HORTGRO SCIENCE

ANNUAL REPORT 18 19

CON

TENT

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CHAIRMAN'S REPORT

The email from Theresa Sonnenberg asking me to prepare my annual Chairman's report reminded me how fleeting time is. With our Industry so focused on the evolving seasons, continuous changes and challenges, time seems to fly by.

The year under review has been filled with amazing highlights and a few challenges. The Hortgro Science Advisory committee, together with Management and a few invited guests embarked on a strategic review of our activities and attempted to clarify the medium- and long-term key activities that we need to focus on, this is what we came up with:

1. CLEAR MANDATE FROM THE INDUSTRY

Hortgro Science plays a pivotal role in assisting and addressing short term market access issues by preparing protocols that provide scientific solutions; this does not form part of the R&D mandate but is vital/critical to the Industry. This needs to be recognised in a revised mandate.

2. CAPACITY

Positions filled by capable human resources that have the capacity to carry out the mandate required by Industry.

3. SUCCESSION PLANNING

The passing of time needs to be recognised and a well thought out and implemented succession process needs to be in place.

4. RECORDED SYSTEMS AND PROCESSES IN PLACE

To ensure a smooth transition into mandate and succession.

5. BUILD RESEARCH COLLABORATION AND NETWORKS

In order to achieve mandate.

6. DATA

Clearly understand our role and responsibility in this developing field.

The focus of the Advisory Council will be on ensuring that Management has plans in place to implement and deliver on these key focus areas while ensuring the high standard of delivery we have come to expect of the team continues.

We have welcomed 3 new Advisory Council members, Wesley Hendricks, Frikkie Jacobs representing pome fruit and Raymond Koopstad on the stone fruit side. Wesley and Raymond are the Deciduous Fruit Development Chamber representatives; we look forward to their contribution and input.

Lastly, I would like to thank all those Industry players that give of their time in developing the strategic direction that ensures Hortgro Science remains relevant and delivers on expectations. Thanks to the amazing Hortgro Science management team that together with the synergistic management relationships with Hortgro, continue to surpass what's expected of them. With a clear mandate and plans in place, I am confident that the team will conquer the real challenges and maximise the opportunities that lie ahead.

- Stephen Rabe

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GENERAL MANAGER'S REPORT

As a break from the norm I would like to share the progress that we as Hortgro Science have made over the past 4 years in addressing the strategic objectives set by the Hortgro Science Advisory Council in consultation with management in 2015.

Industry future vision

Strategic Initiative	Description	Progress
Orchard of the Future (OoF)	• Review OoF phase 1 • Set new targets for phase 2 • Look to broaden to stone fruit	• Aligned research objective with OoF objectives • Published series of articles on OoF – further to follow in FQ • OoF helped catalyse uptake of dwarfing rootstocks (M9) • Limited progress on stone fruit OoF • OoF phase 2 being initiated
Cultivar acquisition strategy	• Review industry cultivar programme (breeding / imports /evaluation / commercialisation)	• Cultivar acquisition strategy developed and currently being implemented • Separate, focused Cultivar acquisition structure created within Hortgro • Breeding programme re-engineered – more focused & led by industry • Independent evaluation scheme implemented • Re-aligning acquisition strategy
Identify and list key risks to industry	• List risks and develop mitigation per research programme	• Risk 'heat-map' developed which helps drive research projects & priorities
Identify the key industry bottleneck / sticky issues:	• Identified rootstocks, nursery tree quality & water stewardship	• Rootstock evaluation strategy being implemented • Nursery tree research plan & projects implemented • Drought strategy developed in conjunction with industry

Long term research strategy

Strategic Initiative	Description	Progress
Identify the key focus areas per research programme	• Address risks and future challenges	• Each research programme prioritised into sub-programmes with workgroups identifying the key research questions
Identify capacity and infrastructure requirements of focus areas	• List what research capacity (people) is required to keep industry sustainable over long term • Review the current research model and test its ability to meet research requirements of industry (includes research structures / facilities)	• Review document in place • Certain critical placements made as part of process to ensure sustained research capacity in place in strategic areas
Establish CA research centre	• Investigate the creation of a centralised CA research facility to serve the expanded CA needs of industry	• CA research facilities created at Stell Univ Horticultural Science
Explore R&D needs that can be sourced from elsewhere	• List potential local (SA) and international collaborators	• Collaborations on local level have been broadened but not at an international level

Communications strategy

Strategic Initiative	Description	Progress
Identify customer needs	• Identify different customers and identify communication needs for each group	• Mini survey done in 2015 • Customer base stratified into different groupings
Develop a R&D communications strategy	• Identify different communication platforms required to meet the different communication requirements	• Clear strategy in place with 15 platforms covering the different bases
Integrate strategy with Hortgro strategy	• Link science strategy in with overall Hortgro strategy and align	• Communications strategy falls under Group Communication Manager to ensure coordination and alignment across Hortgro
Execution of strategy – develop a dedicated communication tool for R&D	• Identify tools to operate on different platforms with the required resources	• Fresh Quarterly introduced in June 2018 as focused R&D feedback vehicle. • Focused capacity put in place to support different communication initiatives

Funding strategy

Strategic Initiative	Description	Progress
Increase R&D funding	• Benchmark industry & total funding • Seek to increase R&D funding as a % of GDP	• Deciduous funding benchmarked against other SA fruit and agric industries • Total R&D funding benchmarked against competing countries • Current R&D spending well below international benchmarks
Improve access to government funding	• Align R&D strategy with national government priorities & NDP • Increase number of black researchers and bursaries to black post grad students	• R&D strategy aligned with elements of the NDP but shortfalls exist relating to meeting all the targets • ± 50% of post graduate students black • Government has changed a number of the requirements for funding which has reduced industries leverage of government funds (notably THRIP funds)
Pursue collaborations	• Establish collaborations with industry bodies in other countries • Identify leading researchers in SA to build international collaborations	• Collaborations exist between researchers and a number of international collaborators • Limited collaboration initiated with other industries
Seek new funding sources	• Identify local and international funding sources	• Little success to date in leveraging new funding

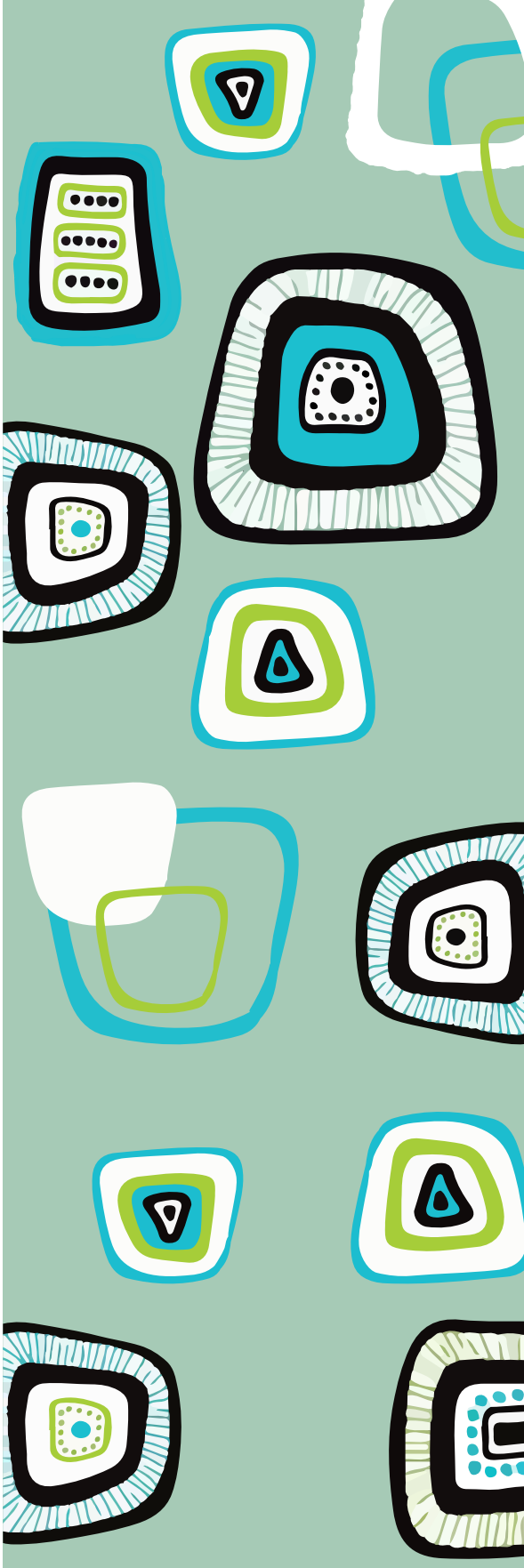
Operational excellence strategy

Strategic Initiative	Description	Progress
Develop a R&D project database	• Build a comprehensive database for all projects funded by industry	• Database up and running
Develop an information database	• Identify what should be included in an information database and how to resource it	• Partially addressed
Offices – identify better options	• Find appropriate office space that is fit for purpose	• Stell Univ Agrohub at Welgevallen created office space aligned with similar industries and close to research centres

As we move into the next phase and look at the period ahead we will be setting new targets as noted in our chairman's report. I would like to note that funding is an enabler. Our current level of funding of research (both levy and leveraged external funding) is at 50% of the international benchmark and well below the objective set in the National Development Plan. We will continue to explore ways of increasing our investment in research. It is clear that we need to take more control of the full spectrum activities associated with research. This includes the critical issue of people capacity and structures that we set up to drive the research process into the future in order to assist growers to meet the risks and challenges that lie ahead in the competitive world of international commodity markets.

It is a pleasure working in a team and a broader community that is filled with highly competent and committed individuals. Thank you to our Hortgro team and a very special thanks to the 170 odd industry members of our peer work groups, technical advisory committees, work groups and other groupings for your participation and the extremely valuable contributions that you make to our industry. I would like to end by thanking all the members of our Advisory Council for your leadership and support during this past year.

- Hugh Campbell



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THE HORTGRO SCIENCE TEAM

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THE STAFF SECONDED TO STELLENBOSCH UNIVERSITY

DR XOLANI SIBOZA
DEPARTMENT OF HORTICULTURAL SCIENCE

DR KEN PRINGLE (5/8 APPOINTMENT)
DEPARTMENT OF CONSERVATION ECOLOGY AND ENTOMOLOGY

DR SHELLEY JOHNSON
DEPARTMENT OF CONSERVATION ECOLOGY AND ENTOMOLOGY

CHAIR IN APPLIED PRE-HARVEST DECIDUOUS FRUIT RESEARCH AT STELLENBOSCH UNIVERSITY

PROF KAREN THERON

CONTRACT POSITIONS FUNDED THROUGH RESEARCH PROJECTS

LAURA ALLDERMAN
DORMANCY PROJECTS

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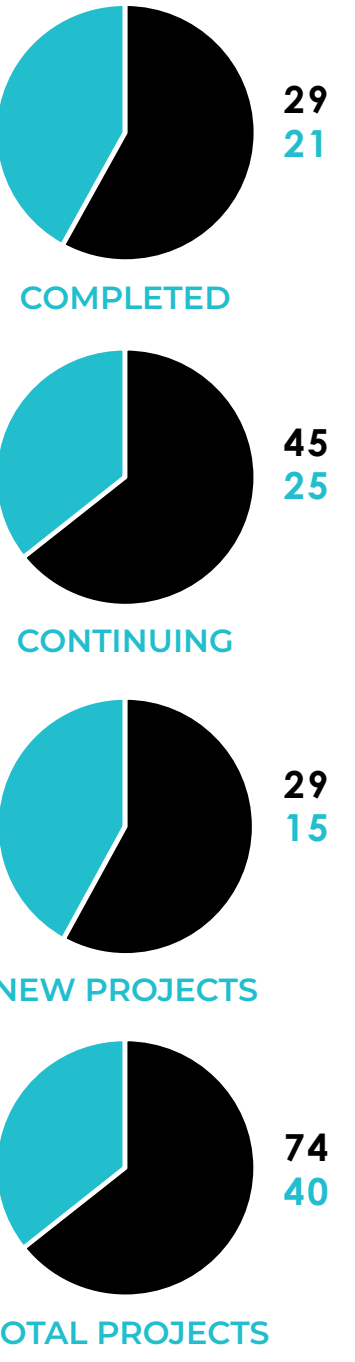
YEAR AT A GLANCE

PROJECTS

SUMMARY OF RESEARCH PROJECTS IN 2018/19

This is a summary of the research projects in 2018/19 and includes market access projects.

Please note that 18 of these projects are co-funded by both Hortgro Pome and Hortgro Stone, and are thus included in both the pome fruit and stone fruit totals.



Summary of research projects 2018-19, including market access projects

PROJECTS COMPLETED IN 2018-19

PROJECTS CONTINUING IN 2018-19

NEW PROJECTS IN 2018-19

TOTAL PROJECTS IN 2018-19

FUNDING

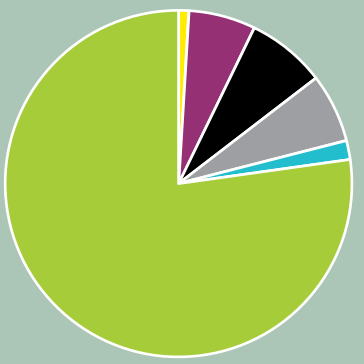
FUNDING ALLOCATIONS 2018/19

This chart illustrates the distribution of the industry's funding for research.

