigated pre – plant with Metham Sodium
- Nutrients and soil amendments adjusted pre plant (BMP)
- M.26 rootstock
- 2857 trees /ha
- To be a netted orchard
- Drip irrigated and fertigated
- 6 tree training strategies x 4 replicates
- All flowers removed 1st year
- Extensive use of Gibberelic acid sprays to growing tip

"Control"

- as provided by nursery – all feathers below 800 mm removed

At planting – Oct 2014

March 2015

"Whips"

At Planting – Oct 2014

March - 2015

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2 treatments grown this way

1 treatment will have all branches (feathers) removed (stubbed) back to approximately 1 cm at end of first year

Objective – branches 2 years younger than leader

"Headed Whips"

At Planting – Oct 2014

March - 2015

2 treatments grown this way

1 treatment will have all branches (feathers) removed (stubbed) back to approximately 1 cm at end of first year

Growers Option

At Planting - October 2014

March 2015

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Growers Option

- Whipped and headed (900mm) at planting
- Feathers allowed to develop above 800mm
- Best positioned feather selected for new leader
- Others removed post Christmas
- Leader allowed to develop
- Any side feathers will be stubbed back
- New feathers will develop on 1 year older leader

Baseline Measurements

4 Rep Averages @ Planting

Treatment	TCSA Cm^2	Tree Height Cm	Graft Union Height Cm
Control	1.72	168	12.3
Whipped 1	1.75	168	12.3
Whipped 2	1.78	166	12.6
Whipped & Headed 1	1.69	169*	12.5
Whipped & Headed 2	1.61	163*	12.9
Grower Option	1.74	171*	12.8

* Reduced to 90 cm after treatments applied

Measurements – May 2015

4 Rep Averages

Treatment	TCSA Cm^2	Tree Height Cm	Ave number of feathers / tree	Number of feathers <900 mm
Control	5.41	235	7.1	1.6
Whipped 1	5.39	240	10.2	1.9
Whipped 2	5.61	240	9.9	2.2
Whipped & Headed 1	4.67	224	6.4	4.8
Whipped & Headed 2	4.43	223	5.9	5.2
Grower Option	4.05	246	7.1	1.6
All tree average	4.93	235	8.1	2.94

Retained nursery feathers vs no feathers

	Retained Feathers	No Feathers
Average Tree Height (m)	2.25	2.44
Av Circumference @ 800 mm (cm)	7.63	6.35
Av Circumference @ 1250 mm (cm)	4.56	5.23
Difference (cm)	3.06	1.13
% Difference	40.2%	17.7%
Av TCSA @ 800 mm (Cm^2)	4.64	3.21
Av TCSA @ 1250 mm (Cm^2)	1.66	2.18
Difference (Cm^2)	2.98	1.03
% Difference	64.3%	32.2%

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Un-headed vs Headed

Which one do you prefer?

Thankyou

SINCE 1933
Lenswood
APPLES

Fruit set and crop load management of Australian-bred scab resistant apples

Dr. Osi Tabing
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Kalei is the first scab-resistant apple developed from the Applethorpe Research Facility (ARF) breeding programme. As Kalei is newly developed, several aspects of its physiology are largely unknown, particularly suitability of polliniser cultivars and self-compatibility. A pollination study was carried out at ARF to determine the efficiency of different apple cultivars as potential pollinisers for Kalei. Braeburn, RS103-110 and Sundowner had a very high percentage of fruit set with 62%, 58% and 53% respectively followed by Pink Lady™ 44% and Manchurian 42%. Kalei was found to be self-incompatible with only 6% fruit set. RS103-110 is a highly coloured red apple with excellent fruit quality and very high packouts of over 95%.

However, it is a small apple and hence tree management is important to maximise seasonal fruit size potential and yield. In a thinning experiment, RS103-110 trees were hand-thinned at 5, 6½, 8 or 9½ weeks after full bloom (wafb). Thinning at 9½ wafb reduced average fruit weight by 10g relative to thinning at 5 wafb. As a result, thinning at 9½ wafb reduced the average packout of first grade fruit from the 92% achieved by thinning 5 wafb, down to 83%, primarily through the increased production of smaller apples.

Fruit set and crop load management of Australian-bred scab resistant apples

Osi Tabing and Simon Middleton
Heidi Parkes, Allan McWaters and Peter Nimmo

Kalei (RS103-130)

- First scab-resistant selection from ARF breeding programme
- Matures 2 weeks before Pink Lady™
- Broken red stripe to almost full block red
- Sweet, low-acid, mild flavour
- Juicy, crisp, breaking flesh
- 3 weeks shelf life
- Semi-spur growth habit

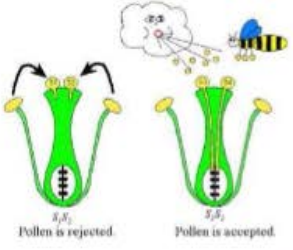
As Kalei is newly developed, several aspects of its physiology is largely unknown particularly poliniser varieties or self-compatibility

Objective:

- To study the efficiency of different apple varieties as potential poliniser variety for Kalei and to check its self-fertility

What is Self-incompatibility?

- Mechanism that allows the pistil of flowering plants to distinguish between genetically related and unrelated pollen to prevent inbreeding and promote out crossing
- In apple, incompatibility is caused by a gametophytic self-incompatibility (GIS) system due to the presence of a gene called *S*-locus



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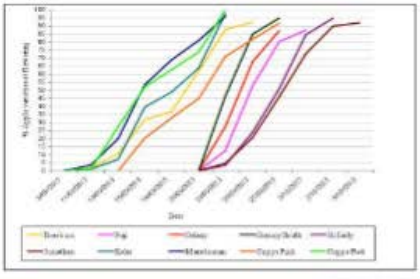
Flowering time of different apple varieties in ARF



Emasculation and artificial pollination

- Pollination was carried out at balloon stage

Fruit set counting

Result

Pollinizer	% Fruit set	Seed no.
Control	4[a]	3[a]
Kalei	8[a]	5[a]
Manchurian	42[b]	8[c]
Pink Lady	44[b]	9[d]
Sundowner	53[bc]	9[d]
RS103-110	58[c]	9[d]
Breeburn	62[c]	9[d]

	High	Medium	Low
% Fruit set	Braeburn, RS103-110, Sundowner	Pink Lady, Manchurian	Kalei, Control
Seed number	Braeburn, RS103-110, Sundowner, Pink Lady	Manchurian	Kalei, Control

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Conclusion

- Appropriate polliniser varieties for Kalei are:
  Braeburn
  RS103-110
  Sundowner
  Pink Lady
- Kalei is self-incompatible

Selection 2 (RS103-110)

- Matures immediately after Royal Gala
- Dark red over-stripe on yellow-green ground
- Fine texture, crisp and juicy
- Sweet, low-acid, mild flavour
- Tolerance to *Alternaria*
- Small to medium fruit size (mean fruit weight is 130 to 145 g) can limit orchard productivity

Objective:

- Determine the latest timing at which crop loads should be established to maximise fruit size and yield

Materials and method

- Applethorpe Research Facility (28° 37'S)
- Planted: 2005
- Spacing: 3.7 m x 0.75 m (3603 trees/ha)
  3.7 m x 0.625 m (4324 trees/ha)
- Rootstock: MM.106, MM.102, M.26, M.9 and Ottawa 3
- RS103-110 trees were hand thinned (November to December)
- Thinning timings: 5, 6½, 8 or 9½ weeks after full bloom (wafb)

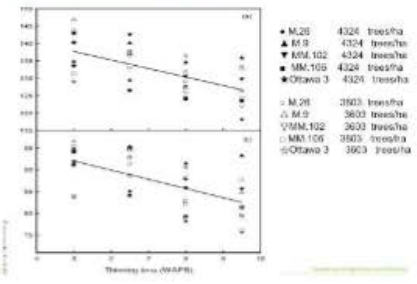
Result

- Thinning at 9½ wafb reduced average fruit weight by 10 g relative to 5 wafb
- Thinning at 9½ wafb reduced average packout of first grade fruit to 83% compared to 92% achieved by 5 wafb

↓

The reduction in first grade fruit is primarily through increased production of smaller apples at the later pruning time

Effect of timing of thinning on (a) mean fruit weight and (b) % first grade fruit at harvest (7th leaf)



Conclusion

- Fruitlet thinning of RS103-110 should occur as soon as practicable after blossoming in spring

Thankyou

Kalei RS103-110

Developing thinning programs for European pears

Dr. Sally Bound
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Perennial Horticulture Centre, Tasmanian Institute of Agriculture (TIA)
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As there is little information available on chemical thinning programs for European pears or on the effect of chemical thinning agents on pear fruit quality, the work described here was undertaken to examine chemical thinning options for European pear and to develop the most viable options into practical programs for pear orchardists. Unless properly understood, the use of chemical thinners involves a large commercial risk. The development of reliable recommendations for chemical thinning of pear cultivars, and a move away from reliance on hand-thinning, should assist growers through lower production costs, better fruit quality and increased returns.

The cultivar 'Packhams Triumph' (Packham) was used in these studies. Chemicals examined included the desiccating agents ammonium thiosulphate (ATS) and potassium thiosulphate (KTS) and the hormonal thinner ethephon applied during the flowering period and 6-benzyladenine (BA) applied as a post-bloom thinner. The ultimate goal was to put in place sustainable low risk chemical thinning programs using the least amount of chemicals and spray timings.

Trial work was undertaken over a period of three years in both the Goulburn Valley, Victoria and at Nubeena, Tasmania. Results from the Victorian trials have proved to be very similar to results of similar trial work undertaken in Tasmania. This demonstrates that the results and recommendations arising from trial work undertaken in the cooler Tasmanian conditions are applicable to other growing areas in Australia.

The desiccating agent ATS has proved to be an effective blossom thinner, and an initial application at 20-25% bloom stage would be recommended, with a follow up second application from 50% bloom to enhance the thinning effect. Once full bloom has been reached it is too late to apply desiccants as they act by damaging the style/stigma of the flower, thus preventing pollination. ATS can also be effectively combined in a program with the post-bloom thinner BA, thus giving growers increased options when determining their thinning programs.

Trial results showed that BA was a consistent thinner of Packham, and it can be applied as early as 10 dAFB to as late as 40 dAFB following a blossom application of either ethephon or ATS. However there was a loss in fruit size with later applications, most likely due to resources being directed to fruit which later drops. If thinning is completed earlier there is less wastage of photosynthate into fruit which will ultimately be removed by thinning chemicals (or hand thinning).

While BA can be used as a stand alone thinner of Packham, it is risky to rely on one spray application in case weather conditions are unsuitable for application. Two applications of BA did not increase the thinning effect, hence would not be recommended.

The preliminary work with KTS demonstrated that it also has potential as a blossom thinner. Being acceptable to the organic market this product needs to be followed up to determine the most effective concentration. KTS should also be trialled in conjunction with post-bloom thinners.

All chemicals examined maintained or improved fruit quality measured as size, firmness and sugar content, but ATS caused a slight increase in skin russet.

This work has resulted in practical recommendations for the use of a range of chemical thinning agents to manage crop load in Packham pear.

It should be noted that in the trials described here all chemicals were applied at high volume. If low volume CDA technology is used for application of desiccants then the recommendation for concentration is likely to alter. These results also only refer to one cultivar, 'Packhams Triumph', and caution is required if transferring recommendations to other cultivars without further scientific justification.

This project produced sufficient data to enable registration of the blossom desiccant ATS and the post-bloom thinner BA as thinning agents for 'Packhams Triumph' pear.

Developing thinning programs for European pears

Sally Bound
Perennial Horticulture Centre
Tasmanian Institute of Agriculture

Introduction

Lack of information on:

- chemical thinning programs for pear
- effect of chemical thinning agents on pear fruit quality

Objectives:

- examine impact of blossom and post-bloom thinners on pear crop load and fruit quality
- develop a thinning program for 'Packham's Triumph' pear

Trial details

Trial sites:

- Nubeena, Tasmania
- Goulburn Valley, Victoria

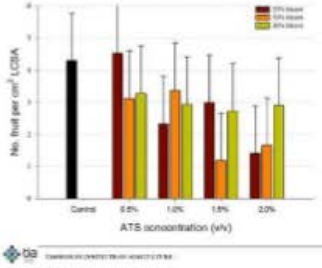
Cultivars:

- Packham's Triumph

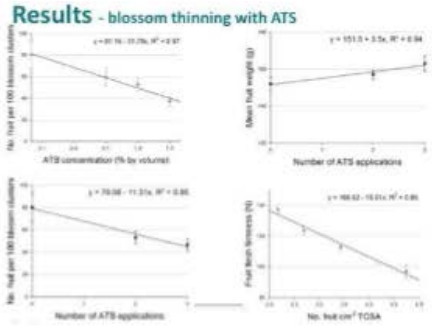
Thinning agents examined:

- ammonium thiosulphate (ATS)
- potassium thiosulphate (KTS)
- ethephon
- 6-benzyladenine (BA)

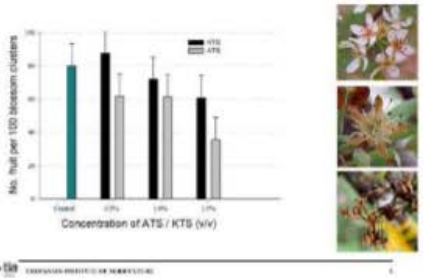
Results - blossom thinning with ATS



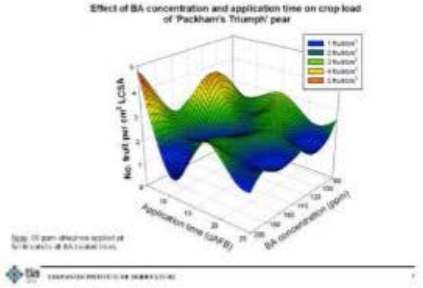
Results - blossom thinning with ATS



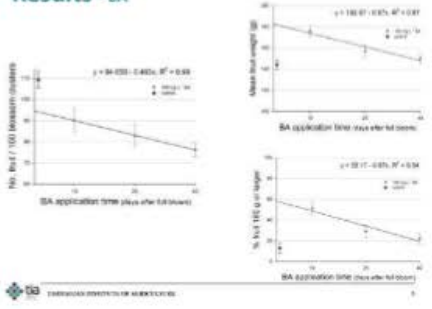
Results - blossom thinning with ATS & KTS



Results - post-bloom thinning with BA



Results - BA



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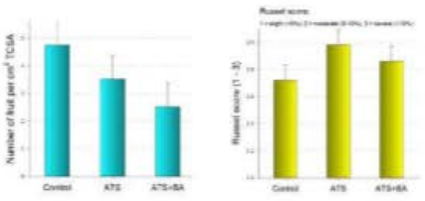
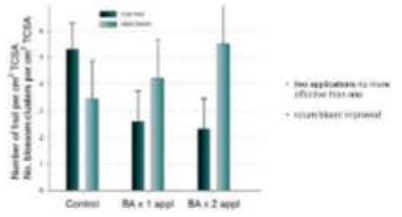
Results - ATS / BA program



Results - multiple BA applications



Key findings

- Results from Goulburn Valley similar to Tasmania
- ATS effective blossom thinner
  - 2 applications recommended (20 & 50% bloom)
  - concentration of 1% (v/v)
- KTS showing potential as a blossom thinner
- BA consistent post-bloom thinner
  - from 10 to 40 dAFB
  - apply after bloom application of either ethephon or ATS
  - multiple applications no better than single

Thanks to...

Growers who donated trees for use in this work:
Jeff and Scott Hansen, Nubeena, Tasmania
Nethersole Orchards, Ardmona, Victoria
S Varapodio & Son, Ardmona, Victoria

Les Mitchell (AgriSearch Services) for managing the Victorian trials

Valent BioScience for supply of BA
Ferro Corporation (Aust.) Pty Ltd for supply of ATS

Dave Jennings, Laurence Ballard & Shenan Daniels for technical assistance

Funding for this project was provided by the Horticultural Research and Development Corporation (now HIA) through the Apple and Pear Levy.

Brevis. A new thinner for Australian apple orchards?

Stephen Tancred
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Orchard Services
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WHO Brevis is being developed by Adama Australia. Trials were done by Orchard Services in Qld and Eurofins-Agrisearch in Victoria. Apple and pear growers will be the beneficiaries.

WHY Fruit growers aim to set the exact number of apples and pears on their trees they wish to pick. But Mother Nature intervenes and light or heavy crops are often set. Heavy crops are thinned by primary and secondary chemical thinners and by hand – but hand thinning is expensive. If adequate thinning isn't done early then trees can initiate too few fruiting buds and set a light crop in the subsequent year (biennial bearing).

WHERE Brevis was launched globally November 2014 at Interpoma in Italy. Brevis is presently registered in Italy, Belguim, France and Serbia and will be progressively rolled out globally. Australia is on the list but we have to do the registration work, and also learn how to best use it under our conditions.

WHEN Aim is for registration for use in the 2018-19 season. This gives us the opportunity to do another couple of years of small-plot registration trials and then some fine tuning and learning.

WHAT Brevis is the name of a new chemical fruit thinner being developed for post-bloom use in apples and pears. In 2014-15 two replicated small-plot trials were conducted on Red Delicious (Oregon Spur) in Stanthorpe, Qld and Pink Lady in Tatura Vic. Two rates (1.1 and 2.2 kg/ha) were applied once and twice and compared to the industry standard thinner Bugmaster (ai carbaryl).

Brevis is not a PGR, it's a.i. is a herbicide (metamitron), in a granule formulation. It disrupts photosynthesis for 7 to 10 days after application and this stress period leads to an increase in fruit drop. Thinning is rate dependant and may be enhanced by cloudy weather. Average temperatures for the 10 days after the first application were 11.4 to 27.3 °C at Stanthorpe. Applications were at 19 and 26 days after full bloom on 8-10 then 10-20 mm in sized fruitlets.

TRIAL LEARNINGS.

- Brevis was a very effective thinner on Oregon Spur Red Delicious apples.
- There was trend for a greater thinning effect of Brevis when applied at 2.2 L/ha than when applied at 1.1 L/ha.

- Brevis was equally as efficacious at reducing fruit numbers as Bugmaster (a.i. carbaryl). However, the average size of fruit was greater when Brevis was used once or twice at 2.2 L/ha than when Bugmaster was used.

- Trees treated with two applications of Brevis had a greater total length of vegetative shoots than untreated trees. But Bugmaster treated trees had the greatest shoot length.

- Leaf fall was not affected by the application of spray thinners. Return bloom will be assessed in October 2015.

- Brevis caused slight phytotoxicity two weeks after application which generally dissipated within four weeks of application. Fruit treated with Brevis or Bugmaster had no more skin russet at harvest than fruit from untreated trees.

Some advantageous over carbaryl may be; Brevis is rate responsive but carbaryl isn't. Brevis has a 60 day withholding period overseas, carbaryl has 77 day WHP in Australia, so late or serial applications of carbaryl may impinge on early harvested Gala apples. Some export destinations don't accept carbaryl treated fruit. Brevis is reported to be safe on beneficial insects, whereas carbaryl is toxic to predatory mites. Carbaryl can russet if applied around cold weather.

Some advantageous over BA thinners (eg Maxcel) may be; Brevis is reported to be active from 10 to 25° C whereas BA thinners require temperatures of at least 15°C and are better at 20°C. More than one application is possible with Brevis and its application window may be wider. Brevis is rate responsive, but only a single application of Maxcel is usual.

	Brevis	Carbaryl	Maxcel
Temperatures	10 to 25°C	Warm conditions best Caution when cold	Max > 15°C+
Withholding period	60 days planned	77 days	NA
Export	Ok	Restrictions	Ok
Rate responsive	Yes	No	Probably
Timing window	Medium	Wide	Narrow
Multiple sprays	Yes	Yes	No
Predatory mites	Ok	Toxic	Ok

FUTURE WORK for registration will include trials on more varieties of apples, on a range of stocks and different weather conditions, and work on pears. To get the best from this new tool we need to know more about; crop safety, effect on predators, compatibility with fungicides and insecticides, residue trials, explore interactions, check the rate response, mixtures with other thinners. Not all of this will be done by Adama as their aim is gaining registration and local commercial confidence. But hopefully our industry and research community will rise to the challenge of fine tuning this new tool.

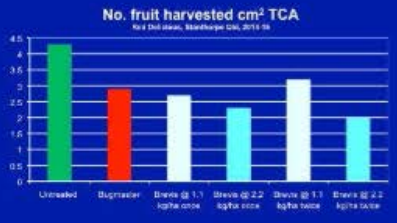
BREVIS – a potential new thinner for Australian apple orchards

Stephen Tancred

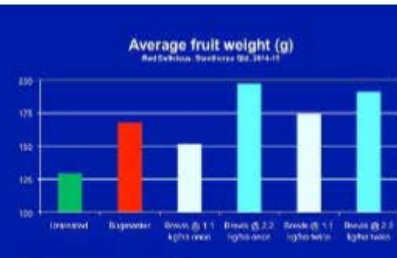
APAL Conference, 25 June 2015

ORCHARD SERVICES

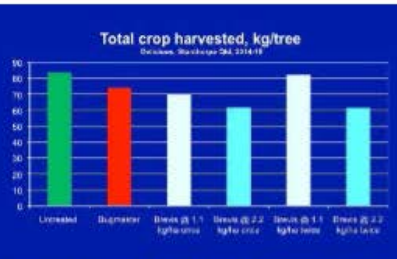
apal



Significant thinning effect
Rate response from 1.1 to 2.2 kg/ha



Significantly larger fruit
Rate response from 1.1 to 2.2 kg/ha



Untreated tree yield was 51 t/ha.
606 trees/ha, canopy 2.6 m high

68


16 Days after 1st application
Untreated
Carbaryl
Brevis


16 Days after 1st application
Untreated
Carbaryl
Brevis


Brevis thinned
No thinning

69

	Brevis	Carbaryl	Maxcel
Temps	10 to 25°C	Warm is best Caution when cold	Max > 15°C+
Withholding period	60 days planned	77 days	NA
Export	Ok	restrictions	Ok
Rate responsive	Yes	No	Probably
Timing window	Medium	Wide	Narrow
Multiple sprays	Yes	Yes	No
Predatory mites	OK	Toxic	Ok

Where to from here?

Trials on - more varieties
- range of stocks
- under different weather conditions

Crop safety
Effect on predators
Compatibility with fungicides/insecticides
Work on pears
Residue trials
Explore interactions
Check the rate response
Mixtures with other thinners

70

Precision fertigation for improved apple orchard productivity

Dr. Nigel Swarts
Research Fellow
Tasmanian Institute of Agriculture, University of Tasmania
Nigel.Swarts@utas.edu.au

Nitrogen (N) fertiliser management remains somewhat of a black box in the understanding of tree N dynamics and optimising N use efficiency in apple orcharding. In this three year fertigation project, with a team of researchers from Tasmania, Victoria and New Zealand, we are investigating the influence of nitrogen and irrigation on the quality and post-harvest shelf-life of 'Royal Gala' apples in southern Tasmania. We are also evaluating the effectiveness of pre- vs post-harvest fertigation and the influence of irrigation on N movement through soil. Our data will be used to guide growers and agronomists in determining an ideal rate of N fertiliser to achieve desired fruit quality outcomes with minimal environmental impacts. Results from the third and final season of treatments will be presented demonstrating marked influence of N and irrigation treatments on fruit size, colour, firmness and sugars.