- ARC Project **7%**
- Tech Transfer **4%**
- ExperiCo **13%**
- Research Posts **18%**
- International congress etc **1%**
- Other research institutes **8%**
- Stellenbosch University **39%**
- Prog / project man / Tech services **10%**

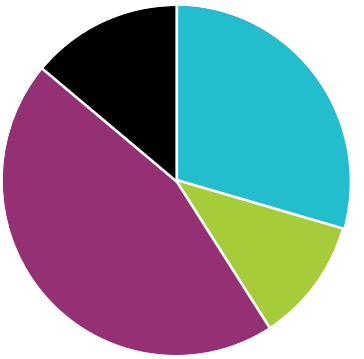
EXTERNAL FUNDING LEVERAGED

This chart illustrates external funds leveraged as a result of industry project funding for the 2018/19 financial year.



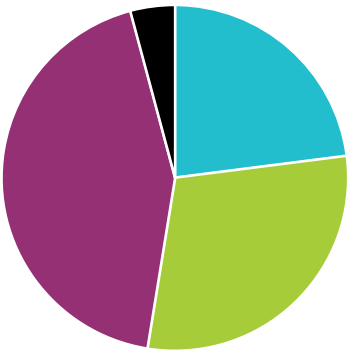
- Parliamentary Grant (ARC) **6%**
- PHI **7%**
- Pome/Stone Levy (Projects) **77%**
- THRIP **1%**
- Other Industries **7%**
- WCDoA **2%**

INVESTMENT PER RESEARCH FOCUS AREA FOR 2018/19 – STONE FRUIT



- Sustainable Farming (Crop Protection) **30%**
- Product Integrity through the Supply Chain (Post-Harvest) **45%**
- Sustainable Farming (Crop Production) **11%**
- Market Alignment (Market Access) 1**4%**

INVESTMENT PER RESEARCH FOCUS AREA FOR 2018/19 – POME FRUIT



- Sustainable Farming (Crop Protection) **23%**
- Product Integrity through the Supply Chain (Post-Harvest) **43%**
- Sustainable Farming (Crop Production) **30%**
- Market Alignment (Market Access) **4%**

RESEARCH PROJECTS BY RESEARCH INSTITUTION FROM 2012-2019

Research Institute	Projects						
	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
ARC Infruitec-Nietvoorbij	36	36	30	29	24	20	6
ARC Breeding	*21*	*21*	*21*	*20*	*16*	*15*	*0**
ARC Research Projects	*15*	*15*	*9*	*9*	*8*	*5*	*6*
Stellenbosch University	38	39	34	33	36	49	48
Dept Horticulture	*15*	*16*	*14*	*12*	*12*	*15*	*22*
Dept Pathology	*5*	*5*	*5*	*5*	*7*	*8*	*9*
Dept Entomology	*18*	*18*	*14*	*14*	*16*	*21*	*12*
Dept Engineering			*1*	*1*		*2*	*2*
Dept Soil Science				*1*	*1*	*1*	*1*
Dept Logistics						*1*	
Dept Genetics							*1*
CREST						*1*	*1*
Hortgro Science Technical Services	20	20	15	18	20	4	0
ExperiCo	15	16	19	18	21	17	22
CA Science	1	1	1		1	1	
Nemlab	1	1	1	2	2	1	
Blue North	1	1	1	1	1	1	1
University of Pretoria	1	1	2	2	3	2	1
Dept Zoology	*1*	*1*	*1*	*1*	*1*		
Dept Plant Production and Soil Science			*1*	*1*	*1*	*1*	
Dept Pathology					*1*	*1*	*1*
University of Kwazulu-Natal							1
CSIR	1	1	1	1	1	1	0
Westcape Biotech			1	1	2	2	0
Provar					5	12	14
Consultants			5	4		6	3
C Jarmain			*1*			*1*	*1*
P Stassen			*3*	*3*	*3*	*3*	*3*
K Bouwer			*1*	*1*			
SAPO						*1*	*1*
T Ware						*1*	*1*
	114	116	110	109	116	116	96

* Note: Breeding projects have moved out of the research portfolio into the "Plant Improvement" portfolio of HORTGRO

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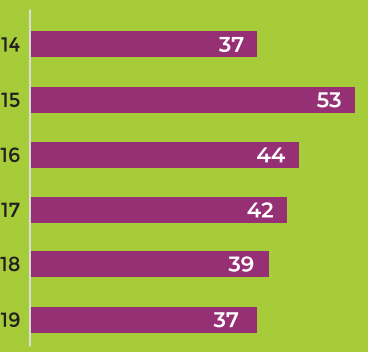
STUDENTS AND TRANSFORMATION

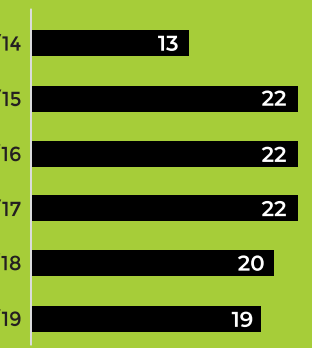
TRANSFORMATION IN RESEARCH FROM 2013 TO 2019

These tables show the percentage of projects with women leaders, projects with black leaders, and projects with postgraduate students.

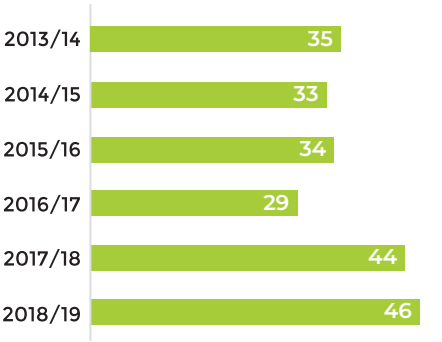
% Projects with a female project leader



% Projects with a black project leader



% projects with a postgraduate student



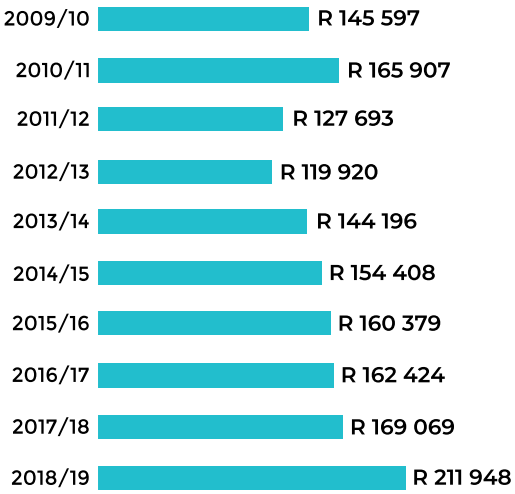
PROFILES OF STUDENTS WORKING ON HORTGRO POME AND HORTGRO STONE FUNDED PROJECTS

This table depicts the profile of the 53 postgraduate students working on projects funded by Hortgro Pome and Hortgro Stone.
Bursary costs total R 3 951 400.

DEGREE	BLACK MALE	BLACK FEMALE	WHITE MALE	WHITE FEMALE	TOTAL
Hons	3	6	0	0	9
MSc	3	10	4	6	23
PhD	5	4	1	6	16
Postdoc	1	0	1	3	5
TOTAL	12	20	6	15	53

AVERAGE COST PER PROJECT

This graph illustrates the average cost per project per year, including inflation, over the past few years. The average cost is influenced by the nature of the research, as well as other factors such as external funding and student bursaries.



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CROP PRODUCTION RESEARCH PROGRAMME

Research within the Crop Production programme addresses current problems experienced by fruit growers, but is also future-directed – research has a long lead time and it is important to now already build the capacity and conduct the research for the solutions that we will need in the future. In this sense, the Crop Production research strategy is directed and aligned with the requirements and key risks to the Orchard of the Future. Hence, rootstocks, plant quality, water- and climate-related research are the strategic priorities of this programme.

The Crop Production research programme is structured into six themes, namely Dormancy, Farming Technology, Irrigation and Nutrition, Rootstocks and Nursery Tree Quality, Growing Season Climate, and Reproductive Biology. Research strategy for each theme is determined by a workgroup (a workgroup per theme) consisting of fruit growers, technical advisors and researchers. When considering research strategy, the workgroups always keep in mind the changes we need to make to our orchards to remain internationally competitive as well as profitable. They also consider the major future risks, as identified within the overarching research strategy, which may jeopardise our profitability.

DORMANCY

Abstracts for these projects can be found on pages 74-82

Research in this theme is aimed at understanding the progression of dormancy under mild winter conditions. We also study dormancy release in order to potentially identify new, safer rest breaking chemicals – Dr Xolani Siboza is currently busy with field evaluation of potential new rest breaking programmes while Dr Esmé Louw is generating very informative data on the impact of insufficient winter chill on apple fruit quality and mixed maturity – the latter is one of our biggest post-harvest banes.

EXPERTISE

Dormancy Workgroup

RESEARCH TEAM

Prof Wiehann Steyn –
Crop Production Programme Leader

RESEARCHERS

Dr Esmé Louw
Dr Xolani Siboza
Prof Karen Theron
Ms Laura Allderman
Dr Iwan Labuschagne

STUDENTS

Mr Andrew van Lingen – MSc student

Mr Dian Craven – MSc student

Ms Micheline Inamahoro
– PhD student

Dr Leandra Möller – Postdoctoral Research Fellow

NEW PROJECTS

- Investigating the effect of different autumn/winter/spring scenarios on budbreak in apple trees. (E Louw and L Allderman)
- Validation of the shoot assay as a proxy to determine progression of dormancy in intact apple trees. (E Louw and L Allderman)
- Evaluation of alternative rest breaking agents for apples. (X Siboza, K Theron and D Craven)
- Adaptability indexing of new pome (apple) and stone fruit (plum) cultivars in diverse South African growing areas. (I Labuschagne and E Louw) – *also Growing Season Climate*
- Leaf defoliation of Cripps' Pink and Granny Smith apples in the EGVV – effect on vegetative and reproductive development. (X Siboza, K Theron and D Craven) – *also Reproductive Biology*
- Scientific and practical guide to climate change and pome/ stone fruit production in South Africa. (S Midgley) – *see Growing Season Climate and also Irrigation and Nutrition*

CURRENT PROJECTS

- Quantifying the impact of insufficient winter chill on apple fruit quality. (E Louw and A van Lingen)
- Physiological dynamics of dormancy in apple buds grown in areas with insufficient cold. (E Louw, L Möller and M Inamahoro)
- Investigating the effects of different autumn temperatures on endodormancy progression. (E Louw and L Allderman)

COMPLETED PROJECT

- Evaluate rest breaking programmes for warm winter regions. (X Siboza and D Craven)

PUBLICATIONS

- Fresh Quarterly July 2019: Bestbier, G. *Late bloomers (Dr Esme Louw)*

EVENTS

Hortgro Science Technical Symposium 03-07 June 2019

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ROOTSTOCKS AND NURSERY TREE QUALITY

Finding more precocious and productive rootstocks adapted to South African conditions is integral to our Orchard of the Future vision. For this reason, various pome and stone fruit rootstocks are evaluated in an increasing number of industry trials in commercial orchards. Hortgro Science has appointed Provar to run new rootstock trials under the supervision of Dr Xolani Siboza and with input from Dr Piet Stassen and the Rootstock Evaluation Committee. Together with the new funding strategy of rootstock evaluation, which involves co-funding by IP owners and licensees, this increases the number of trials that can be handled. More trials mean better data and hopefully earlier and more confident recommendations regarding new rootstocks. Dr Piet Stassen's comprehensive stone fruit rootstocks trials have been summarised in the Fresh Quarterly of Sept 2019. Prof Stephanie Midgley's research on water deficit tolerance of apple rootstocks suggests that M9 is not necessarily more susceptible to water stress. Other rootstock research is aimed at characterising new rootstocks in terms of adaptation and disease and pest tolerance.

Abstracts for these projects can be found on pages 83-97

EXPERTISE

Rootstock and Nursery Tree Quality Workgroup

Rootstock Evaluation Committee

RESEARCH TEAM

Prof Wiehann Steyn – Crop Production Programme Leader

RESEARCHERS

Dr Iwan Labuschagne
Dr Xolani Siboza
Dr Piet Stassen
Prof Stephanie Midgley
Prof Karen Theron

STUDENTS

Mr Werner Truter – MSc student
Ms Lindsay Muchena – PhD student

NEW PROJECTS

- Evaluation of apple rootstocks tolerance against specific apple replant disease (SARD). (I Labuschagne, A McLeod and X Siboza) – *also Pre-and Post-Harvest Pathology*

CURRENT PROJECTS

- Evaluation of pear rootstocks for the South African industry. Packham's Triumph in Grabouw. (X Siboza and I Labuschagne)

- Evaluation of pear rootstocks for the South African industry. Forelle in Wolseley (Mostertshoek) (X Siboza and I Labuschagne)
- Evaluation of pear rootstocks for the South African industry. Cheeky in Wolseley (Mostertshoek). (X Siboza and I Labuschagne)
- Evaluation of peach rootstocks for the South African fruit industry at Vaalwater, Limpopo. (P Stassen and I Labuschagne)
- Evaluation of peach rootstocks for the South African fruit industry: Rawsonville planting (Slanghoek). (P Stassen and I Labuschagne)
- Evaluation of plum rootstocks for the South African industry at Simondium (Keunenberg). (P Stassen and I Labuschagne)
- Evaluation of plum rootstocks for the South African fruit Industry: Robertson planting (Roodehoogte). (P Stassen and I Labuschagne)
- Evaluation of new apple rootstocks and interstem combinations in Grabouw (Oak Valley). (X Siboza and I Labuschagne)
- Evaluation of new apple rootstocks and interstem combinations in Grabouw (Breëvlei). (X Siboza and I Labuschagne)
- Evaluation of new apple rootstocks and interstem combinations in the Langkloof (Helderwater). (X Siboza and I Labuschagne)
- Evaluation of new apple rootstocks representing two vigour classes in two growing areas (Bokveldskloof and Molteno). (X Siboza and I Labuschagne)
- Evaluation of new apple rootstocks representing three vigour classes at Môrester and Oak Valley. (X Siboza and I Labuschagne)
- Sensitivity of various apple rootstocks to water stress. (S Midgley and L Muchena)
- Establishing quantitative relationships between water relations, growth, yield and quality of high performing commercial apple orchards. (S Midgley and S Zirebwa) – *see Irrigation and Nutrition*

COMPLETED PROJECTS

- Evaluate methods to produce and handle containerised nursery trees. (K Theron and W Truter)

PUBLICATIONS

- SAFJ October/November 2018: Voigt, F. *Progress report on Geneva rootstocks for commercialisation and further testing in South Africa:* pp. 45 – 47.
- SAFJ August/September 2019: De Klerk, A. *Letselaalwurms in appelkwekery en –boorde*: bl. 71-74.
- Fresh Quarterly December 2018: Stassen, P. *Rootstocks: choose what is best for your crop*
- Fresh Quarterly December 2018: Stassen, P. *Rootstocks for stone fruit*
- Fresh Quarterly September 2019: Stassen, P., Du Plessis, P. *Stone fruit rootstocks revisited*

EVENTS

Langkloof Seminar and Orchard Walk
29 November 2018

Hortgro Science Technical Symposium
03-07 June 2019

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GROWING SEASON CLIMATE

Of the "serious" pome fruit producers, South Africa, together with Brazil, have the production areas closest to the equator. This means higher summer temperatures and generally just altogether more plant stress and more fruit downgraded for processing compared to our major competitors. The great inefficiency of caring for fruit that ultimately ends up in a juice bin would have seriously endangered deciduous fruit production in South Africa if not for the favourable exchange rate. It shouldn't be surprising that research under this theme is predominantly aimed at decreasing sunburn and internal fruit quality defects brought about by photothermal stress. One of the key drivers of the second phase of the Orchard of the Future programme is also to increase the portion of the fruit on the tree that can be sold at the highest prices. Fruit production is a long term enterprise. A good handle on how future climate change may affect fruit production is therefore of considerable importance. Hence, we have commissioned Prof Stephanie Midgley and team to develop a scientific and practical guide to climate change and its predicted effects on pome and stone fruit production.

Abstracts for these projects can be found on pages 98-102

EXPERTISE

Growing Season Climate Workgroup

RESEARCH TEAM

Prof Wiehann Steyn – Crop Production Programme Leader

RESEARCHERS

Prof Karen Theron
Dr Mariana Jooste
Dr Elke Crouch
Prof Stephanie Midgley

STUDENTS

Ms Nasreen van Rensburg – MSc student
Mr Brian Makeredza – PhD student
Ms Liza-Marie Dippenaar – MSc student
Dr Letitia Schoeman – Postdoctoral Research Fellow

NEW PROJECT

- Scientific and practical guide to climate change and pome/stone fruit production in South Africa. (S Midgley) – *also Dormancy, and Irrigation and Nutrition*
- Adaptability indexing of new pome (apple) and stone fruit (plum) cultivars in diverse South African growing areas. (I Labuschagne and E Louw) – *see Dormancy*

CURRENT PROJECTS

- Determining 'Forelle' pre-harvest mealiness / cavity development stage, due to environmental factors and exploring prevention of mealiness developing after storage and ripening. (E Crouch, L Schoeman and L-M Dippenaar) *– also Physiological Defects, Post-Harvest Programme*
- Effect of nets on growth, yield and fruit quality as well economic feasibility in plums. (K Theron and N van Rensburg)

COMPLETED PROJECTS

- Heat damage in plums. (W Steyn, M Jooste and B Makeredza)

PUBLICATIONS

- SAFJ June/July 2019: Steenkamp, E. *Challenging stone fruit season for growers:* pp. 24-25.
- SAFJ June/July 2019: Steenkamp, E. *Waarnatoe met nette*: bl. 25.

EVENTS

Langkloof Seminar and Orchard Walk
29 November 2018

Hortgro Science Technical
Symposium 03-07 June 2019

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Growing Fruit IQ

REPRODUCTIVE BIOLOGY

Research in this field is aimed at obtaining regular high yields of good quality fruit. The research is mostly applied and in recent years, the work done by Prof Karen Theron has provided us with a mechanical thinning option for stone fruit that considerably saves time and cost. Prof Theron has also evaluated a very promising chemical stone fruit option that is awaiting registration. In projects funded by Philagro, Prof Theron is continuing the evaluation of plant hormones as environmentally more acceptable chemical thinning agents.

EXPERTISE

Reproductive Biology Workgroup

RESEARCH TEAM

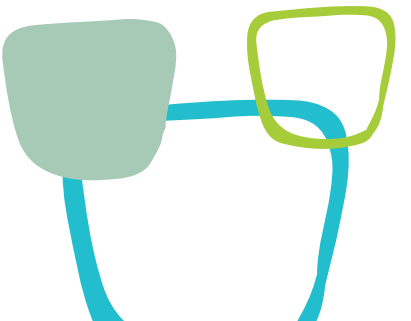
Prof Wiehann Steyn – Crop Production Programme Leader

RESEARCHERS

Dr Xolani Siboza
Prof Karen Theron
Dr Nicky Taylor

STUDENTS

Mr Dian Craven – MSc student
Ms Suzann Oosthuizen – MSc student



NEW PROJECT

- Leaf defoliation of Cripps' Pink and Granny Smith apples in the EGVV – effect on vegetative and reproductive development. (X Siboza, K Theron and D Craven) *– see Dormancy*

REPORT DUE 2020

- Carbon partitioning in low chill peach cultivars: the impact on yield in summer rainfall areas of South Africa. (N Taylor and S Oosthuizen)

PUBLICATIONS

- Fresh Quarterly March 2019: Theron, K., Reynolds, S., Van der Merwe, S. *Who's who in chemical thinners*.
- Fresh Quarterly March 2019: Theron, K. *How do the different chemicals thin?*
- Fresh Quarterly March 2019: Theron, K. *A South African perspective on chemical thinners.*
- Fresh Quarterly July 2019: Bestbier, G. *From blossom to apple (Prof Karen Theron)*

EVENTS

Hortgro Science Technical Symposium 03-07 June 2019

IRRIGATION AND NUTRITION

Water availability is the highest risk to the Orchard of the Future within the Crop Production programme. The Crop Production water strategy involves 1) determining how much water highly productive deciduous fruit trees use, 2) conducting research on various water saving technologies (a new WRC co-funded project on water saving under fixed and draped nets commenced in 2018/19), and 3) conducting research to show growers the negative effects of over-irrigation on production and quality. Hortgro has commissioned Dr Caren Jarmain to conduct an encompassing knowledge review on deciduous tree water use, irrigation practices, water stress etc. that will underpin research and planning relating to the Orchard of the Future within the Irrigation and Nutrition theme.

Abstracts for these projects can be found on pages 103-106

EXPERTISE

Irrigation and Nutrition Workgroup

RESEARCH TEAM

Prof Wiehann Steyn –
Crop Production Programme Leader

RESEARCHERS

Prof Stephanie Midgley
Mr Stephan Daiber
Dr Eduard Hoffman
Dr Johan van Zyl
Dr Caren Jarmain
Dr Nicky Taylor
Prof Adriaan van Niekerk

STUDENTS

Ms Aline Stofberg– PhD student
Mr Solomon Zirebwa – PhD student
Ms Ncamsile Shongwe – MSc student

NEW PROJECTS

- Investigating the potential of fixed and draped netting technology for increasing water productivity and water savings in full bearing apple orchards under micro-irrigation. (S Midgley)
- The effect of a water deficit on fruit tree phenology, fruit production, fruit quality and storability of Fuji and Cripps' Pink apples. (S Midgley and S Daiber) – *see Quality Management*
- Scientific and practical guide to climate change and pome/stone fruit production in South Africa. (S Midgley) – *see Growing Season Climate and also Dormancy*

CURRENT PROJECTS

- The effect of irrigation on the performance of young apple trees in newly established orchards. (E Hoffman, J van Zyl and A Stofberg)
- Water use of pome and stone fruit: knowledge status, relevance and gap analysis. (C Jarmain, N Tayler, A van Niekerk and N Shongwe)
- Establishing quantitative relationships between water relations, growth, yield and quality of high performing commercial apple orchards. (S Midgley and S Zirebwa) – *also Rootstocks and Nursery Tree Quality*

PUBLICATIONS

- SAFJ December 2018/January 2019: Midgley, S., Dzikiti, S., Volschenk, T., Lötze, E., Gush, M. *Are water savings in apple orchards under shade netting an additional benefit? :* pp. 81-83.
- SAFJ April/May 2019: Bestbier, G. *Crisis – best teacher for resilience*: pp. 16 -17.
- SAFJ April/May 2019: Goudriaan, R., Jarmain, C., Andriessen, M., Abraham, K., Naudé, R., Keuck, P. *A case study using FruitLook data*: pp. 18-21.
- Fresh Quarterly July 2019: Duvenage, E. *To the last drop (Prof Eilon Adar)*
- Fresh Quarterly July 2019: Bestbier, G. *Be savvy with salt (Mico Stander/Karen van der Westhuizen)*
- Fresh Quarterly July 2019: Bestbier, G. *Below the surface (Prof Eilon Adar)*
- Fresh Quarterly September 2019: Mouton, A. *Salinization – why does it occur and what can you do about it?*
- Fresh Quarterly September 2019: Mouton, A. *Getting ahead of salinization.*

EVENTS

Water Dialogue 07 November 2018

Hortgro Science Technical Symposium 03-07 June 2019

HORTGRO
Growing Fruit IQ

FARMING TECHNOLOGY

Research in this theme used to focus mainly on orchard mechanization. One of the major outcomes of this research was to highlight inefficiencies in especially pome fruit tree structure, which emphasized the need to encourage industry towards planting higher density orchards with more two-dimensional trees on productive and precocious rootstocks. There are currently no running projects under this theme. However, the theme has been expanded to also include research relating to technology drivers such as big data, remote sensing, robotics, and GIS that will all contribute to changing the way we produce our fruit in our orchards of the future. This theme's workgroup continue to meet annually and is keeping Hortgro abreast of the newest developments in fruit production.