Estimating tree water use (PIPS)

Dr. Ian Goodwin
Research Manager – Horticulture Production Science,
Agriculture Research Division
Department of Economic Development, Jobs,
Transport and Resources (DEDJTR)
Ian.Goodwin@ecodev.vic.gov.au

Tree water use was investigated to better understand the irrigation requirement in modern high-density apple and pear orchards. Specifically this study focused on exploring the relationships between tree size, weather and tree water use (i.e. transpiration) and developing simple approaches to estimate tree size. Tree size and tree water use were measured by light interception and sap flow, respectively. On-site weather stations measured temperature, relative humidity, solar radiation and wind speed.

Results showed that tree water use can be determined from the shade cast by trees and the weather conditions. Observations in a netted apple orchard showed that netting reduced the evaporative demand in proportion to the reduction in light levels. Future R&D needs to implement the relationships derived in this project into user friendly irrigation scheduling tools and further explore the use of satellite remote sensing for irrigation management.

Estimating tree water use

Ian Goodwin, Research Manager, Horticulture Production Systems
Department of Economic Development, Jobs, Transport & Resources, Tatura


Introduction

Tree Water Use (TWU)

Major determinant of orchard irrigation requirement to maximise yield and fruit quality:

- water budgeting
- irrigation system design
- implementing strategies such as RDI
- irrigation scheduling

Introduction

Standard approach to estimate TWU:

$$TWU = K_{cb} \times ET_o$$

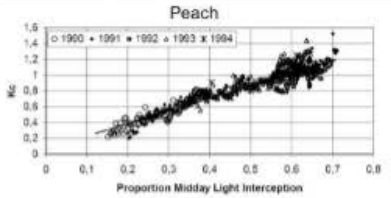
- K_{cb} is the **basal** (tree) crop coefficient
- ET_o is reference crop evapotranspiration (water use of grass calculated from wind speed, relative humidity, temperature and solar radiation)
- ET_o is available http://www.bom.gov.au/watl/eto/

Introduction

Orchard K_{cb} varies with tree size, training system, planting arrangement and leaf area density

Introduction

Radiation interception may account for these differences



Source: Johnson et al. (2000) Acta Hort.

Objective

To investigate practical approaches to estimate irrigation requirements in apple and pear orchards by measuring TWU, ET_o and intercepted radiation.

Materials and methods

Tree water use and ET_o

Sap flow
Heat pulse compensation
- multiple sites in commercial orchards
- sap velocity measured at 4 depths
- measured at 30-minute intervals

ET_o
- wind speed
- solar radiation
- PAR
- temperature
- humidity

Materials and methods

Radiation interception

Fraction of intercepted PAR (f_{int}) = $1 - \frac{PAR_T}{PAR_o}$

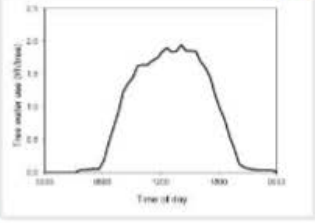
Materials and methods

Radiation interception

Fraction of intercepted PAR (f_{PAR}) = $1 - \frac{PAR_T}{PAR_I}$

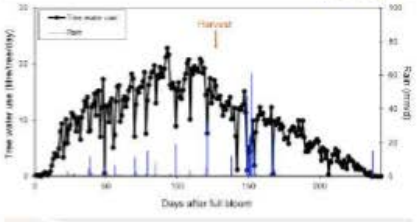
Results

Tree water use



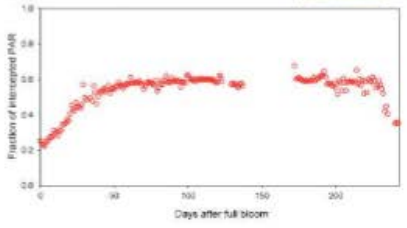
Results

Tree water use



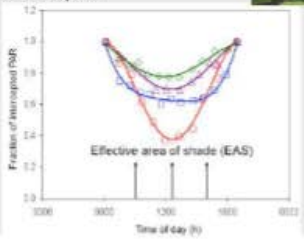
Results

Radiation interception



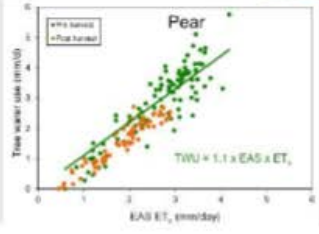
Results

Radiation interception



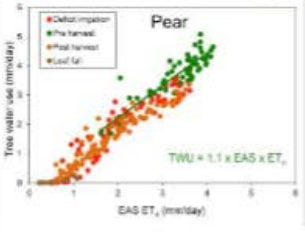
Results

Tree water use and EAS-weighted ET_o



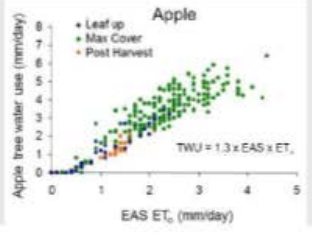
Results

Tree water use and EAS-weighted ET_o



Results

Tree water use and EAS-weighted ET_o



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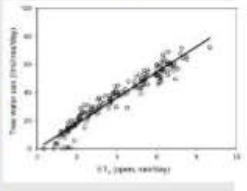
Results

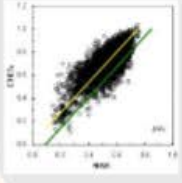
Tree water use in netted apple orchard

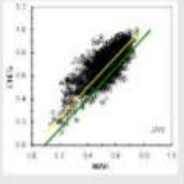
Netting:
- No effect on air temperature
- Small increase in humidity
- Reduced wind speed by 23%
- **Reduced global radiation by 30%**
- **Reduced ET_c by 21%**



Results

Satellite remote sensing of orchard water use





Implementation

Effective area of shade

Conclusions

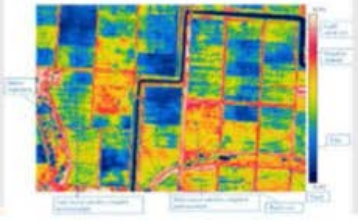
- Irrigation can be calculated from
  - Pear 1.1 x EAS x ET_o
  - Apple 1.3 x EAS x ET_o
- EAS can be estimated from observations of the fraction of shade on the orchard floor in the morning (0900 h), at solar noon (1230 h) and in the afternoon (1600 h)
- EAS is constant for most of the season
- ET_c is available on the web

Future projects

- Combine with satellite remote sensing of crop water requirements
  - FarmWeb

Future projects

- Combine with remote sensing of crop water stress



Thank you

ian.goodwin@ecodev.vic.gov.au

Questions

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Netting the benefits of climate change

Susie Murphy White
Temperate Fruit Development Officer
Department of Agriculture and Food Western Australia (DAFWA)
Susan.murphy-white@agric.wa.gov.au

The WA Netting demonstration site was established in October 2013. This demonstration site aims to show the value of netting to improve water use efficiency and orchard productivity in high density production systems. The demonstration is now heading into the final year of a three-year trial, to assess the value of permanent netting as a way to improve water use efficiency and orchard productivity. The project is comparing the effect of black and white netting on water use, fruit quality, tree growth and chilling accrual in a high density apple production system.

Netting set-up
The 1.2 hectare (ha) demonstration has 0.5ha of permanent fully enclosed net constructed over an established Cripps Pink and Fuji apple orchard. 16mm quad nets in black and white were installed, each covering 0.25ha. The remaining area contains two comparison blocks, a DAFWA-managed control, and a grower practice control.

Irrigation comparisons
Independent irrigation systems have been established within four areas of the 1.2ha trial block. The system allows areas under each netted section, a control area and a possible third netted area to be scheduled independently and compared to growers' standard practices.

Monitoring equipment in each block provides real-time information that allows fine-tuning of irrigation decisions on the basis of water availability and plant needs. Watering decisions are based on weather conditions, evaporation and soil moisture measurements. Using the available technology enables better irrigation decisions to be made, improving water use efficiency. Observations during the 2013/2014 irrigation season were made that crop vigour and sod culture growth was excessive under the netted area. The decision was made to convert an area to drip irrigation to limit sod culture growth and potentially reduce crop vigour. Two lines of pressure compensated drip tube approximately 35cm either side of the tree line were installed in each of four rows between the black and white netted areas. Under tree sprinklers were not used in this section of the orchard.

The cumulative water use at harvest time in the drip area (3.0ML/ha) was 54 percent lower than water applied outside the net by DAFWA (6.6ML/ha) and 45 percent less than that of the grower irrigated area (5.4ML/ha). Sod culture between rows was reduced along with crop vigour. Prior to rain in early March the area between rows of trees was almost bare compared with a lush sod culture that required maintenance.

Countering climate change

Netting apple orchards is one way to adapt to climate change. The South West of Western Australia is expected to experience higher than average temperatures, reduced rainfall and increases in evaporation as a result of a changing climate. These climatic conditions have the potential to affect the pome fruit industry, resulting in increases in water use, more extreme temperatures and changes to winter chill accumulation.

The chill accumulation under the netting shows minor differences between the black and white netted areas and the non-netted areas, with a slight decrease in maximum temperatures under the black net. A small amount of additional chill was accumulated under the black nets. The results show that netting, established for other management outcomes, does not influence winter chill accumulation in a meaningful way. The use of netting is similar to a cloud cover effect which reduces radiant heat loss overnight and reflects a portion of incoming daytime radiation reducing maximum temperatures.

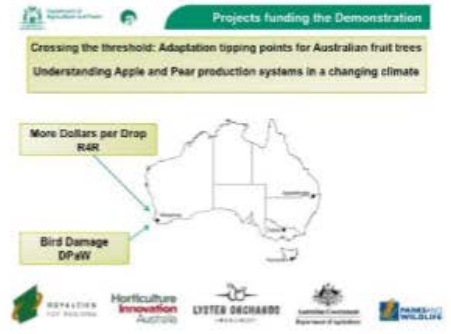
The fruit surface temperatures of 120 apples under the black, white and non-netted area were monitored using thermocouples summer 2014 and 2015. During the summer of 2014 highest FST was 55°C on 1st March 2014 when the air temperature was 37.8°C outside the net. Over February and March of 2014 there were 7 days under the white net, 10 days under black net and 17 days with no nets above a FST of 45°C. Generally the white net was cooler and less incidence of sunburn damage. But the white netted block also experienced a higher relative humidity, which can increase the pressure from pests and disease. During the demonstration period both 2014 and 2015 the bird pressure from Cockatoo's has been minimal. No significant damage was done in the non-netted area and no damage to the fruit occurred under the nets.

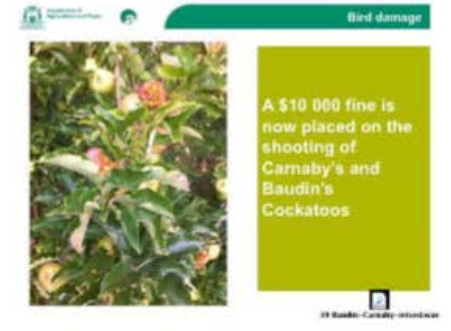
Funding sources

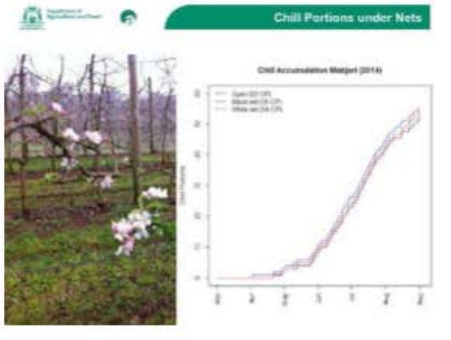
The WA netting demonstration site has multiple projects working together and funding from several organisations. The demonstration also complements the Manjimup SuperTown project that is exploring ways to revitalise the town and region as a centre of fruit production.