EXPERTISE

Farming Technology Workgroup

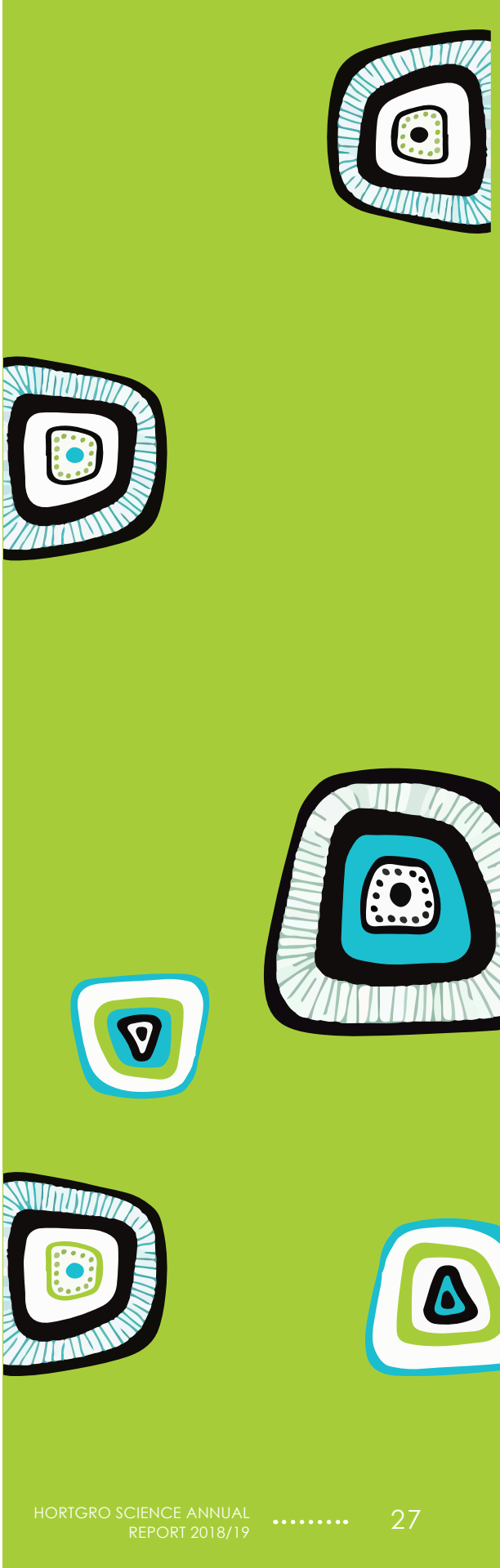
PUBLICATIONS

- SAFJ June/July 2019: Steenkamp, E. *Waarnatoe met nette*: bl. 25.
- Fresh Quarterly July 2019: Bestbier, G. *Train your trees for the future (Dr Alberto Dorigoni)*
- Fresh Quarterly July 2019: Bestbier, G. *Less is not more (Anton Muller)*

EVENTS

Langkloof Seminar and Orchard Walk 29 November 2018

Hortgro Science Technical Symposium 03-07 June 2019



CROP PROTECTION RESEARCH PROGRAMME

The Crop Protection programme is multidisciplinary and includes research on nematology, entomology and plant pathology. The programme is broken down into a number of themes that are reported on below. Sustainability of the fruit production process is regarded as a critical aspect in crop protection research and emphasis is placed on biological control of pests and diseases, orchard ecology, phytosanitary issues and precision agriculture.

Crop protection research during this season has been productive and a significant number of projects have been completed.

NEMATOLOGY

Abstracts for these projects can be found on pages 107-115

The nematode research programme continues to be highly productive. Past and current research has allowed for the development of a number of potential biological control agents one of which is being commercialised. Entomopathogenic fungi are also being integrated into the research programme and the results are encouraging. The research on plant parasitic nematodes is seen as critical and will lead to a better management of these pests.

EXPERTISE

Integrated Pest Management Group

Soil Health Workgroup

RESEARCH TEAM

Matthew Addison – Crop Protection Programme Leader

RESEARCHERS

Prof Antoinette Malan
Dr Nomakholwe Stokwe
Dr Rinus Knoetze
Ms Sheila Storey

STUDENTS

Ms Caro Kapp – PhD student
Ms Deidré Odendaal – PhD student
Ms Letodi Mathulwe – MSc student

NEW PROJECTS

- Control of the obscure mealybug, *Pseudococcus viburni*, using entomopathogenic fungi and nematodes in deciduous fruit orchards (N Stokwe and L Mathulwe)
- Screening of apple rootstocks for resistance against the most prevalent *Pratylenchus* species affecting orchards in South Africa. (R Knoetze)

CURRENT PROJECTS

- Host status of certain cover crops for the root lesion nematode, a major pest of economic importance in apples. (R Knoetze)

COMPLETED PROJECTS

- Control of woolly apple aphid using entomopathogenic fungi. (N Stokwe and L Mathulwe)
- Incorporating entomopathogenic nematodes and fungi in an integrated pest management system for the control of codling moth. (A Malan and D Odendaal)
- Nematode community structure and function as a bio-indicator of the effects of soil amendments on soil health in deciduous fruit orchards. (S Storey and C Kapp) *– also Soil Health*

PUBLICATIONS

- SAFJ August/September 2019: De Klerk, A. *Letselaalwurms in appelkwekery en –boorde*: bl. 71-74.

EVENTS

Hortgro Science Technical Symposium
03-07 June 2019

SOIL HEALTH

Research on soil health continues to attract a lot of attention and is seen as critical. The study of orchard floor ecology and hence soil health is an important component of the research programme. Current research is focused on cover crops and their effects on the pest and disease complex as well as fruit production.

Abstracts for these projects can be found on page 116

EXPERTISE

Soil Health Workgroup

Integrated Pest Management Group

RESEARCH TEAM

Matthew Addison – Crop Protection Programme Leader

RESEARCHERS

Ms Sheila Storey

STUDENT

Ms Caro Kapp – PhD student

CURRENT PROJECT

- Orchard floor management and soil health in deciduous fruit orchards. (M Addison)

COMPLETED PROJECTS

- Nematode community structure and function as a bio-indicator of the effects of soil amendments on soil health in deciduous fruit orchards. (S Storey and C Kapp) – *see Nematology*

PUBLICATIONS

- SAFJ August/September 2019: Bonthuys, J. *Regenerative agriculture – a sustainable tool for fruit farmers*: pp. 65-68.

EVENTS

Hortgro Science Technical Symposium 03-07 June 2019

HORTGRO
Growing Fruit IQ

PRECISION AGRICULTURE

The application of new technology within integrated pest management and fruit production is becoming critical. The development of more efficient spray application methods is important to efficient pest and disease control. Coupled to this is the use of predictive models and various decision support methodologies. The current research programme has addressed both aspects. In addition a wide variety of pest and disease management issues have and are being addressed.

Abstracts for these projects can be found on pages 117-123

EXPERTISE

Spray Application Group
Integrated Pest Management Group

RESEARCH TEAM

Matthew Addison – Crop Protection Programme Leader

RESEARCHERS

Prof Adele McLeod
Dr Pia Addison
Dr Gideon van Zyl

STUDENTS

Mr Philip Rebel – MSc student
Mr Francois Bekker – Postdoctoral Research Fellow

NEW PROJECTS

- Spray application techniques on pome and stone fruit trees to improve spray deposition parameters for the control of late season red spider mite, mealybug and scale insects. (G van Zyl)
- Artificial intelligence for managing economic fruit pest efficiently. (P Addison and F Bekker)

COMPLETED PROJECTS

- Integration of GIS and spatial analysis with monitoring data of major pests for the purposes of area-wide management. (P Addison and F Bekker)
- Evaluation of the MABO dosing model for pesticide spray application in modern high-density apple orchards. (A McLeod and P Rebel)

PUBLICATIONS

- SAFJ August/September 2019: Bonthuys, J. *Studying fruit fly through machine learning*: pp. 61-63.
- Fresh Quarterly July 2019: Duvenage, E. *Maintain your net benefits (Dr Gideon van Zyl)*
- Fresh Quarterly July 2019: Duvenage, E. *Data-driven farming (Dr Gideon van Zyl)*

EVENTS

Precision Agriculture Seminar
12-15 August 2019

Hortgro Science Technical Symposium
03-07 June 2019

HORTGRO
Growing Fruit IQ

INTEGRATED PEST MANAGEMENT

The IPM research programme deals with a wide variety of crop protection issues. The research is aimed at allowing for the more efficient and sustainable management of pests and diseases. Invasive insects such as oriental fruit fly and other phytosanitary pests have influenced the research programme. Research on false codling moth has yielded significant results as has research on biological control.

Abstracts for these projects can be found on pages 124-136

EXPERTISE

Integrated Pest Management Group

RESEARCH TEAM

Matthew Addison – Crop Protection Programme Leader

RESEARCHERS

Dr Pia Addison
Prof John Terblanche
Dr Ruan Veldtman
Mr Mike Allsopp
Mr Thomas Platt

TECHNICAL ASSISTANT

Mr Terence Asia

STUDENTS

Dr Minette Karsten – Postdoctoral Research Fellow
Mr Bonginkhosi Dlamini – PhD student
Mr Meshack Magagula – MSc student
Mr Francois du Preez – PhD student
Mr Vernon Steyn – PhD student
Ms Erika Huisamen – PhD student
Ms Bianca Stead – Honours student

NEW PROJECTS

- Implementation of biological control options against false codling moth in laboratory and field trials. (P Addison and F du Preez)
- Assessment of management methods against pome fruit mites. (T Platt and P Addison)

CURRENT PROJECTS

- Sequencing the genome and transcriptome of false codling moth, *Thaumatotibia leucotreta*, for pest management. (J Terblanche and M Karsten)
- Exploration of orchard sanitation and the potential of parasitic wasps for the biological control of fruit flies in South Africa. (P Addison and B Stead)
- Determining the contribution of wild honey bees (pollination ecosystem service) to commercial deciduous fruit production. (R Veldtman and M Allsopp)
- False codling moth population genetics: gene flow in agricultural environments. (J Terblanche, M Karsten and E Huisamen)
- Maintaining and rearing of insect cultures. (M Addison and T Asia)

COMPLETED PROJECTS

- Pest and disease monitoring in orchards under shade net. (M Addison)
- Using biological control (fungi and nematodes) against two sporadic pests in vineyards and orchards. (P Addison and B Dlamini)
- Integrated management of the control of false codling moth, *Thaumatotibia leucotreta*, on stone fruit and table grapes. (P Addison and V Steyn)
- The effects of biotic and abiotic factors on the distribution of economically important weevils in the deciduous fruit industry. (P Addison and M Magagula)

PUBLICATIONS

- SAFJ April/May 2019: Pieterse, W., Manrakhan, A., Terblanche, J., Addison, P. *Assessing the biology of Bactrocera dorsalis (Hendel) (Diptera: Tephritidae) to understand its invasion potential into the Western Cape of South Africa:* pp. 63-65.
- SAFJ June/July 2019: Bestbier, G. *The Stellenbosch insectary – a hive of activity*: pp. 16-17.
- SAFJ August/September 2019: Bonthuys, J. *Studying fruit fly through machine learning*: pp. 61-63.
- Fresh Notes 156 – 11 February 2019: *PSHB*
- Fresh Notes 157 – 22 February 2019: *Mites in a hot and dry 2018/19*
- Fresh Quarterly December 2018: McDonald, D. *Indigenous fruit flies.*
- Fresh Quarterly July 2019: Duvenage, E. *Fruit fly expert calls for new policies (Prof James Carey)*
- Fresh Quarterly July 2019: Duvenage, E. *Biological controls of fruit fly (Dr Pia Addison)*
- Fresh Quarterly July 2019: Duvenage, E. *Some like it hot (Dr Minette Karsten)*
- Fresh Quarterly September 2019: Campbell, H. *Getting more out of monitoring.*

EVENTS

Langkloof Seminar and Orchard Walk
29 November 2018

Hortgro Science Technical Symposium
03-07 June 2019

HORTGRO
Growing Fruit IQ

PHYTOSANITARY AND MARKET ACCESS

Phytosanitary issues are a significant risk to the industry. Oriental fruit fly and the concerns regarding false codling moth are relevant examples. The current research projects address a number of relevant issues including applied research on fumigation using novel materials. The research programme is aimed at ensuring effective management of phytosanitary pests and diseases and ensuring access to markets. The carbon calculator has become a necessity in order to be able to do business in major export markets.

Abstracts for these projects can be found on pages 137-139

EXPERTISE

Integrated Pest Management Group
Plastics Workgroup

RESEARCH TEAM

Matthew Addison – Crop Protection Programme Leader

Researchers

Dr Shelley Johnson
Dr Tony Ware
Ms Anél Blignaut
Mr Handré Viljoen

TECHNICAL ASSISTANCE

Mr Terence Asia

STUDENTS

Ms Renate Smit – PhD student

NEW PROJECTS

- Comparison of cold disinfestation treatments of *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) in peaches, plums (*Prunus spp*.) and media. (T Ware)
- Disinfestation of *Bactrocera dorsalis* fruit fly-infested apples, pears, nectarines and plums using cold treatment. (T Ware)
- Upscale and customise ethyl formate fumigation from shipping container to cold room capacity for the control of key phytosanitary pests. (S Johnson)
- Effect of irradiation as a mitigation treatment on storage quality of early peaches and nectarines for airfreight consignments. (H Viljoen) *– also Quality Management*

CURRENT PROJECTS

- Confronting Climate Change Initiative (A Blignaut)

COMPLETED PROJECTS

- Ethyl formate fumigation technology – upscaling application towards commercialisation. (S Johnson and R Smit) – funded by the Post-Harvest Innovation (PHI) Programme

PUBLICATIONS

- Fresh Notes 150 – 19 October 2018: *Grain chinch bug*
- Fresh Notes 151 – October 2018: *MRL Notification – all deciduous*
- Fresh Notes 159—23 April 2019: *B. dorsalis monitoring*
- Fresh Notes 160—16 July 2019: *MRL notification*
- Fresh Notes 161—31 July 2019: *MRL notification updated*
- Fresh Quarterly December 2018: McDonald, D. *Nip Phytosanitary risk in the bud.*
- Fresh Quarterly July 2019: Mouton, A. *Exterminate grain chinch bug (Dr Shelley Johnson)*

EVENTS

Hortgro Science Technical Symposium
03-07 June 2019

Fruit Fly Stone Fruit Handling Protocols
06 August 2019

HORTGRO
Growing Fruit IQ

PRE-AND POST-HARVEST PATHOLOGY

The pre-and post-harvest pathology research programme addresses a number of important industry issues. The research on incidence and distribution of fungal pathogens in young trees is highly relevant as is the integrated management of apple scab. Apple replant disease and various aspects of post-harvest pathology are also receiving attention.