- More Dollars per Drop project funded by Royalties for Regions
- Comparing Bird Damage in a netted and non-netted orchard, funded by Department of Parks and Wildlife.
- Crossing the threshold: Adaptation tipping points for Australian fruit trees project is supported by funding from the Department of Agriculture.
- Understanding Apple and Pear production systems in a changing climate project is funded by Horticulture Innovation Australia using apple and pear industry levies and matched funds from the Australian government supported by funding from Horticulture Innovation Australia.


Netting the Benefits of Climate Change
Susie Murphy White
Development Officer
DAFWA, Manjimup
Horticulture Innovation Australia
LYSTEK ORCHARDS

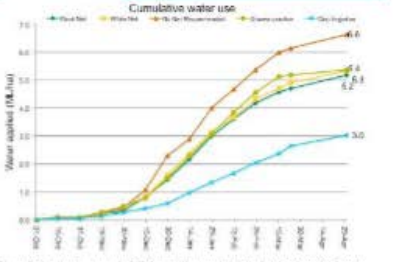

Projects funding the Demonstration
Crossing the threshold: Adaptation tipping points for Australian fruit trees
Understanding Apple and Pear production systems in a changing climate
More Dollars per Drop R4R
Bird Damage DPaW
Horticulture Innovation Australia
LYSTEK ORCHARDS


Bird damage
A $10 000 fine is now placed on the shooting of Carnaby's and Baudin's Cockatoos


Chill Portions under Nets

81

Irrigation

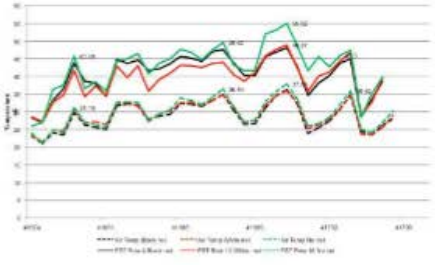


Cumulative water use in ML/ha at the netted apple demonstration in Manjimup 2014/15.

Sod Culture on the Drip Line

29 Jan 2015

Daily maximum Fruit Surface Temperature



Annual Field Walks

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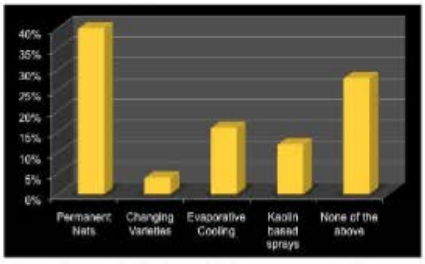
Leading to change

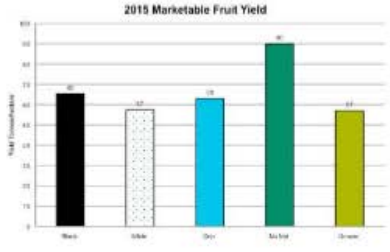


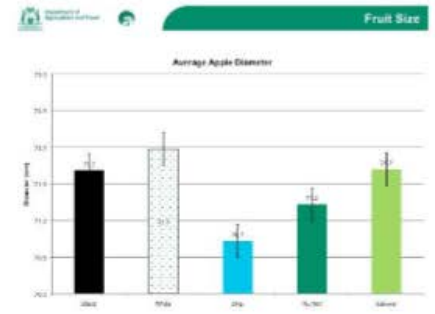
Are you using any of the following strategies to manage extreme heat?

Matching colour and maturity

Harvest

Yield




Fruit Size
Average Apple Diameter


Thankyou
Any questions?
Horticulture Innovation Australia
LYSTEK DECRAUDO

84

A hazy shade of winter (chill)

Dr. Rebecca Darbyshire
Research Fellow
The University of Melbourne
rebecca.darbyshire@unimelb.edu.au

This presentation will briefly consider the history of recent Australian research into winter chill. Much effort has been directed towards evaluation of outputs from winter chill models both under current and future climate conditions. Results indicate regional differences in potential risk for lower chill conditions in the future, ranging from a lowering of risk through to much higher exposure. To compliment these modelling efforts, evaluation of varietal chilling requirements are being conducted to allow for site by variety assessments. Such research enables mapping of suitable current and future growing regions.

Although these findings have advanced our knowledge base, much is still unknown. To conclude, several key questions will be proposed highlighting the need for greater understanding to assist with on-farm application of winter chill research.

A Hazy Shade of Winter (Chill)

Rebecca Darbyshire
rebecca.darbyshire@unimelb.edu.au

Winter Chill

- Australia is potentially exposed to low chill years and these may increase in frequency with climate change.
- Low chill influences flowering (light, late, variable and protracted)
  - Can influence yield and maturation synchrony
  - Changes to phenology may decouple cross-pollinators/ bees

Winter Chill – my brief history

- First imp … wide was conducte

Winter Chill – my brief history

First application of Dynamic chill model to Australian conditions

First projections using this model (Aus, globally?)

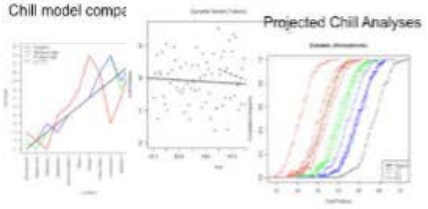
Winter Chill – my brief history

2010-2013

Historical Chill Analyses

Chill model compa

Projected Chill Analyses

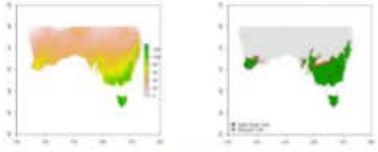


Winter Chill – my brief history

2013+

Chill conditions

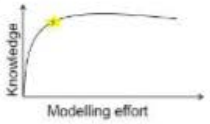
Chill suitability - Sweetheart



www.hin.com.au/projects/winter-chill-and-fruit-trees

So why the hazy shade of winter?

"In this song, the singer seems to be lamenting how he [she] was looking for something perfect, but never found it, and now time is running out on his [her] dreams."



http://www.songfacts.com/detail.php?id=8051

What do the modellers say?

"See this is why we need to understand the genetics"

"Bud temperature is different from air temperature, this impedes reducing model errors"

"We don't have any knowledge about end of the chilling period, this is a big issue for phenology modelling"

"We need to revisit some of the original temperature experiments"

"Well what is the connection to the roots?"

'Dreams'

- Leaf defoliation
- Dormex action
- ?

- Estimating chilling requirements
- Rootstock influence
- Dormancy entrance
- Relation to yield
- ?
- Dynamic model

Dynamic model - 1987

$120,025

THE UNIVERSITY OF MELBOURNE

Thank You

Towards an understanding of bud burst and flowering in a changing climate: approaches to research and extension

Dr. Heidi Parkes
Horticulturalist
Horticulture and Forestry Science, Agri-Science Queensland
Department of Agriculture and Fisheries Queensland
heidi.parkes@daff.qld.gov.au

Australia's annual mean temperature has warmed by 0.9°C since 1910 and this warming trend is likely to continue. It is not yet clear how the changing growing environment will impact on apple and pear production. Understanding the nature of potential impacts is important because it determines how the industry might adapt to a warming climate.

The early implementation of appropriate adaptation strategies will reduce the industry's vulnerability to the changing climate in the longer term. One objective of the project 'Understanding apple and pear production systems in a changing climate' is to investigate potential impacts of a warming climate on dormancy progression, and bud burst and flowering. These developmental phases are important for the production of high marketable yields, and are particularly vulnerable to changes in temperature.

Approaches to the research and some initial findings

To predict changes in bud burst and flowering that might occur in response to changes in climate, it is necessary to first understand the complex relationships between these developmental phases, and temperature under current climates.

Specifically, this project seeks to understand the nature of the relationship between temperatures experienced in the orchard before, during and after dormancy, and the timing and quality of bud burst and flowering events. How does a mild winter impact the date and length of flowering in different varieties? How much chill do different varieties need to break dormancy?

Detailed temperature, bud burst and flowering data sets are being collected from three climatically distinct pome-fruit growing regions around Australia (Applethorpe (QLD), Shepparton (Vic) and Manjimup (WA)). Initial analysis of the three years of data collected to date, has found differences in the pattern of chill accumulation between the three locations, which are associated with variability in the timing and pattern of bud burst and flowering.

2012, 2013 and 2014 were low chill years for Manjimup with the number of chill portions accumulated falling below their long-term average of 67. 2013 and 2014 were particularly low, with just 54 chill portions received. Shepparton and Applethorpe received average or above average chill in those years. Bud burst and flowering dates were later and more protracted in Manjimup in 2012 and 2013

relative to the other sites. Delayed and uneven bud burst are symptoms of inadequate chill and it is possible that the observed patterns of bud burst and flowering in Manjimup were in response to mild winter conditions.

Approaches to extension and communication

The extension component of this project seeks to combine research results with grower know-how and experience, to ensure effective communication of climate change impact and adaptation issues with industry. In 2013, a review under taken as part of this project, showed a clear lack of readily accessible and reliable climate change information for apple and pear growers.

This study aims to fill the gap through publication of research findings in industry magazines, use of APAL and Horticulture Industry Network websites and the production of grower information packages.

In addition, workshops for apple and pear producers were conducted in Vic, Qld and WA in 2014 with the purpose of communicating research outcomes, and identifying and discussing local production issues and trends related to climate.

Some thoughts for industry

Warmer temperatures in future are likely to mean less winter chill for most growing regions of Australia. Successful adaptation by the industry will require:

a) Clear understanding of potential impacts this reduction in chill might have on flowering, and therefore fruit set and marketable yields.
b) Detailed information about chilling requirements of new and existing varieties, so growers can make variety choices appropriate to their region.
c) Consideration of chill requirement in apple and pear breeding programs when selecting potential cultivars for development and release.
d) Understanding of the efficacy of using dormancy-breaking sprays.

To achieve these objectives, further investigation is required to fill a number of 'gaps' in current knowledge.

Current knowledge 'gaps'

How much chill is enough? We still do not have a good understanding of varietal chill requirements under different climatic conditions. When do trees and buds enter into dormancy and when do they become sensitive to chilling temperatures?

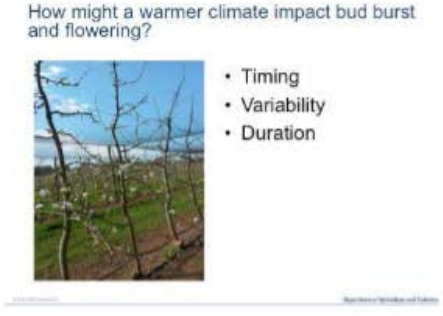
In order to provide better information to growers about the chilling requirements of different apple and pear varieties, we first need to understand bud dormancy progression and how winter chilling acts to break dormancy.

A number of Australian growers are using dormancy-breaking sprays to improve uniformity of bud burst in some apple varieties however we don't yet fully understand how best to use these products or how they work.

Dormancy-breaking sprays are used as standard practice in other parts of the world such as South Africa. It would be worth looking closely at how orchards are managed in these warmer growing regions where growers have been growing apples under low chill conditions for years.


Towards understanding bud burst and flowering in a changing climate:
approaches to research and extension
Heidi Parkes
apal
Horticulture Innovation Australia
tia


Growing apples under future climates
CLIMATE CHANGE
?


How might a warmer climate impact bud burst and flowering?
Timing
Variability
Duration


How might this impact orchard management practices and profitability?
Fruit set
More sprays
Timing of chemical thinner application difficult
Variable fruit maturity at harvest

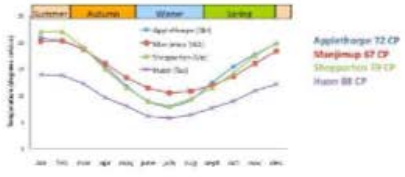
How can we get some answers to these questions?