Abstracts for these projects can be found on pages 140-166

EXPERTISE

Integrated Pest Management Group

Plant Pathology Workgroup

PRE-HARVEST

RESEARCH TEAM

Matthew Addison – Crop Protection Programme Leader

RESEARCHERS

Prof Teresa Coutinho
Dr Pieter Louw
Prof Adele McLeod
Prof Lizel Mostert
Mr Abraham Vermeulen

STUDENTS

Mr Vernon Jacobs – Honours student
Ms Khumbuzile Bophela – PhD student
Ms Mateka Modiba – MSc student
Mr Makomborero Nyoni – PhD student
Mr Greg Gatsi – MSc student
Ms Doré de Villiers – MSc student
Mr Shahrooz Moein – MSc student
Ms Elzane Froneman – MSc student
Ms Rochelle Janse van Rensburg – PhD student

NEW PROJECTS

- The influence of climatically different seasons on the reproductive strategy of *Venturia inequalis* and the RIMpro disease forecasting model. (A McLeod and E Froneman)
- The effect of organic amendments on the severity of apple replant diseases in subsequent apple orchard replantings. (A McLeod and R Janse van Rensburg)
- Evaluation of apple rootstocks tolerance against specific apple replant disease (SARD). (I Labuschagne, A McLeod and X Siboza) – *see Rootstocks and Nursery Tree Quality*

CURRENT PROJECTS

- Evaluation of pruning wound protectants on nursery apple trees. (L Mostert and G Gatsi)
- Alternatives for the management of apple replant disease. (A McLeod and D de Villiers)
- Determine fungicide efficacy using qRT-PCR for detection and quantification of *Botrytis cinerea* inoculum and viability on pear leaves as a substrate, before and after fungicide application. (P Louw)
- Screening apple rootstocks for tolerance to *Phytophthora* crown rot. (A Vermeulen)
- Survey of stem canker pathogens on stone fruit propagation material and young stone fruit trees. (L Mostert and V Jacobs)

COMPLETED PROJECTS

- Identification of inoculum sources of oomycetes, a major contributor to apple replant disease, and the management thereof. (A McLeod, M Nyoni and S Moein)
- The role of stress factors in predisposing plum trees to invasion by bacterial pathogen *Pseudomonas syringae* pv. *syringae*. (T Coutinho, K Bophela and M Modiba)

POST-HARVEST

RESEARCH TEAM

RESEARCHERS

Mr Arrie de Kock
Dr Stephan Ferreira
Dr Cheryl Lennox
Dr Robbie Pott
Dr Julia Meitz-Hopkins
Dr Ida Wilson
Dr Oluwafemi Caleb
Dr Pieter Louw

STUDENTS

Mr André Russouw – MSc student
Ms Janis von Johannides – MEng student
Ms Sinovujo Magwebu – MSc student
Mr George Teke – MEng student
Ms Nandi Nyamende – MSc student
Dr Zinash Belay – Postdoctoral Research Fellow

POME FRUIT PROJECTS

NEW PROJECTS

- Thermal and non-thermal treatments of stone and pome fruit: Towards efficient phytosanitary measures. (O Caleb, Z Belay and N Nyamende) – *also Quality Management*
- Bioreactor and process development for the production of antimicrobial lipopeptides produced by *Bacillus* spp. for biological control of postharvest phytopathogens in the perishable fruit industry. (R Pott)

CURRENT PROJECTS

- Pursuit of sanitiser products for potential use in the apple and pear industry. (P Louw)
- Purification of antimicrobial lipopeptides produced by *Bacillus spp*. for biological control of postharvest phytopathogens in the perishable fruit industry. (R Pott, J van Johannides and G Teke)
- Lipopeptides Fengycin and Iturin a as postharvest fungicide on pome fruit. (C Lennox, J Meitz-Hopkins and S Magwebu)
- The development of an integrated management strategy for Bull's Eye rot of apples. (C Lennox, J Meitz-Hopkins and A Russouw)

COMPLETED PROJECTS

- Lipopeptides for the biological control of postharvest phytopathogens. (R Pott, G Teke, D Baloyi, J Marais and S Magwebu) – funded by the Post-Harvest Innovation (PHI) Programme
- Evaluating the relationship between quantified *Botrytis cinerea* levels in pear fruit at harvest and the *Botrytis* rot incidence and severity at the end of storage: Towards the development of a *Botrytis* rot management model. (S Ferreira and I Wilson)

STONE FRUIT PROJECTS

NEW PROJECTS

- Thermal and non-thermal treatments of stone and pome fruit: Towards efficient phytosanitary measures. (O Caleb, Z Belay and N Nyamende) – *also Quality Management*
- Develop a storage protocol for plums stored for 6 weeks in bins prior to packing – decay control using alternative gas regimes of CO_2 and O_2 manipulation, fungicides and GRAS products by drenching and Ozone treatment. (P Louw) – *also Storage Techniques*

COMPLETED PROJECTS

- Quantification of the presence of *Botrytis cinerea, Monilinia laxa* and *Penicillium expansum* in blossoms and plums at harvest, and correlation of relative pathogen presence to decay after shelf-life: Potential application of diagnostic information early in the season to use as a management tool of plum decay post storage and shelf life. (S Ferreira and I Wilson)
- Factors that influence the retention of fungicide residues on plums. (A de Kock)
- Survey and investigation on the impact of various fungicide application methods and technologies on decay control of plums in the pack-house. (A de Kock and I Wilson)

PUBLICATIONS

- SAFJ February/March 2019: Louw, J.P., Korsten, L. *Penicillium rot of nectarine and plum*: pp. 58-61
- SAFJ February/March 2019: De Kock, V.A. *Research on spray and atomiser fungicide application systems for use on plum pack lines*: pp. 69-74
- Fresh Quarterly March 2019: Bestbier, G. *Stopping the rot.*
- Fresh Quarterly July 2019: Duvenage, E. *Save money with scientific dosing (Philip Rebel)*
- Fresh Quarterly July 2019: Mouton, A. *Put the brakes on decay (Arrie de Kock)*

EVENTS

Hortgro Science Technical Symposium

03-07 June 2019

POST-HARVEST RESEARCH PROGRAMME

Post-harvest supports and enhances the processes throughout the supply-chain critical to ensuring that intrinsic product integrity is maintained, and that a quality product is available to the end-consumer in local and distant global markets. Post-harvest covers producers, packhouses, marketing co-ordination, logistics and shipping, receivers/wholesalers and end consumers. The Post-harvest research programme is structured into four themes, namely Quality Management, Physiological Defects, Storage Techniques, and Packaging and Logistics. Research strategy for each theme is determined by a workgroup (a workgroup per theme) consisting of exporters, pre- and post-harvest technical specialists, industry consultants and researchers. Additional workgroups are formed as and when needed, for instance, the DPA Work Group was formed in 2008 to look at strategies to mitigate the potential loss of DPA to the EU, which occurred in 2013.

When considering research strategy, the workgroups always keep in mind the objectives of the Post-Harvest research programme, which are the following:

- To increase the marketable tons of fruit delivered per ton of fruit loaded;
- To present clients all along the post-harvest value chain extending up to the consumer with a safe product of reliable, good quality;
- To reduce wastage and losses from defects and pathogens (see the Crop Protection programme for post-harvest pathology research);
- To increase efficiencies throughout the post-harvest value chain;
- To increase the sustainability of post-harvest practices;
- To reduce risk within the post-harvest value chain.

Research needs relating to pre-harvest factors that affect post-harvest quality and storability are addressed within the Crop Production programme. The Post-Harvest and Crop Production programmes share a programme manager with the effect that research is very well integrated over the two programmes.

QUALITY MANAGEMENT

Abstracts for these projects can be found on pages 167-185

Quality management refers to maintaining quality throughout the logistical chain to the end consumer. With reference to stone fruit, shrivel due to moisture loss is the main post-harvest defect and therefore the key research focus area. Dr Elmi Lötze and PhD student Dr Imke Kritzinger investigated peel properties affecting cultivar and fruit susceptibility to shrivel. They found that moisture loss, although a key driver of shrivel, doesn't necessarily determine whether shrivel develops or not. The peel properties and components of some cultivars decrease their susceptibility to shrivel despite considerable moisture loss. This information can potentially be used in the selection of new cultivars and may also in future allow us to predict the shrivel risk in particular seasons.

EXPERTISE

Quality Management Workgroup

RESEARCH TEAM

Wiehann Steyn – Post-Harvest Programme Leader

RESEARCHERS

Ms Anél Botes
Dr Elmi Lötze
Mr Daniël Viljoen
Mr Stephan Daiber
Mr Arrie de Kock
Mr Handré Viljoen
Dr Olaniyi Fawole
Dr Oluwafemi Caleb

STUDENTS

Ms Shannon Riva – MSc student
Ms Imke Kritzinger – PhD student
Ms Taongashe Majoni – MSc student
Ms Nicole Jenneker – MSc student
Ms Nandi Nyamende – MSc student
Ms Makiwe Nkohla – MEng student
Dr Zinash Belay – Postdoctoral Research Fellow

POME FRUIT PROJECTS

NEW PROJECTS

- Thermal and non-thermal treatments of stone and pome fruit: Towards efficient phytosanitary measures. (O Caleb, Z Belay and N Nyamende) – *see Pre-and Post-Harvest Pathology*
- The effect of a water deficit on fruit tree phenology, fruit production, fruit quality and storability of Fuji and Cripps' Pink apples. (S Midgley and S Daiber) – *also Irrigation and Nutrition*
- Moisture loss studies in pears. (A Botes)
- Revision of FEMA release standards when fruit do not make FEMA firmness or sugar criteria. (D Viljoen)
- To develop marketing protocols for FEMA designated orchards that are harvested two to three weeks after normal release but do not qualify for FEMA release. (D Viljoen)
- Integrated post-harvest ethylene management along the value chain: From the farm to the consumer (O Caleb, Z Belay and M Nkohla)

CURRENT PROJECTS

- The use of Harvista™ (pre-harvest 1-MCP) application to prevent green colour loss and reduce blush of Granny Smith apples. (D Viljoen)

COMPLETED PROJECTS

- The effect of DPA on fruit quality in pome fruit. (A Botes)
- Quantifying the effect of bag perforations on forced-air cooling cycles and post storage quality of apples. (D Viljoen)
- The use of Harvista™ (pre-harvest 1-MCP) application to control superficial scald on Packham's Triumph pears. (D Viljoen)

STONE FRUIT PROJECTS

NEW PROJECTS

- Thermal and non-thermal treatments of stone and pome fruit: Towards efficient phytosanitary measures. (O Caleb, Z Belay and N Nyamende) – *see Pre-and Post-Harvest Pathology*
- Determine the CO_2 sensitivity of the four main plum cultivars. (A de Kock)
- Effect of irradiation as a mitigation treatment on storage quality of early peaches and nectarines for airfreight consignments. (H Viljoen) – *see Phytosanitary and Market Access*
- Evaluation of the 8mm penetrometer plunger to determine harvest maturity on plums. (A de Kock)

- Application of postharvest bioactive edible coatings and natural antimicrobial peptides as a green solution to alleviate shrivel and extend storage life of plums. (O Fawole and N Jenneker)

CURRENT PROJECTS

- Develop a six week storage protocol for plums harvested from week 5 onwards. (H Viljoen)

COMPLETED PROJECTS

- Identify and test improved packaging as well as humidity control in cold stores to reduce moisture loss and shrivel in plums. (H Viljoen)
- Identify and test improved packaging as well as humidity control in cold stores to reduce moisture loss and shrivel in nectarines. (H Viljoen)
- Develop optimum ripening protocols for nectarines and plums arriving too green (skin colour) or too firm in market. (H Viljoen)
- Postharvest moisture loss studies in Japanese plums (*Prunus salicina* Lindl). (E Lötze and I Kritzinger)

REPORTS DUE 2020

- Application of postharvest edible coatings to alleviate shrivel in plums and nectarines. (O Fawole and S Riva)
- Profiling sugar metabolism and accumulation in plums as related to maturity, cultivar difference and postharvest storage regimes. (O Fawole and T Majoni)

PUBLICATIONS

- SAFJ October/November 2018: Fawole, O.A. *Let's seal the deal: Edible Coating application on stone fruit*: pp. 99-101
- SAFJ February/March 2019: De Kock, V.A. *Comparison of standard 11-mm penetrometer plungers against 8-mm plungers to establish the optimum harvest maturity of late season nectarines using flesh firmness as indices*: pp. 62-68
- Fresh Notes 155—04 February 2019: *FEMA*
- Fresh Quarterly December 2018: Mouton, A. *Forelle early market access: Unlocking new value from an old cultivar.*
- Fresh Quarterly March 2019: Mouton, A. *The sharpest tool in the shed – measuring flesh firmness in late-season nectarines with the 8mm penetrometer.*
- Fresh Quarterly July 2019: Mouton, A. *Minimising moisture loss in pears during storage. (Frank van de Geijn)*
- Fresh Quarterly July 2019: Mouton, A. *Edible coatings. (Dr Olaniyi Fawole)*
- Fresh Quarterly September 2019: Bestbier, G. *Straightening out shrivel in plums.*
- Fresh Quarterly September 2019: Bestbier, G. *Turning up the heat on shrivel.*

EVENTS

Hortgro Science Technical Symposium
03-07 June 2019

HORTGRO
Growing Fruit IQ

PHYSIOLOGICAL DEFECTS

The main internal quality defects receiving research attention are lenticel breakdown, mealiness, superficial scald and internal browning. Research is aimed at understanding the underlying causative factors (both pre- and post-harvest) and biochemistry of these defects so as to allow the development of technology to limit or prevent their occurrence. Other aims are to generate best practice guidelines for handling of fruit both pre- and post-harvest and to develop indicators to predict the risk of the various defects in a given season.