- Research
- Extension and communication

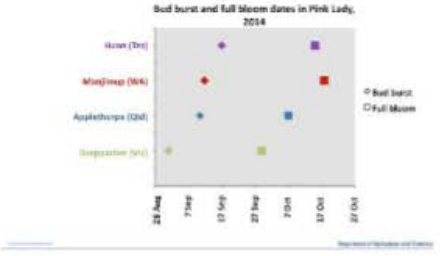
1. Approaches to research

Research methods

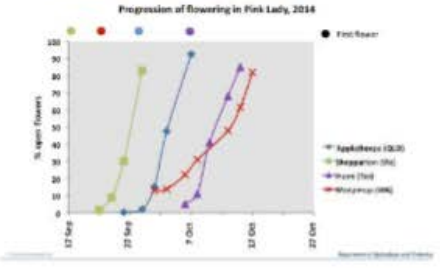
What does the climate look like in these different growing regions?



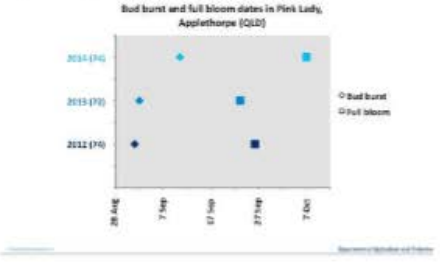
What does bud burst and flowering look like under the different climates of these regions?



What does bud burst and flowering look like under the different climates of these regions?



How variable is bud burst and flowering from year to year?



Research findings to date

- 3 seasons of bud burst and flowering data have been collected from 4 geographically and climatically distinct regions of Australia.
- There are differences in the pattern of chill accumulation at each site.

↓

This was associated with variability in the timing and pattern of bud burst and flowering

- 2013 and 2014 were low chill years in Manjimup (WA).

↓

This was associated with a protracted pattern of flowering

2. Approaches to extension and communication

Meetings and workshops

Publications and websites

Grower surveys

SurveyMonkey

Why is communication with growers and industry important for this research?

- Feedback to inform current and future research
- Share research findings
- Improve industry knowledge
- Enable adoption

What will the climate feel like in apple and pear growing regions of Australia in the future?

- In 2030?
- In 2050?

Some thoughts for industry…

- Adaptation to less winter chill:
  - Clear understanding of potential impact on flowering, fruit set and marketable yields.
  - Detailed information about chilling requirements of new and existing varieties.
  - Consideration of chill requirement in breeding programs.
  - Dormancy-breaking sprays.
- Further investigation is required to fill a number of knowledge 'gaps'.

Project Team and funding organisations

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Do dormancy breakers have a role in fruit production?

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Unlike many northern hemisphere pome fruit production regions, the climate across Australian apple growing regions is characterised by gradual transitions between seasons, and often lack of winter chill. This means that fruit trees come out of winter dormancy slowly and erratically with flowering periods lasting 6 weeks or more in some regions / cultivars.

Future predicted changes in climate also mean that more fruit production areas will become marginal in terms of achieving sufficient chill exposure for specific cultivars.

So what is the problem with non-synchronous bud-break and flowering?
Extended bud-break and flowering can make cultural practices such as fruit thinning, tree training and harvest complicated due to the different stages of growth on the tree at any one time. The long flowering period often makes for unpredictable responses to thinning chemicals. This, combined with a lack of uniformity of fruit maturity at harvest necessitating multiple picks from each tree, impacts on orchard profitability.

Bud break can be manipulated by the use of chemical rest breaking agents (dormancy breakers). These chemicals reduce the chilling requirement by forcing bud-break, and in addition to bringing about a synchronous bud-break, can also be used to manipulate the timing of bud-break and flowering.

There are many products that can influence bud-break, commonly used chemicals include hydrogen cyanamide, mineral oils, potassium nitrate, thidiazuron and fatty acids. In Australia, Dormex® (520 g/L cyanamide, Crop Care Australasia Pty Ltd) is one of the most commonly used dormancy breakers, however it has toxicological drawbacks. The advent of Waiken® (388 g/L methyl esters of fatty acids, SST Australia Pty Ltd) is the result of efforts to develop a safer chemical that would penetrate the bark of dormant trees to mimic dormancy.

Work in Tasmania with Dormex on Fuji apple demonstrated the impact on bud-break and flowering. Application 40 days before estimated bud-break (dBEB) brought bud-break forward by 10 days and full bloom by 8 days, and compressed the flowering period. Applying Dormex 20 dBEB had no effect on bud-break or time of flowering, and the closer that Dormex was applied to the estimated date of bud-break the greater the delay in both bud-break and flowering and the longer the flowering period. Phytotoxic damage to trees, measured as bud death, increased from 5% following application 40 dBEB to 20% when applied at bud-break.

Waiken trials in Tasmania and Victoria on a range of apple cultivars demonstrated that, in addition to concentrating the flowering period, Waiken can also be used to extend the dormant period or to bring the flowering period forward, depending on time of application. Waiken can be safely applied as late as bud swell / green-tip. While application of Waiken to growing tissue resulted in burning, trees outgrew this effect and by the time flowering was complete there was no evidence of damage. The phytotoxic damage caused by Dormex has lasting effects, resulting in dieback of twigs.

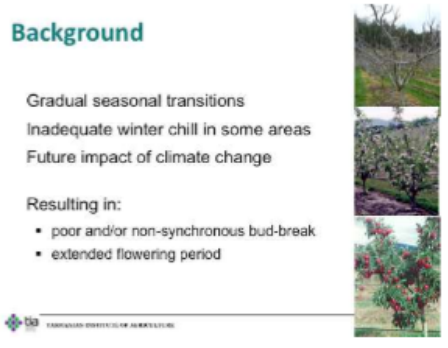
As Waiken can be applied late in the season, unlike Dormex which needs to be applied 40-30 days before estimated bud-break to be effective and reduce phytotoxic effects, Waiken gives growers more opportunity to apply a rest breaker. The recommendation from this work would be to apply Waiken 6 weeks before anticipated full bloom - if the season is early this will slow budburst and flowering; if the season is late, will speed budburst and flowering

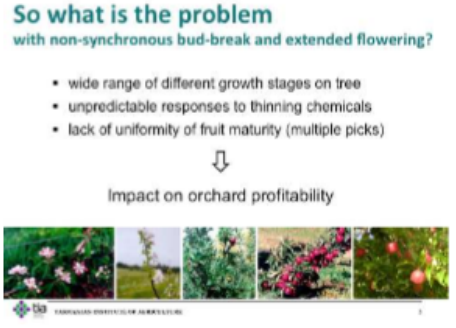
While the recommended application rate for Waiken would be 4%, higher rates may be useful for holding trees in dormancy for longer, thus delaying flowering in frost prone areas. However further work is needed to verify the effectiveness of this approach.

The use of Waiken during the dormant period also improved the effectiveness of the thinning agent ammonium thiosulphate (ATS) by compressing the flowering period, thus causing a greater percentage of flowers to be open at the time of application. This is a major benefit and is likely to make thinning programs more predictable.

Under a variation to project AP12029 (Understanding apple and pear production systems in a changing climate), a study assessing dormancy breaking sprays as a potential orchard management adaptation to inadequate winter chill will be conducted this coming season. Trials will be established in three states (Qld, WA and Tas) comparing Dormex and Waiken treatments on Gala apple. The objectives of this study are to determine:

1. the efficacy of using Waiken or Dormex to induce earlier flowering and a more concentrated flowering period in Gala under Australian conditions;
2. whether the use of these dormancy-breaking sprays is cost effective - does a more concentrated flowering period result in the need for fewer Western Flower Thrips and dimpling bug sprays; is the efficiency of blossom thinning likely to be improved?
3. whether Waiken and Dormex are equally effective; and
4. the impact of these chemicals on fruit set, yield, variability of maturity at harvest, length of harvest?





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Can we solve the problem?

Chemical manipulation to terminate dormancy

1. reduce the chilling requirement
2. modulate the timing of budbreak, flowering and fruit maturity
3. increase the number of buds breaking dormancy of strong apically dominant species, subsequently increasing flowering and yield

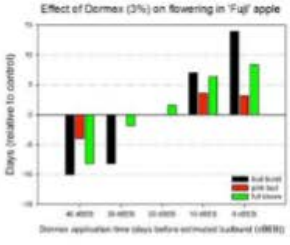
Chemicals used as rest breakers

- dormex (hydrogen cyanamide) (DHC)
- thiourea (TU)
- Armobreak (plant oil mix)
- thidiazuron ($C_9H_8N_4OS$)
- gibberellic acid (GA_3)
- Dormex-lift (hydrogen cyanamide)
- Waiken (fatty acid esters)
- potassium nitrate (KNO_3)

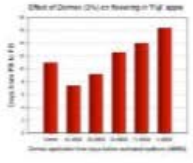
Australian studies

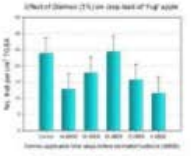
Chemicals: Dormex, Waiken, Armobreak
Sites: Tasmania - Grove, Cradoc
Victoria - Officer, Shepparton
Cultivars: Fuji, Imperial Gala, Granny Smith, Pink Lady, Sundowner

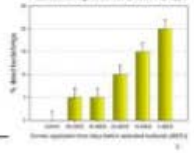
Results - Dormex



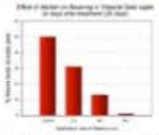
Results - Dormex

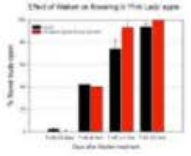


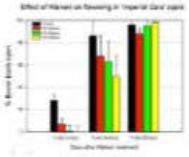


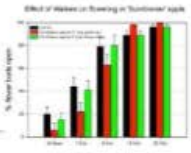


Results - Waiken

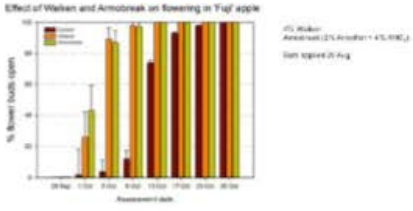






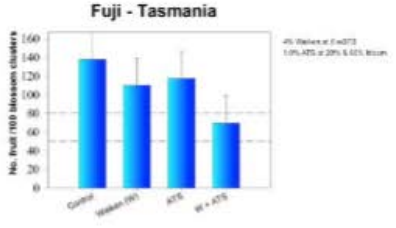


Results - Walken & Armobreak



Walken & Armobreak compressed flowering period from 33 to 16 days

Results - impact with thinning program



Key findings

Dormex
- effective but toxic chemical
- must be applied while trees dormant, otherwise phytotoxic effect

Walken
- can apply later in season, up to greentip
  recommended around 6 weeks before anticipated FB

Questions arising
- comparison between Dormex and Walken
- clarify impact on thinning program
- effect on fruit maturity

Where to from here?

AP12029 (project variation)

Understanding apple & pear production systems in a changing climate

Project Leader: Dr Heidi Parkes (DAF, Qld)

Team: Dr Heidi Parkes, Dr Osi Tabing (DAF, Qld)
Susie Murphy-White , John Sutton (DAFWA)
Dr Sally Bound, Steve Paterson (TIA, Tas)

Trial details: 3 locations (Qld, WA, Tas)
1 cultivar (Gala)
2 chemicals: Dormex & Walken

AP12029 (project variation)

Objectives – to determine:

1. The efficacy of Waiken and Dormex for inducing earlier flowering and concentrating the flowering period in Gala under Australian conditions?
2. If the use of these dormancy-breaking sprays is cost effective:
   - does a more concentrated flowering period result in the need for fewer sprays for Western Flower Thrips and dimpling bug?
   - is the efficiency of blossom thinning likely to be improved?
3. Whether Waiken and Dormex are equally effective?
4. The impact of these chemicals on fruit set, yield, variability of maturity at harvest, length of harvest?