Abstracts for these projects can be found on pages 186-193

EXPERTISE

DPA Focus Group
Physiological Defects Workgroup

RESEARCH TEAM

Wiehann Steyn – Post-Harvest Programme Leader

RESEARCHERS

Dr Elke Crouch
Dr Elmi Lötze
Dr Ian Crouch
Ms Anél Botes
Dr Patricia Mathabe
Mr Daniël Viljoen
Mr Arrie de Kock

STUDENTS

Mr Kenias Chigwaya – PhD student
Mr Rudolph Cronje – MSc student
Dr Walter Fourie – Postdoctoral Research Fellow
Dr Letitia Schoeman – Postdoctoral Research Fellow
Dr Tavagwisa Muziri – Postdoctoral Research Fellow
Ms Liza-Marie Dippenaar – MSc student
Ms Nolubabalo Mzizi – MSc student
Mr Alone Hlungwani – PhD student
Ms Monja Gerber – PhD student
Dr Thirupathi Pandian – Postdoctoral Research Fellow

NEW PROJECTS

- Compilation of a database of high quality images of pome fruit disorders from South African growing and storage conditions to contribute to the further development of software-based determination (APP) for the detection and reduction of bearing damage in fruit (Frudistor) in an international context. (I Crouch)
- Quantifying the role of vapour pressure deficit in the development of lenticel breakdown in Braeburn apples. (E Lötze, D Viljoen and N Mzizi)
- Superficial scald on Granny Smith – understanding the mechanisms and limitations of the storage protocols used by industry and assess risk indicators in storage for scald development. (E Crouch, A Botes, P Mathabe, D Viljoen, T Pandian, M Gerber and A Hlungwani)
- Detection of internal heat damage and identification of techniques to prevent the expression of the disorder in plums. (A de Kock) – *also Storage Techniques*

CURRENT PROJECTS

- Determining 'Forelle' pre-harvest mealiness / cavity development stage, due to environmental factors and exploring prevention of mealiness developing after storage and ripening. (E Crouch, L Schoeman and L-M Dippenaar) – *see Growing Season Climate, Crop Production Programme*
- Fuji browning types explored via x-ray CT in collaboration with existing trial. (E Crouch and K Chigwaya)
- Identification of factors involved in the expression of internal browning in Fuji apples and the development of a strategy to reduce risk of incidence. (D Viljoen)

COMPLETED PROJECTS

- To assess Internal Browning development potential from high watercore incidence FEMA Forelle. (D Viljoen)

REPORT DUE 2020

- Post-harvest 'Forelle' (*Pyrus communis L.)* mealiness development, detected at harvest by CT-x ray scanning and semi-commercial colour pre-sorting influenced by canopy position at harvest as well as pollination. (E Crouch, R Cronje, W Fourie, T Muziri and L Schoeman)

PUBLICATIONS

- SAFJ August/September 2019: Crouch E. Tayler, H., Viljoen, D.W., Crouch I.J. *Rosy Glow Apples – postharvest physiological profile*: pp. 34-43

EVENTS

Hortgro Science Technical Symposium
03-07 June 2019

STORAGE TECHNIQUES

Non-chemical scald control and prevention of internal browning are major focusses of the evaluation of storage technologies and protocols. On the browning front, recent research by Dr Elke Crouch and Heleen Tayler showed that stepdown cooling has considerable potential in preventing or reducing internal browning incidence. A major outcome of research in this theme is the development of protocols to prevent or reduce the incidence of disorders and to maintain fruit quality.

Abstracts for these projects can be found on pages 194-199

EXPERTISE

CA and Post-Harvest Group
DPA Focus Group

RESEARCH TEAM

Wiehann Steyn – Post-Harvest Programme Leader

RESEARCHERS

Ms Anél Botes
Dr Elke Crouch
Mr Daniël Viljoen
Dr Asanda Mditshwa
Mr Handré Viljoen
Dr Pieter Louw
Ms Heleen Tayler
Mr Arrie de Kock

STUDENT

Mr Tsepo Kholoane – Honours student

NEW PROJECTS

- Detection of internal heat damage and identification of techniques to prevent the expression of the disorder in plums. (A de Kock) – *see Physiological Defects*
- Performance evaluation of three controlled atmosphere storage equipment / techniques on Granny Smith apples. (E Crouch)
- Studies on the effect of ozone on postharvest quality of apples. (A Mditshwa)
- The effect of OTFLOW system on temperature distribution in containers specifically for cold steri protocols. (H Viljoen)
- Develop a storage protocol for plums stored for 6 weeks in bins prior to packing – decay control using alternative gas regimes of CO_2 and O_2 manipulation, fungicides and GRAS products by drenching and Ozone treatment. (P Louw) –x *see Pre-and Post-Harvest Pathology*

CURRENT PROJECTS

- Determine optimum storage conditions for Abate Fetel pears. (A Botes)
- To investigate different step down cooling regimes, utilised in conjunction with SmartFresh^{SM}, to reduce the risk of internal browning of Cripps' Pink apples and provide year round supply of good quality fruit. (H Tayler, D Viljoen, E Crouch and T Kholoane)

COMPLETED PROJECT

- Optimisation of RLOS protocol for superficial scald prevention on Packham's Triumph pears. (A Botes)

PUBLICATIONS

- SAFJ February/March 2019: Steenkamp, E: *State of the art CA facility launched at SU:* p. 34
- Fresh Quarterly December 2018: Hurndall, R. *A meander along South Africa's CA storage road.*
- Fresh Quarterly July 2019: Mouton, A. *Dynamic fruit needs dynamic storage (Frank van de Geijn)*

EVENTS

CA Meeting and launch of new CA Equipment 06 November 2018

Hortgro Science Technical Symposium 03-07 June 2019

PACKAGING / LOGISTICS

Logistics projects are focussing on the optimisation of shipping container space utilisation while packaging projects are aimed at reducing plastic packaging or finding alternatives to non-recyclable, single-use plastics without jeopardising fruit quality or the structural integrity of the packaging. The Store-It group of pome fruit post-harvest technical experts has identified plastic packaging as the most pressing post-harvest issue that needs to be addressed. The Plastic Workgroup of the Packhouse Action Group is providing direction in terms of where industry needs to go with regard to plastic packaging. Going forward, Hortgro will be initiating projects on the needs identified by the Plastic Workgroup. The research of Dr Ola Fawole on edible coatings (see the Quality Management theme) is delivering very promising results. Dr Fawole found that some edible coatings have the potential to prevent shrivel and extend the storage life of plums and nectarines while potentially precluding the need for plastic packaging to prevent excessive moisture loss.

Abstracts for these projects can be found on pages 200-203

EXPERTISE

Packhouse Action Group
Plastics Workgroup

RESEARCH TEAM

Wiehann Steyn – Post-Harvest Programme Leader

RESEARCHERS

Dr Tarl Berry
Prof Leila Goedhals-Gerber

STUDENTS

Ms Tiffany Adams – BCom Honours student
Ms Chelna Neethling – BCom Honours student
Mr Adewale Nuryan Tiamiyu – MSc student

CURRENT PROJECT

- Implementation of Next-generation Packaging Systems in High Cube Refrigerated Containers for Efficient Cooling and improved Volume Usage. (T Berry and A Tiamiyu)

COMPLETED PROJECT

- Logistical considerations and limitations of refrigerated containers used in the pome and stone fruit export markets. (L Goedhals-Gerber, T Adams and C Neethling)

PUBLICATIONS

- SAFJ April/May 2019: Berry, T., Opara, U.L. *A multi-parameter approach to optimise the design and performance of ventilated fruit packaging*: pp. 56-62
- SAFJ June/July 2019: Steenkamp, E. *Industry initiaties plastics task team*: pp. 8-9
- Fresh Notes 153 – 04 December 2018: *Packhouse Action Group Feedback*
- Fresh Notes 158 – 29 March 2019: *Packhouse Action Group Feedback*
- Fresh Notes 162 – 01 August 2019: *Packhouse Action Group Feedback*
- Fresh Quarterly July 2019: Mouton, A. *Parting ways with plastic (Lorren de Kock)*

EVENTS

Hortgro Science Technical Symposium
03-07 June 2019

RETURN ON INVESTMENT

"Why are you doing the research and what is the impact of that research" is a common and legitimate question that funders ask of researchers and research organisations. Hortgro Science, as a manager of research requires an objective and ongoing measurement tool or a matrix of tools to help quantify the outputs of research conducted. The Centre for Research on Evaluation, Science and Technology (CREST), based in the Faculty of Arts and Social Sciences at Stellenbosch University has research evaluation and impact assessment studies as one of the core focus areas. The listed project is part of a process of addressing the identified need.

The abstract for this project can be found on page 204

RESEARCHERS

Dr Nelius Boshoff

STUDENTS

Mr Harrie Esterhuyse – PhD student

CURRENT PROJECT

- Developing a research information system for two South African agricultural industries: Learning about the impact of funded research. (N Boshoff and H Esterhuyse)

SUPPORT STRUCTURES

Hortgro Science is dependent on its extensive support structures that are made up of colleagues and role-players in the deciduous fruit industry. Approximately 170 individuals tirelessly give of their time, intellect and passion to serve the needs of the industry. The various committees that service the needs of Hortgro Science are noted below. We extend our heartfelt thanks and gratitude to each one of these individuals who have contributed to Hortgro Science.

HORTGRO SCIENCE ADVISORY COUNCIL

Hortgro Science is grateful for the many years of service generously given by Joseph Hendricks who stepped down from the Advisory Council. We are excited to welcome 3 new members to the Advisory Council, namely; Frikkie Jacobs, Wesley Hendricks and Raymond Koopstad. Thembi Xaba from the DFDC will have observer status on the Advisory Council.

Stephen Rabe – Chair
Grant Smuts – Vice-Chair
Linde du Toit
Wesley Hendricks
Frikkie Jacobs
Raymond Koopstad
Charl Stander
Louis von Broembsen
Thembi Xaba (observer)

PEER WORK GROUPS

Objectives of the PWGs

- Evaluate the scientific correctness of prioritised new research proposals
- Evaluate the scientific standard of progress and final reports

ENTOMOLOGY PEER WORK GROUP

Matthew Addison
Dr Brian Barnes
Hugh Campbell
Dr Martin Gilbert
Richard Hurndall
Dr Welma Pieterse
Dr Ken Pringle
Prof Wiehann Steyn

SOIL SCIENCE PEER WORK GROUP

Hugh Campbell
Dr Nigel Cook
Dr Eduard Hoffman
Richard Hurndall
Dr Pieter Raath
Prof Wiehann Steyn
Dr Nicky Taylor
Dr Johan van Zyl

HORTICULTURE PEER WORK GROUP

Hugh Campbell
Dr Nigel Cook
Richard Hurndall
Jakkie Stander
Dr Piet Stassen
Prof Wiehann Steyn
Dr Nicky Taylor
Prof Karen Theron

PATHOLOGY PEER WORK GROUP

Matthew Addison
Lindi Benic
Hugh Campbell
Dr Johan Fourie
Richard Hurndall
Dr Cheryl Lennox
Prof Adele McLeod
Prof Wiehann Steyn
Ferdi van Zyl
Prof Altus Viljoen

POST-HARVEST PEER WORK GROUP

Hugh Campbell
Dr Paul Cronje
Dr Elke Crouch
Richard Hurndall
Prof Marius Huysamer
Prof Linus Opara
Prof Wiehann Steyn
Prof Karen Theron

TECHNICAL ADVISORY COMMITTEES

Objectives of the TACs

- Identify industry research needs or gaps
- Determine the relevance of concept proposals
- Prioritise new project proposals
- Evaluate the technical merits of progress and final reports
- Identify technology transfer opportunities
- Advisory to Hortgro Science

CROP PRODUCTION TECHNICAL ADVISORY COMMITTEE

Keith Bradley
Daan Brink
Dr Nigel Cook
Andrew Hacking
Hammies Hamman
Chris Jurisch
Willie Kotze
Graeme Krige
Anton Muller
Stephen Rabe
Louis Reynolds
Pierre Rossouw
Charl Stander
Mico Stander
Prof Wiehann Steyn
Tobie van Rooyen

CROP PROTECTION TECHNICAL ADVISORY COMMITTEE

Matthew Addison
Lindi Benic
Aty Burger
Nico Ferreira
Jacques Fouche
Gustav Groenewald
Andrew Hacking
Richard Hurndall
Anton Muller
Hendrik Pohl
Dr Ken Pringle
Stephen Rabe
Sheila Storey
Steven Versfeld
Bekker Wessels
Martin Wohlfarter

POST-HARVEST TECHNICAL ADVISORY COMMITTEE

Lindi Benic
Lohan Bester
Malcolm Dodd
Elizabeth Downes
Petru du Plessis
Jacques du Preez
Nico Ferreira
Henk Griessel
Richard Hurndall
Angelique Marais
Jaco Moelich
Bibbie Potgieter
Margaret Reinecke
Grant Smuts
Charl Stander
Prof Wiehann Steyn
Adriaan Theron
Karin van Rensburg

TECHNOLOGY TRANSFER ADVISORY COMMITTEE

Matthew Addison
Keith Bradley
Hugh Campbell
Dr Nigel Cook
Dr Ian Crouch
Peter Dall
Pierre du Plooy
Linde du Toit
Graeme Krige
Stephen Rabe
Charl Stander
Elise-Marie Steenkamp
Prof Wiehann Steyn
Christo Strydom
Marinus van der Merwe
Charl van Rooyen
Tobie van Rooyen
Thea van Zyl

ADVISORY AND FOCUS WORKGROUPS

Objectives of Advisory Groups:

- Assist programme with formulation of strategic research planning in defined areas of research
- Identify new technologies of relevance
- Seek collaborative research opportunities across local and international research/technical organisations
- Seek funding opportunities to ensure inputs into targeted research focus areas
- Meetings as required
- Advisory to programme manager

Objectives of Focus Groups:

- Convene specific expertise to deal with specific industry issues
- Identify research requirements
- Evaluate research findings and make recommendations
- Identify technology transfer opportunities and communicate findings to industry via appropriate forums

CA And Post-Harvest Group

Dormancy Workgroup

DPA Focus Group

Farming Technology Workgroup

Growing Season Climate Workgroup (including Fruit External Quality)

Integrated Pest Management Group

Irrigation and Nutrition Workgroup

Orchard of the Future Workgroup

Packhouse Action Group

Physiological Defects Workgroup

Plant Pathology Workgroup (incorporating post-harvest pathology)

Plastics Workgroup

Quality Management Workgroup (including Eating Quality)

Reproductive Biology Workgroup

Rootstock and Nursery Tree Quality Workgroup

Rootstock Evaluation Committee

Soil Health Workgroup

Spray Application Group

HORTGRO SCIENCE REPRESENTATION ON COMMITTEES AND BOARDS

Hortgro Science represents Hortgro Pome and Hortgro Stone as follows:

Name	External Committees and Boards
Hugh Campbell	• Post-Harvest Innovation (PHI) Management Committee • Deciduous Fruit Plant Improvement Association (DPA) – Hortgro Pome Representative on Board • Deciduous Fruit Plant Improvement Association Technical Committee – Chairman • Western Cape Government Rural And Agriculture Sector Support Committee On Drought And Water Security • *Bactrocera dorsalis* National Steering Committee • Polyphagous Shot Hole Borer National Steering Committee • National Agricultural Research Forum Steering Committee • Western Cape Agricultural Research Forum • Confronting Climate Change – Chairman • Crop Protection Advisory Group (CPAG)
Wiehann Steyn	• Water Research Commission reference group: Investigating the potential of fixed and draped netting technology for increasing water use productivity and water savings in full bearing apple orchards under micro irrigation • Water Research Commission reference group: Development and testing of a smart-phone application for predicting near real time water requirements of fruit tree orchards • South African Pink Lady Association Exco • Packhouse Action Group (PAG) • Plastic Packaging Workgroup of PAG • Pome and Stone Fruit Joint Marketing Forums • Hortgro Plant Material Advisory Committee (Pome and Stone fruit) • Forelle Producers Association • Western Cape Agricultural Research Forum
Matthew Addison	• Water Research Commission reference group: An Integrated approach to managing and mitigating the risk of agricultural nonpoint source pesticide pollution to the aquatic environment • Polyphagous Shot Hole Borer National Steering Committee • SAMAC Research Committee
Xolani Siboza	• South African Society for Horticultural Sciences Board member • Stellenbosch University-AgriSciences: Recruitment and Marketing Committee
Shelley Johnson	• Phytosanitary Risk Forum • Phytosanitary Measures Research Group • Grain Chinch Bug Focus Group
Ken Pringle	• Crop Protection Advisory Group (CPAG) • Phytosanitary Risk Forum
Elise-Marie Steenkamp	• Hort Forum • Fruit SA Communications Committee • Stronger Together Steering Committee • Agri's Got Talent Planning Committee • Deciduous Fruit Gala Evening Committee

COMMUNICATION

Bob Dylan sings "How many roads must a man walk down, before you call him a man?"

In science communication, the conundrum is (with apologies to Mr Dylan): "How many platforms must you engage, before you get the message across?" There is no doubt that "getting critical messages to our diverse stakeholder grouping," is an ongoing challenge. Therefore, we are obliged to use all the platforms that are available to us, to get messages to our key audience – the South African deciduous fruit producers.

The overall communication strategy at Hortgro Science is to simplify research and keep our clients informed on the latest technologies to ensure profit. Science communication is there to close the loop between a) industry problems b) research (investigating these problems), and c) transferring the generated knowledge to our stakeholders.

Rewriting data into an engaging story creates tension between researchers and writers. That is normal and necessary. We therefore rely heavily on visual aids to assist with knowledge transfer.

Updating our platforms and keeping our material fresh is an ongoing endeavour. Our main publications include: the Fresh Quarterly (science magazine); the monthly stone fruit Timely Hints, the Fresh Notes (technical newsletter), as well as pamphlets, and semi-scientific articles published in the South African Fruit Journal – which is sent to growers bi-monthly and which can also be accessed on www.safj.co.za.

Apart from the above-mentioned channels of communication, we like to engage with our clients online through the monthly Hortgro News, the electronic monthly newsletter, and on our social media platforms which include Facebook, Twitter, Instagram, and YouTube. To connect with us on these platforms, please search @Hortgro.

We have seen steady growth on our social media platforms with our audiences reaching:

- 3464 Facebook followers
- 1662 Twitter followers
- 366 YouTube subscribers (with Apricot Pruning video being the most watched, 9.5k views)
- 626 Instagram followers

This past year we also hosted a range of events to engage with industry members. These events included the launch of a new CA

facility, a Water Dialogue Workshop, a Langkloof Seminar and Orchard Walk, a Northern Province Producer Study Group, a Bursary Function, the Hortgro Technical Symposium, Stone Fruit Fly Handling Protocols, and a Precision Agriculture Seminar. We also provided summaries and feedback of these events including a Hortgro Technical Symposium Summary Report in the Fresh Quarterly #5. A full list of events and attendance figures can be found in this report.

At the end of last year we employed two independent media analysis groups to investigate Hortgro's platforms and presence in print/ broadcast/radio (Red Book) and on social media (Meltwater).

Combined the figures achieved are as follows:

- R24 million (AVE) Advertising Value Equivalent
- 150 million people reached

Given our limited budget we were overjoyed with these figures as it clearly indicated that "of the many roads we follow" some sure hit the market.

All other information regarding what we do and how we can help our industry's growers is also available on our Hortgro and Hortgro Science websites.

www.hortgro.co.za
www.hortgroscience.co.za
Elise-Marie Steenkamp

EVENTS LIST AND ATTENDANCE FIGURES

The primary focus of technology transfer and communication within Hortgro Science is to close the research loop, that is, ensure that the research results get back to the users of the technology. This section summarises the events used to communicate with our growers and technical people in the industry.

CA Meeting and launch of new CA equipment
06 November 2018
Stellenbosch
61 attendees

Water dialogue
07 November 2018
Stellenbosch
30 attendees

Langkloof Seminar and Orchard Walk
29 November 2018
Louterwater
56 attendees

Hortgro Science Technical Symposium
03-07 June 2019
Somerset West
Attendance figures:

- Pome Fruit Field Day – 294
- Pre-Harvest Day 1 – 395
- Pre-Harvest Day 2 – 283
- Post-Harvest Day – 232
- Fruit Farming 101 – 209

Fruit Fly Stone Fruit Handling Protocols
06 August 2019
Stellenbosch
66 attendees

Precision Agriculture Seminar
12-15 August 2019
Stellenbosch, Grabouw, Ceres, Langkloof
110 attendee

AWARDS

The following awards were made during the 2018/19 year. Hortgro Science would like to congratulate the award winners.

Hortgro Science / Daan Strydom Award for Best Student in Horticulture 2018
- Johan Herbst van der Merwe

Best final reports of 2019
- Postharvest moisture loss studies in Japanese plums (*Prunus salicina* Lindl). (E Lötze)
- Survey and investigation on the impact of various fungicide application methods and technologies on decay control of plums in the pack-house. (A de Kock and I Wilson)

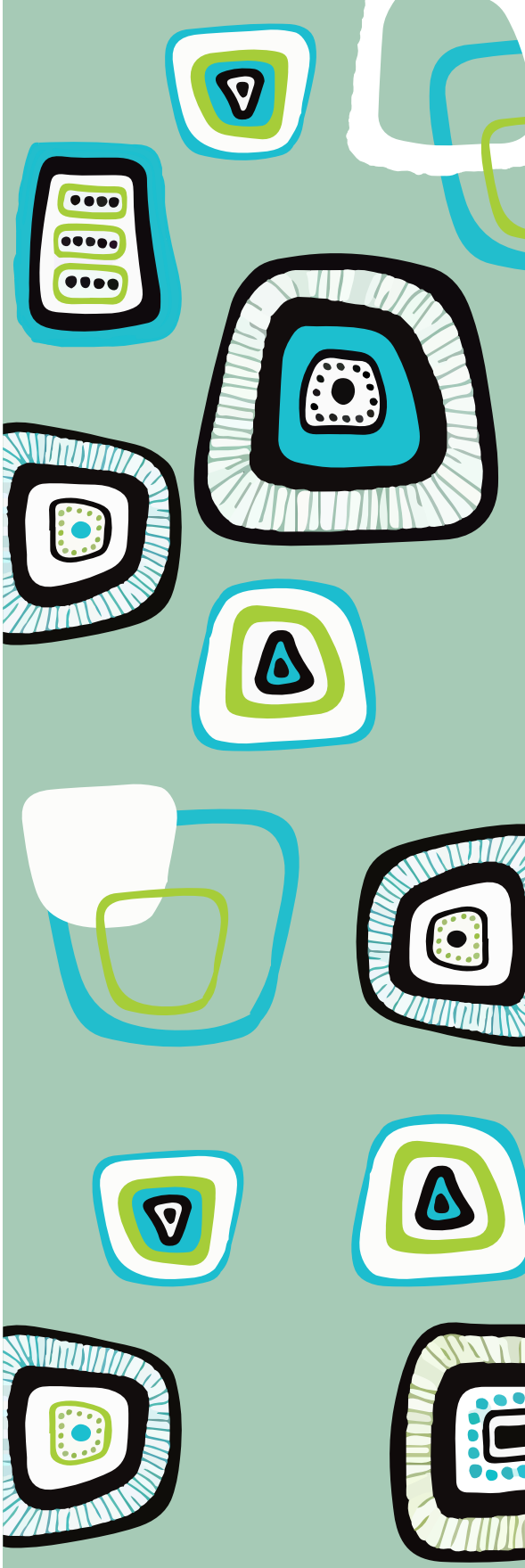
OVERSEAS TOURS AND SPONSORSHIPS

South African researchers in the deciduous fruit industry continue to engage on an international level with researchers from around the world. The industry assisted in the financing of 3 international visits of South African researchers and research staff to international congresses and meetings during this past year.

8th International Pear Symposium in Montevideo, Uruguay
04-07 December 2018
Attended by Prof Wiehann Steyn

V International Symposium on Postharvest Pathology in Liege, Belgium
19-24 May 2019
Attended by Dr Cheryl Lennox

Epidemiology and Population Genetics Course by Professor Laurence V Madden in Oslo, Norway
04-12 May 2019
Attended by Dr Julia Meitz-Hopkins and Mr Junré Marais



PUBLICATIONS

Here is a list of all Hortgro Science related articles from 2018/19 that were published in the SAFJ, Fresh Quarterly and Fresh Notes. We have compiled some interesting statistics on the Fresh Quarterly and encourage you to read this quarterly publication.

SAFJ

October/November 2018

Voigt, F. *Progress report on Geneva rootstocks for commercialisation and further testing in South Africa:* pp. 45-47.

Beerwinkel, E., McDonald, D., Mouton, A. *Summary of Hortgro Symposium 2018:* pp. 82-97.

Fawole, O.A. *Let's seal the deal: Edible Coating application on stone fruit*: pp. 99-101.

December 2018 / January 2019

Steenkamp, E. *Richard Hurndall's deep footprints:* pp. 18-20.