Acknowledgements

Paul Miller (Paul Miller & Associates, Victoria) & **Les Mitchell** (Agrisearch Services, Shepparton) for conduct of the Victorian trials

SST Australia Pty Ltd for supply of Waiken and provision of funding for the initial Victorian trials

HRDC (now HIA) for provision of funding for the Dormex studies under project AP94043, and the later Waiken studies under project AP98011

HIA for providing funds for the project variation for project AP12029

Physiological, metabolic and molecular basis of biennial bearing in apples

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A major constraint to flowering and production of apples is biennial bearing – the annual cyclical changes in cropping characterised by "on" and "off" years with "heavy" and "light" fruit loads, respectively. It is still unclear how flowering in apples is inhibited or promoted by changes in gene expression and metabolic signals formed within the plant in response to ontogeny, plant resources, cultural practices and environmental cues.

Consequently, we are interested in investigating the underlying mechanisms of flower bud induction and initiation in biennial versus non-biennial apple cultivars and the apetalous parthenocarpic apple cultivar 'Spencer Seedless', which can be either seedless without pollination or seeded if pollinated. It is generally accepted, that seeds of developing fruit are one of the major factors suppressing flower induction in nearby apical meristems.

Utilising this knowledge, fruit growers usually remove excess flowers and fruitlets in "on" years, using medium effective, but time and cost intensive, horticultural practices to increase fruit size in the current and the amount of bloom in the subsequent year. The aim is to develop smart and more effective strategies for the future by addressing the following key research questions:

1. When and how is the fate of an apple meristem determined?
2. What signals are sent by the fruit or other organs, causing the apical meristem of the bourse shoot to remain vegetative?

The presentation will outline our attempt to increase the understanding of the molecular and physiological mechanisms involved in flowering time control of apple and present first results.

Improved management of apple and pear scab primary infection

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Oscar Villalta[A], David Williams[A] and Robert Beresford[B]
[A]Department of Economic Development, Jobs, Transport and Resources (DEDJTR), AgriBio, La Trobe University
[B] Plant and Food Research, New Zealand

Preventing primary infection by ascospores of *V. inaequalis* (apple scab) or *Venturia pyrina* (pear scab) is the main reason fungicides are used intensively by Australian apple and pear growers. In some regions, a few mildew and Alternaria sprays have to be combined with scab fungicides to control these two diseases.

Temperature (degree-days) driven models are useful for predicting when scab ascospores are mature enough to be released from over-wintered apple/pear leaves. These models can be used to warn growers when the risk of primary infection from ascospores is high and need for fungicide intervention to prevent scab infection.

Optimising the application of preventive or post-infection spraying against scab can reduce losses to scab and minimise the detrimental effects of some fungicides on beneficial insects and orchard ecology.

In Australia, the implementation of ascospore models as practical risk management tools is held back by a lack of validated models and suitable computer software linked to weather data networks.

The PIPS team (pest and disease sub-program) conducted a review and modelling studies to determine which ascospore model accurately predicts ascospore maturation and release in different regions of Australia. Many temperature models have been developed worldwide for predicting when ascospores are mature enough to be released from overwintered apple and pear leaves. Six of these models including a degree-day model developed for pear scab in Victoria were validated using historical data from Australia and overseas (Eikemo *et al.* 2011, Villalta *et al.* 2001). All models described well the cumulative percentage of the season's ascospore available over the 2-3 month primary infection season, which is September to November in Australia.

However, predicting the beginning, middle and end of the ascospores season was difficult with all these models. In climates where spring rainfall occurs sporadically, like several fruit growing areas in Australia, a high proportion (e.g. 30%) of ascospores can be released on a single rainy day. It is therefore critical that a model predicts accurately the seasonal availability of ascospores and amount available for release during rainfall events.

Beresford (1999) developed an ascospore maturation and release model for the New Zealand apple industry that predicts both maturation and daily release of ascospores. This model identifies the specific days during the ascospore release season which have the greatest potential to result in scab establishment.

Additional modelling work using new ascospore data sets from five fruit growing regions in Australia (Tatura, Lenswood, Batlow, Applethorpe and Grove) showed that the New Zealand ascospore maturation model was more suitable, with some adaptation, for use in Australia.

The work also indicated that it will be possible to use a single model to predict ascospore maturation and release for both *Venturia* species causing apple scab and pear scab. The next step in adapting the New Zealand model is the incorporation of a rainfall maturation delay to accurately predict ascospore release in seasons with dry weather. This will be done using historical ascospore maturation datasets that are available for both apple and pear scab from Victoria and NSW, as well as by collecting further new regional datasets from other Australian regions. The data collected will be also used to validate PC-based systems including RimPro.

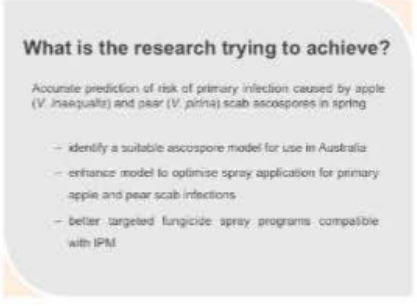
Beresford RM 1999. Validation of an ascospore release prediction model for apple black spot (*Venturia inaequalis*). New Zealand Plant Protection 52 148-152.

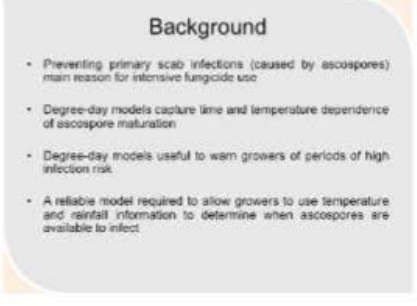
Eikemo H, Gadoury DM, Spotts RA, Villalta O, Creemers P, Seem RC, Stensvand A 2011. Evaluation of six models to estimate ascospore maturation in *Venturia pirina*. Plant Disease 95 (3), 279-284.

Villalta ON Washington WS, Rimmington GM, MacHardy WE 2001. Environmental factors influencing maturation and release of ascospores of Venturia pirina in Victoria, Australia. Australian Journal of Agricultural Research 52, 825-837.


Improving management of scab:
Primary inoculum (ascospore) model
PIPS (Pest & Diseases)
pips
Plant & Food RESEARCH


Team
pips
Oscar Villalta, David Williams
Robert Beresford
Plant & Food RESEARCH


What is the research trying to achieve?
Accurate prediction of risk of primary infection caused by apple (V. inaequalis) and pear (V. pirina) scab ascospores in spring
– identify a suitable ascospore model for use in Australia
– enhance model to optimise spray application for primary apple and pear scab infections
– better targeted fungicide spray programs compatible with IPM


Background
• Preventing primary scab infections (caused by ascospores) main reason for intensive fungicide use
• Degree-day models capture time and temperature dependence of ascospore maturation
• Degree-day models useful to warn growers of periods of high infection risk
• A reliable model required to allow growers to use temperature and rainfall information to determine when ascospores are available to infect

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Outcomes:

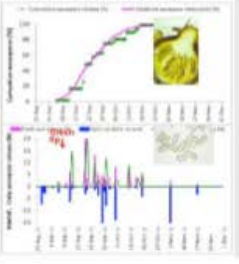
- Six degree day models evaluated with ascospore data sets from around the world and Victoria (Elkinto *et al.*, 2012)
- All models require some calibration of key parameters (e.g. start, 50% and maximum release) for use in Australia
- NZ model validated with new ascospore data sets from Vic, Tasmania, SA, NSW and Qld (2012-2013)
- NZ degree-day model was suitable, with some minor adaptation, for use in Australia
- Data will be used to validate PC-based systems including RimPro

Australian FruitGrower November 2013

Getting the ascospore maturation and release right to identify the days with the greatest potential for scab infections

Predicted cumulative ascospore maturation using degree days

Predicted daily releases of mature ascospores using rainfall



Acknowledgements

- PIPS is funded by HAL via a combination of levy and voluntary contributions matched by the Commonwealth, and co-investment by TIAR (UTAS), DEPI, PFR NZ, and DEEDI
- The research team thanks DEPI staff for support and fruit growers for collaboration with field trials

Codling moth biocontrol and mass-trapping

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The Australian apple and pear industry is the third largest horticultural industry in Australia and invests approximately $3.5m annually in a range of RDE programs.

The 5-year national Orchard Productivity R&D program PIPS aligned investment by research agencies, industry and HAL to reduce duplication; maximise returns on investment; increase breadth of cover; enhance cooperation; and improve stability of funding.

The IPDM sub project was a collaboration between the Victorian Department of Environment and Primary Industries (DEPI, now – DEDJTR) and Plant and Food Research (PFR) New Zealand, with inputs from other Australian states and international collaborators. It built on previous work by DEPI and PFR NZ, capitalised on synergies in the proposed work programs from both countries, and leveraged significant co-investment.

Pheromone-mediated mating disruption of pest moths in orchards currently requires assistance from pesticide applications to reduce high populations of moths to levels controllable by mating disruption alone. However, consumers, domestic and export markets, and regulators are demanding virtually zero residues on produce and high levels of environmental sustainability.

Orchardists require economically viable production techniques that allow them to meet market requirements so that they can stay in business. Every action taken in fruit production has an impact on some other component in the system.

To better understand the interactions between components the PIPS IPDM team undertook a detailed literature review that identified several knowledge gaps and lack of breadth in the tools available to orchardists wishing to adopt pesticide reduction programs.

To address these issues the research team introduced a biocontrol agent (*Mastrus ridens*) against codling moth to supplement pheromone-mediated mating disruption; investigated the biotypes of woolly apple aphid (WAA) present in Australia in preparation for introduction of a predator (*Heringia calcarata*) to supplement control exerted by the parasitoid wasp *Aphelinus mali*; developed an improved scab management program; and conducted a review that concluded *H.calcarata* could make a useful contribution to control of WAA in Australia

provided it could be bred in captivity. These outputs are described in detail in the final report of the PIPS program.

Recommendations from the PIPS IPDM team for further study were to:

- Evaluate the success of *Mastrus ridens* field releases and impact on codling moth.
- Develop a laboratory mating and rearing method for *Heringia calcarata* to allow host-specificity testing in Australia and NZ.
- Investigate integration of beneficial mycorrhizal fungi for improved management of root-zone pests and diseases in apple and pear production systems.
- Develop and validate practicable guidelines that will allow growers to tailor systems that integrate the new tools available to them, for their individual enterprise and context.

These recommendations fit closely within the terms of reference for the PIPS Phase II IPDM research area ("…a holistic approach relating to the orchard of the future based on current pests and diseases causing economic losses and issues relating to their control").

The orchard of the future will be structured around planting and growing systems suited to mechanisation and other ways of encouraging greater labour/input use efficiency and profitability. Pesticides will remain important tools for intervention but their use, and the range of available activity groups, will be limited due to restrictions imposed by reaction to expectations of consumers, export and domestic market MRLs, current use patterns driving development of resistance, and costs. Advances in biological control, enhanced resistance traits and biorational (ecologically benign, highly selective or behaviour modifying) techniques integrated with agronomic practices will provide opportunities for more stable pest, disease, and crop management.

In April 2015 the Tender Review Panel recommended that the budget be reduced to reflect the budgetary constraints of the apple and pear industry with prioritisation of work to be continued from PIPS I, and to remove the components funded via matched voluntary contributions because these were not permitted under the new arrangements for HIA industry-specific projects. Severe pruning of the proposal was required in order to fit the budgetary constraints and, given the priority attached by industry for the *Mastrus* work, we have reduced the scope of the proposal to the completion and evaluation of the *Mastrus* releases and shortened the timeframe to four financial years.

- Evaluation of wasp dispersal conducted after the 2014 release will provide guidelines on the spatial distribution of release sites within orchards. Laboratory cultures will be ramped up to provide sufficient wasps for release in "nursery sites" in Southern Queensland, NSW, SA, Tasmania, and Victoria. Western Australia is not included in *Mastrus* release sites because codling moth is not present in that state.
- Corrugated cardboard bands containing *M.ridens* pupae and parasitised codling moth larvae from the DEDJTR Bundoora colony will be transported to field sites in Victoria and other states for release of adult wasps. Sentinel

bands containing diapausing codling moth larvae will be strategically placed in release sites to assess establishment and dispersal of the released wasps through codling moth parasitism rates.

- The sentinel bands will also be used to detect and evaluate impact of any hyper-parasitism of *M.ridens* in Australia. Codling moth activity at release sites will be monitored using pheromone traps and damage assessments will be conducted at harvest each season to measure trends.
- Impact of pesticides on *M.ridens* will be investigated in laboratory studies utilising the pesticide testing facility at DEDJTR Bundoora.
- Extension activities requiring input from the IPM project team will be funded from the extension sub-project, as per advice from the Tender Review Panel during Stage one.

The outputs from another project, mass-trapping of codling moths in orchards, will complement the *Mastrus* work by providing tools for monitoring and mass-trapping male and female codling moths in orchards treated with pheromone-based mating disruption where pheromone traps are unreliable.

The project was established to deliver an additional "non-chemical" control option that will complement the use of pheromone-mediated mating disruption, entomopathogenic nematodes, codling moth granulosis virus, and the newly introduced parasitoid wasp *Mastrus ridens* for codling moth management in Australian pome fruit orchards. The project builds on work conducted under HAL project MT07028 and aims to develop and test reliable, cost-effective mass-trapping methods that can be integrated with biological control and mating disruption for control of codling moth.

Field trials conducted in 2013-14 at sites with Packham pears, or with Corella pears surrounded by Nashi, in the Goulburn valley tested the relative attractiveness of 24 combinations of pheromones and host plant volatiles in lures for male and female codling moths. The best lure for capturing female codling moths in traps in Packham pears was one of the two best performers in the Corella pears and was chosen for further work to determine the radius of attraction in order to develop a cost-effective mass-trapping system. The identity of the lure components is commercial-in-confidence.

Field trials conducted during 2014-15 utilised grids of 112 traps in pear blocks treated either with or without mating disruption applied against codling moth. The rate of capture of female moths in both MD and non-MD blocks decreased after 3 weeks of trapping whereas the rate of male capture was relatively consistent throughout the season. All female moths captured were gravid.

Average damage levels to the crop by codling moth were 0.57% for the MD treated block and 0.78% in the non-MD block. The active radius of the traps in the mating disruption block appeared to be approximately 33m for female moths and 43m for male moths.

Codling moth biocontrol and mass-trapping

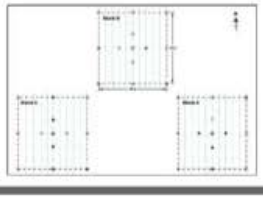
David Williams, Mofakhar Hossain, and Alex Il'ichev

Background

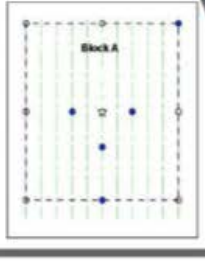
- PIPS 1 finished December 2014
- Sustainable IPDM in orchards
  - Biocontrol of CM to supplement Mating Disruption
  - Biocontrol of WAA to supplement *A.mail*
  - Better targeted scab management programs
  - Understand interactions between various control measures
- PIPS 1 IPDM Achievements
  - *Mastrus ridens* imported, tested, approved & released
  - *Heringia calcarata* reviewed
  - Scab modelling completed
  - Interactions reviewed & reported

PIPS 1 IPDM Outcomes :

- ***Mastrus ridens* released in NZ & Australia**
- **Field releases May & August 2014 and recovered from field >40m away**



PIPS 1 IPDM Outcomes Cont.:



PIPS 1 IPDM Outcomes Cont.:

- WAA biocontrol agent *Heringia calcarata* imported into NZ quarantine
- Reviewed potential in Australia
- Need to get it to breed in captivity
- Scab modelling completed & ascospore release calibrated for Aust.
- Interactions reviewed and reported

PIPS 2 proposal submitted

- Finalise Mastrus releases
- Assess pesticide susceptibility
- Import Heringia
- Explore benefits of mycorhizal fungi for improved pest management & agronomic performance

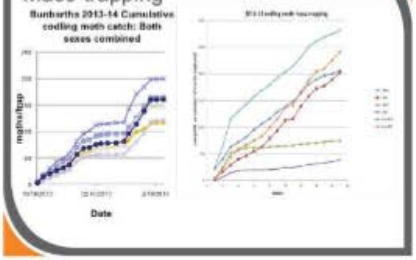
- Mass-trapping codling moth
  - Targeting male and female moths in orchards under pheromone based mating disruption
  - Potential to complement Mastrus and other biocontrols
  - Could have spin offs for pesticide treated and organic orchards

Update

- PIPS 2

  - Finalise Mastrus releases Qld, NSW, SA, Tas, Vic
  - Assess pesticide susceptibility
  - ~~Import Heringia~~
  - ~~Explore benefits of mycorhizal fungi for improved pest management & agronomic performance~~
  - 5yr project cut to 4yrs to fit budget
  - Waiting on approval

Mass-trapping



Next season

- Start PIPS 2 if approved
- Complete final year of Mass-trapping (phase 1?)
  - Improve longevity of HPV
  - Explore cost-effectiveness
- Well on the way towards a package of compatible "soft" options for management of codling moth

Acknowledgments

- DEPI (DEDJTR)
  - HIAL
  - APAL
- PFR (New Zealand)
- Participating Growers

Fruit fly research national overview

Dr. Peter Whittle
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Fruit flies, especially Medfly (in the west) and Qfly (in the north and east), are Australia's costliest group of horticultural pests, through production losses, costs of control, and market access barriers. A further group of native species of lower significance requires attention. Of great concern is the threat posed by exotic species, especially the Oriental fruit fly. These pests affect a wide range of crops, not only pome fruits. In recent years fruit fly importance has increased because of the regulatory withdrawal of key pesticides and the further spread and increased persistence of Qfly causing loss of pest free areas (PFAs) that enable market access.

Because of the cross-horticulture relevance of fruit flies, they are an issue of national strategic importance. National strategic planning for fruit flies was commenced almost a decade ago with the release of a draft National Fruit Fly Strategy (NFFS) in 2008 and an Implementation Action Plan in 2010. The NFFS set five themes: Biosecurity; Management; Market access; Communication and awareness; and R&D. The 2010 Action Plan identified 15 projects to fit into these themes. Recently efforts have been made to evaluate progress against the earlier plans and to update them as required. A National RD&E Plan was released by the Plant Biosecurity CRC in February 2015 and the Action Plan is under revision by the National Fruit Fly Strategy Advisory Committee. The RD&E Plan comments that the NFFS remains current, but has become more urgent and requires both long term and emergency action. It provides a vision:

"Fruit flies are not a constraint to sustainable production or a significant barrier to national and international market access"

It revises the framework to seven investment themes (each with sub-themes): Managing exotic risk; Pre-harvest measures; Post-harvest measures; Market access and regulatory issues; Social issues; Capacity; and Core science. The Plan makes 11 recommendations, in summary: National coordination of fruit fly RD&E; Regional approaches to development and extension; R&D for biosecurity preparedness; RD&E for chemical controls; Applying in-field controls in an integrated pest management (IPM) framework; R&D on eradication technologies; R&D for new disinfestation methodologies and statistical approaches; Standardised R&D approaches to enhance market access acceptance; RD&E on 'other' species; Improved diagnostics; and Plan coordination and implementation.

Part of the final recommendation is an audit of activity and indeed there has been a substantial effort to collect fruit fly information for the Fruit Fly Body of Knowledge. Over the years many projects have involved HAL funding, but many would have been conducted in universities and state departments with other funding sources, including the Plant Biosecurity CRC (HIA is a major cash investor) and its predecessors. A quick search of HAL/HIA projects completed in recent years or current reveals just one project specifically for fruit fly in the Apple & Pear industry, but numerous relevant projects have been funded across industries, due to their broad relevance.

The specific project, AP06006 completed in 2011, aimed at replacing fenthion and dimethoate in apples with a systems approach using pre-harvest protein baiting and packing line inspections. This was quite efficacious but not to the statistical level required for market access, indicating that further measures are required in the system. These other measures, for both Qfly and Medfly, are addressed in a range of HG and MT projects. The approaches include: Sterile insect technique (SIT) for Medfly local suppression and eradication; Improving SIT for Qfly (the SITplus consortium); IPM systems for in-field control using combined measures; area wide management (AWM) and farm wide management; new lure-and-kill methods and chemicals; post-harvest disinfestation.

The situation for fruit fly risk mitigation in pome fruits is promising. The increasingly strategic focus on fruit fly RD&E nationally, including in HIA, is yielding new tools for combination in systems approaches, and knowledge about how to apply them to greatest effect. Achieving sustainable production is one thing, but the great challenge is to achieve the level of market assurance that was previously achieved by PFAs and insecticide dip, and then to negotiate this with desired export markets.

APFIP and pear variety evaluation and certification update

Mark Hankin
Evaluation Coordinator
Australian Pome Fruit Improvement Program® Limited (APFIP)
mark@apfip.com.au

Evaluation: Update on the current evaluation status of varieties form Australia and International breeding programs.

Certification of Plant Material: Update on the propagation and availability of apple and pear plant material carrying the APFIP certification trade mark.

Post Entry Quarantine (PEQ): Update on the Post Entry Plant Industry Consultative Committee (PEPICC), New PEQ Station and PEQ times for apple and pears.

Tree procurement service (TPS): Insight into the TPS and its benefits to apple and pear growers.

Pear rootstock demonstration trial: Update on the findings of the demonstration trial and delivery of the final report.

Australian Pome Fruit Improvement Program Ltd (APFIP)

Presentation to "Speed Updating" seminar,
June 2015
Mark Hankin,
Evaluation Coordinator
APFIP

Horticulture Innovation Australia

APFIP: What we do

- Variety Evaluation
- Tree propagule Certification
- Quarantine liaison/oversight
- Tree Procurement advice/assistance
- Trials – e.g. Pear Rootstock trial

Variety Evaluation

- 8 sites
- 166 apple cultivars
- 66 pear cultivars
- 19 material suppliers
- Evaluation data uploaded at site
- Confidential until released

Tree Propagule Certification

- Certification standards for tree propagules
- Trees that comply can receive Certification Trade Mark
- 10 approved APFIP-Licensed nurseries
- Certified material shown to be free of important viruses

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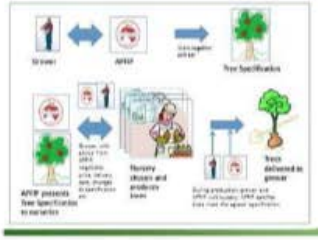
Tree Propagule Certification



Tree Procurement Scheme

- Helps growers and nurseries close information gap.
- Help growers identify and finalise their needs.
- Nursery tree specification guide.

Contact: mark@apfip.com.au
mobile: 0408 503 528
Website: www.apfip.com.au

Tree Propagule Certification: Certified Tree Demonstration Sites

- Located in (i)Huon Valley, (ii) Stanthorpe, (iii) Lenswood
- Goulburn Valley coming
- 500 trees per site
- ALVINA® Gala on M26 stock
- 50% certified propagules
- 50% non-certified materials
- Large differences in growth

Oversight of Quarantine Issues for the industry

- APFIP represents the industry on the Post Entry Plant Industry Consultative Committee (DoA)
- Through this role has APFIP has significantly reduced the post-entry quarantine time for apples and pears – leading to more rapid introduction of new varieties

Trial Work – Pear rootstock trial in the Goulburn Valley

Why? – demonstrate the value of new semi-dwarfing stocks for pears in the Goulburn Valley
Outcomes? – Quince stocks "rule"
Importance? – EcoDev follow on rootstock program for pears

In Summary

Variety Evaluation

Tree Propagule Certification

Quarantine oversight and liaison

Important industry infrastructure

www.apfip.com.au

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The importance of maturity at harvest in pears

Dr. Dario Stefanelli
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Department of Economic Development, Jobs, Transport & Resources (DEDJTR)
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Dario Stefanelli, John Lopresti, Janine Jaeger, Bruce Tomkins and Rod Jones

Unlike apples and stonefruit, some pear varieties do not undergo the classic climacteric fruit ripening process where ethylene is produced to accelerate ripening, either before or after harvest. Pear varieties such as Corella, do not ripen fully on the tree or even after harvest at room temperature. These varieties do not produce ethylene at harvest and need long periods of cold storage of up to 12 weeks to initiate ethylene, ripening and to fully develop characteristic taste and aroma. Asian markets prefer pears that are crisp and green while domestic markets prefer soft, buttery yellow fruit.

To meet consumer requirements in different markets an accurate understanding of pear maturity at harvest and ripening behaviour during handling, storage and distribution is required. At the moment pear harvest maturity is based primarily on firmness as measured by penetrometer, which is destructive, meaning large numbers of fruit cannot be assessed, and not a complete indicator of fruit maturity.

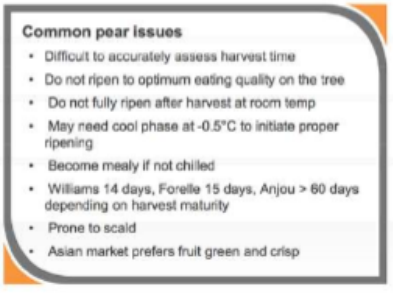
A recent technology, the DA-Meter, correlates the difference of absorbance in chlorophyll-a in the mesocarp tissue and fruit ethylene production. This provides an Index of absorbance difference (I_{AD}), which non-destructively measures the physiological maturity stage of the fruit in relation to ethylene production. The I_{AD} provides a rapid, accurate and non-destructively measure of fruit maturity and ripening before and after harvest at all steps in the handling chain.

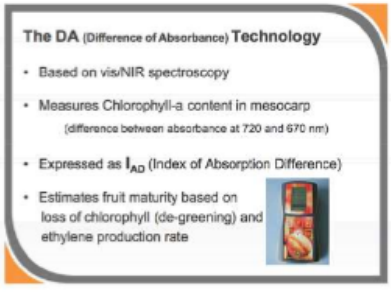
DEDJTR is currently testing the DA-Meter to monitor pear maturity in the orchard and to identify how different maturity classes at harvest behave during postharvest handling, storage and marketing to determine harvest and handling protocols that optimise pear market quality and meet consumer expectations. DEDJTR is conducting maturity and post harvest storage trials on the newly released varieties from the ANPBP, including 0118 (Lanya®), 0131 (Deliza®) and 0534. Trials were conducted on Williams and Lanya in 2013/14 and 2014/15 to determine optimum harvest maturity, based on firmness and I_{AD}, and to monitor ripening both on tree and during post harvest storage.

The DA meter proved effective at quantifying changes in maturity in both cases, despite the fact that ethylene production was not recorded in Lanya. There was a strong correlation between I_{AD} and firmness, as measured by penetrometer. Optimum harvest time in Lanya was approximately 2 weeks later in 2013/14 due to excessive heat; this was reflected in DA data. Pears continue to develop in cool

storage, even at temperatures as low as -0.5°C, and for the first time the DA meter allows us to track ripening in cool stores in a non-destructive manner. Ripening during cool storage (-0.5°C) and shelf life (18°C) was accurately tracked using the DA meter, which gave valuable new information on the behaviour of pear fruit during storage.

Despite the fact that ethylene was not produced by these pear varieties in sufficient quantities to be used to correlate the I_{AD}, the DA meter is a useful tool in tracking maturity and ripening in pears. Future work will include an investigation into other physiological processes involved in ripening (eg softening enzymes, sugar accumulation) that could be used as a substitute for ethylene production as an indicator of ripening stage.





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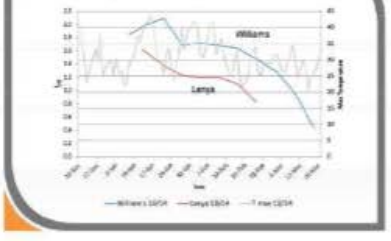
Maturity classes

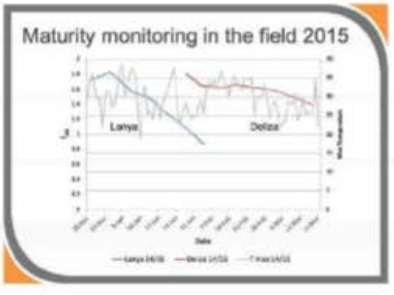
Williams	I_{AD}	Ethylene production
Immature	> 1.70	No
Early pick	1.20 - 1.69	No
Commercial	0.70 - 1.19	Very little
Ready to eat	< 0.70	Substantial

ANP-0118 - Lanya	I_{AD}	Ethylene production
Immature	> 1.50	No
Early pick	1.48 - 1.20	No
Commercial	1.10 - 1.00	No
Ready to eat	< 1.00	No

Maturity monitoring in the field 2014



Maturity monitoring in the field 2015



I_{AD} Shelf life Lanya 2015

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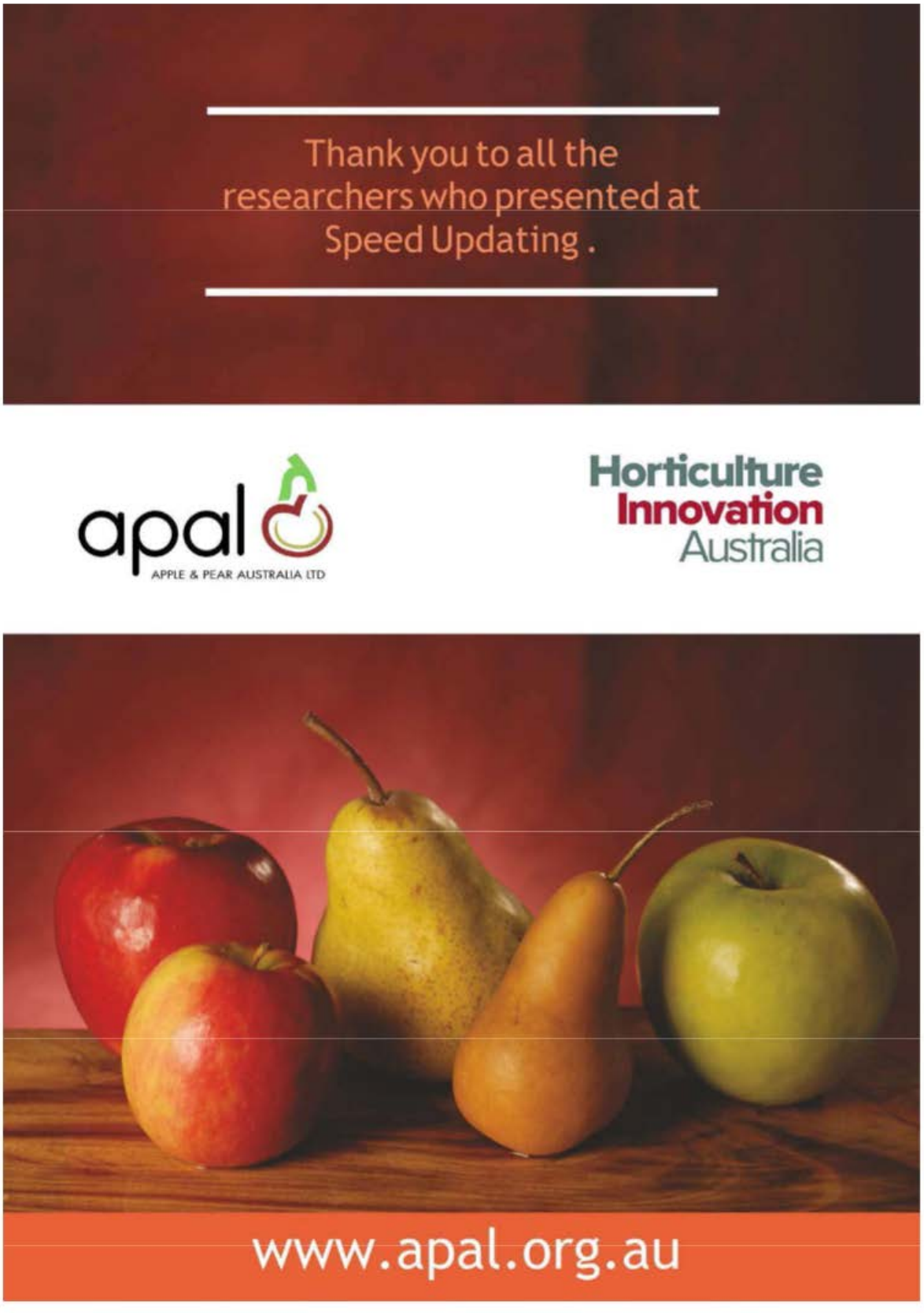
Thank you to all the
researchers who presented at
Speed Updating .
apal
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Horticulture
Innovation
Australia
www.apal.org.au

Attachment 3: Australian Fruit Grower article August 2015

APAL AT HORTCON2015

More than 1,300 people attended the combined APAL and AUSVEG National Horticulture Convention including around 150 apple and pear industry representatives.

Held on the Gold Coast, 25-27 June 2015, the Convention was the first time APAL and AUSVEG have worked together to test run the idea of an all-of-horticulture event.

Combined activities for both industries included a massive Trade Show, plenary speaker sessions and special events for target groups including Women in Horticulture.

APAL is still collecting and analysing all the feedback received, but so far the feedback has been pretty positive across the entire event and particularly APAL's events for the apple and pear industry.

SPEED UPDATING

The first event at HortCon2015 for apple and pear growers was the industry's research review event, Speed Updating, led by APAL Technical Manager Angus Crawford. Speed Updating brings leading scientists and industry together to capture the latest outcomes from Australian based apple and pear industry research.

The intensive one day program is targeted at industry, which includes agronomists, industry development officers, consultants as well as growers, to provide a detailed account of the numerous activities in apple and pear R&D.

Twenty four researchers each gave a ten minute presentation on their work, which has either just started, is underway or has just been completed. Overall, the presentations were grouped into topic areas covering precision horticulture, tree physiology, soils, irrigation, nutrition, plant growth regulators, climate change, varieties and integrated pest and disease management.

Two years ago Speed Updating was piloted and based on the success of that program the event is now likely to be held every two years. A 125-page booklet was provided free to all those that attended and includes a summary of the presentation and presentation slides. These are now also available on the APAL website along with videos of all the speakers.

The feedback forms received indicated that those who attended liked the exposure to a large number of speakers, and the presentations were succinct where they can chase up if more detail if needed. In future, a larger room will be selected and we will consider also reducing the number of presentations due to the information overload which was happening.

A big thank you to all the researchers for participating and to HIA for funding this event.

Attentive audience at the APAL Speaker Session.

> This should be a must-have for future conferences. It is a great format and a great opportunity to get the latest on research that is happening in our industry as well as network with researchers.

APAL Deputy Chair Kevin Sanders stepped up to help chair numerous sessions.