Steenkamp, E. *Hortgro Research Showcase.* pp. 36-37.

Midgley, S., Dzikiti, S., Volschenk, T., Lötze, E., Gush, M. *Are water savings in apple orchards under shade netting an additional benefit?:* pp. 81-83.

February/ March 2019

Steenkamp, E: *State of the art CA facility launched at SU:* p. 34.

Louw, J.P., Korsten, L. *Penicillium rot of nectarine and plum*: pp. 58-61.

De Kock, V.A. *Comparison of standard 11-mm penetrometer plungers against 8-mm plungers to establish the optimum harvest maturity of late season nectarines using flesh firmness as indices*: pp. 62-68.

De Kock, V.A. *Research on spray and atomiser fungicide application systems for use on plum pack lines*: pp. 69-74.

April/ May 2019

Bestbier, G. *Addressing industry challenges*: pp.10-11.

Bestbier, G. *Crisis – best teacher for resilience*: pp.16-17.

Goudriaan, R., Jarmain, C., Andriessen, M., Abraham, K., Naudé, R., Keuck, P. *A case study using FruitLook data*: pp. 18-21.

Bestbier, G. *The chronicles of the travelling pear*: pp. 24-25.

Berry, T., Opara, U.L. *A multi-parameter approach to optimise the design and performance of ventilated fruit packaging*: pp. 56-62.

Pieterse, W., Manrakhan, A., Terblanche, J., Addison, P. *Assessing the biology of Bactrocera dorsalis (Hendel) (Diptera: Tephritidae) to understand its invasion potential into the Western Cape of South Africa*: pp. 63-65.

June/ July 2019

Steenkamp, E. *Industry initiates plastics task team*: pp. 8-9

Steenkamp, E. *Procuring academic excellence to solve industry problems*: p. 12.

Bestbier, G. *The Stellenbosch insectary – a hive of activity*: pp. 16-17.

Steenkamp, E. *Challenging stone fruit season for growers*: pp. 24-25.

Steenkamp, E. *Waarnatoe met nette*: bl. 25.

August/ September 2019

Tayler, H., Viljoen, D.W., Crouch I.J. *Rosy Glow Apples – postharvest physiological profile*: pp. 34-43.

Steenkamp, E. *Hortgro Technical Symposium on a steady growth trajectory*: pp. 44-47.

Duvenage, E. *Maties se beste hortologie-student*: bl. 48-49

Bestbier, G. *Hortgro makes R5.3 m student investment*: pp. 48-49.

Bonthuys, J. *Studying fruit fly through machine learning*: pp. 61-63.

Bonthuys, J. *Regenerative agriculture – a sustainable tool for fruit farmers*: pp. 65-68.

De Klerk, A. *Letselaalwurms in appelkwekery en –boorde*: bl. 71-74.

Fresh Notes

Fresh Notes 150 – 19 Oct 2018
Grain chinch bug

Fresh Notes 151 – Oct 2018
MRL Notification – all deciduous

Fresh Notes 152 – 3 December 2018
Nectarines

Fresh Notes 153 – 4 December 2018
PAG

Fresh Notes 155 – 4 February 2019
FEMA

Fresh Notes 156 – 11 February 2019
PSHB

Fresh Notes 157 – 22 February 2019
Mites in a hot and dry 2018/19

Fresh Notes 158 – 29 March 2019
PAG feedback

Fresh Notes 159 – 23 April 2019
B. dorsalis monitoring

Fresh Notes 160 – 16 July 2019
MRL notification

Fresh Notes 161 – 31 July 2019
MRL notification updated

Fresh Notes 162 – 1 August 2019
PAG feedback

Fresh Quarterly

December 2018

McDonald, D. *NIP Phytosanitary risk in the bud.*

McDonald, D. *Indigenous fruit flies.*

Stassen, P. *Rootstocks: choose what is best for your crop.*

Stassen, P. *Rootstocks for stone fruit.*

Mouton, A. *Forelle early market access: Unlocking new value from an old cultivar.*

Hurndall, R. *A meander along South Africa's CA storage road.*

March 2019

Theron, K., Reynolds, S., Van der Merwe, S. *Who's who in chemical thinners.*

Theron, K. *How do the different chemicals thin?*

Theron, K. *A South African perspective on chemical thinners.*

Bestbier, G. *Stopping the rot.*

Mouton, A. *The sharpest tool in the shed – measuring flesh firmness in late-season nectarines with the 8mm penetrometer.*

July 2019

Duvenage, E. *Reform holds key to economic growth (William Gumede).*

Duvenage, E. *To the last drop (Prof Eilon Adar).*

Bestbier, G. *Be savvy with salt (Mico Stander/Karen van der Westhuizen).*

Bestbier, G. *Below the surface (Prof Eilon Adar).*

Bestbier, G. *Train your trees for the future (Dr Alberto Dorigoni).*

Bestbier, G. *From blossom to apple (Prof Karen Theron).*

Bestbier, G. *Late bloomers (Dr Esme Louw).*

Bestbier, G. *Less is not more (Anton Muller).*

Duvenage, E. *Fruit fly expert calls for new policies (Prof. James Carey).*

Duvenage, E. *Biological controls of fruit fly (Dr Pia Addison).*

Duvenage, E. *Land reform success stories (Landbouweekblad panel discussion).*

Duvenage, E. *Some like it hot (Dr Minette Karsten).*

Duvenage, E. *Save money with scientific dosing (Philip Rebel).*

Duvenage, E. *Maintain your net benefits (Dr Gideon van Zyl).*

Duvenage, E. *Data-driven farming (Dr Gideon van Zyl).*

Mouton, A. *Rewriting the rules (Stephanie van der Walt).*

Mouton, A. *The state of energy in SA (Paul Nel).*

Mouton, A. *Parting ways with plastic (Lorren de Kock).*

Mouton, A. *Minimising moisture loss in pears during storage (Frank van de Geijn).*

Mouton, A. *Edible coatings (Dr Olaniyi Fawole).*

Mouton, A. *Put the brakes on decay (Arrie de Kock).*

Mouton, A. *Exterminate grain chinch bug (Dr Shelley Johnson).*

Mouton, A. *Dynamic fruit needs dynamic storage (Frank van de Geijn).*

September 2019

Mouton, A. *Salinization – why does it occur and what can you do about it?*

Mouton, A. *Getting ahead of salinization.*

Stassen, P., Du Plessis, P. *Stone fruit rootstocks revisited.*

Campbell, H. *Getting more out of monitoring.*

Mouton, A. *Healthy tree, healthy fruit. Monitoring systems for pome and stone fruit.*

Bestbier, G. *Straightening out shrivel in plums.*

Bestbier, G. *Turning up the heat on shrivel.*

Fresh Quarterly

The first six issues

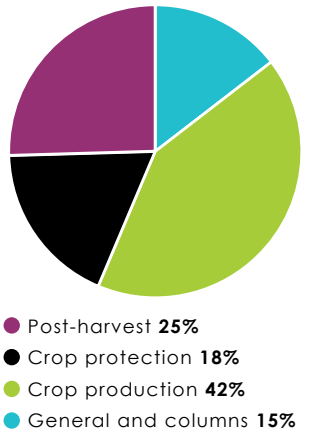
Quick overview

Issue	Date	Number of articles	Number of pages
1	June 2018	7	36
2	September 2018	6	32
3	December 2018	7	32
4	March 2019	5	30
5*	July 2019	23	56
6	September 2019	7	30

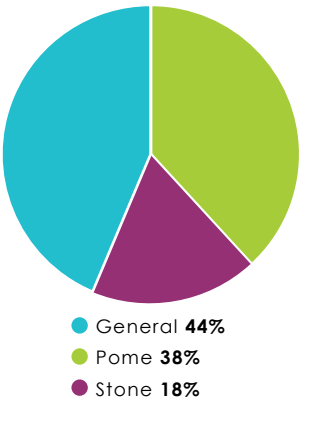
* issue 5 was the special symposium issue.

Article breakdown for all issues

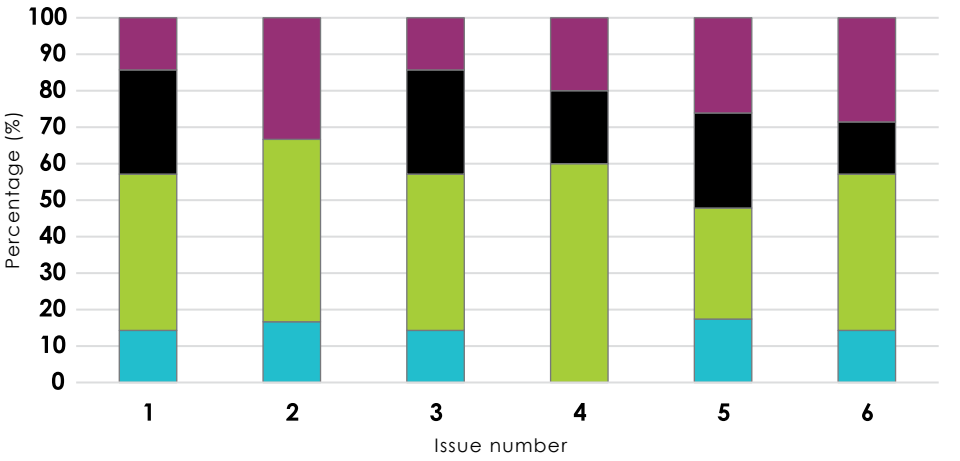
ARTICLE COUNT BY SECTION



ARTICLE COUNT BY FRUIT TYPE



BREAKDOWN OF ARTICLE CATEGORIES BY ISSUE



Summary of articles by topic

Topic	Article count
Cankers and dieback	1
Challenges to farming	5
Chemical thinners	3
Colour development in pome fruit	3
Entomopathogenic nematodes	2
Forelle early market access	1
Fruit flies	3
Fruit set	2
Monitoring for pest and diseases	2
Packaging	1
Penetrometer to measure flesh firmness in nectarines	1
Pest control	5
Phytosanitation	2
Rootstocks	4
Salinization	3
Storage and storage disorders	9
Tree training and pruning	2
Water and irrigation	6
Total	**55**

HORTGRO
Growing Fruit IQ

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ABSTRACTS

DORMANCY

Investigating the effect of different autumn/winter/spring scenarios on bud break in apple trees

E Louw And L Allderman

Objectives and Rationale

Deciduous trees require sufficient winter chill to have a synchronised and condensed bloom period in spring. Yet, even under such conditions, and/or with the use of rest breaking agents, we see protracted bloom and delayed foliation in commercial orchards. Recent research indicated that chill accumulation during the autumn period (dormancy induction period) seems to be important for successful bud break. From this we hypothesis that not just the total amount of cold accumulated throughout the dormancy period contributes to bud break success, but also the distribution of the chill throughout the winter period.

Methods

To investigate the effect of different climate scenarios during the dormant period we are exposing apple trees (nursery trees produced in pots) to different autumn, winter and spring conditions and then monitoring their bud break patterns. This year was the first year of the project and the data generation is currently in progress.

Key Results

To date we have measured the baseline dormancy level of the trees at the start of the autumn scenarios and found that by 19 March 2019 the trees have stopped growing and formed a terminal bud that was paradormant (resumed growth within 8 days of forcing) due to the inhibitory effect of the leaves. After the autumn period the terminal buds were endodormant as they do not yet show signs of growth under forcing conditions. Trees that were exposed to warmer autumn conditions retained their leaves for much longer, but by 24 June 2019 all the trees had lost more than 96% of their leaves.

Conclusion and Discussion

This trial is currently in progress and no further conclusions or results are available.

Validation of the shoot assay as a proxy to determine progression of dormancy in intact apple trees

E Louw and L Allderman

Objectives and Rationale

To date most of our dormancy research relied on the use of a laboratory based "shoot assay" to determine the dormancy level of buds. Recent studies on the induction period of dormancy and the availability of potted apple nursery trees led to the need and possibility to conduct a formal validation of this "shoot assay" as a proxy for dormancy behaviour in intact apple trees.

Methods

The traditional "shoot assay" (forcing of defoliated, 30cm shoots at 25˚C and continuous light) was tested in parallel to the forcing of intact apple nursery trees grown in plastic bags. The trial included trees and shoots with and without leaves to determine the effect of defoliation on dormancy. Trees were kept at a nursery in Simondium and their dormancy levels were determined on eight occasions during the winter period by forcing the intact trees and shoot-cuttings from the trees, including defoliation upon forcing versus natural leaf drop.

Key Results

At the time of the report only four of the eight sampling occasions have started to show signs of bud break. Preliminary results showed that intact leaves inhibit bud growth with bud break only starting once leaves have dropped.

Conclusion and Discussion

This trial is currently in progress and no final conclusions or results are available. The preliminary results lead to the approval of a request to extend the current project by another year with possible additional testing.

Evaluation of alternative rest breaking agents for apples

X Siboza, K Theron and D Craven

Objectives and Rationale

South Africa is in the subtropical region associated with insufficient winter chilling for commercial apple production. Chemical rest breaking agents including hydrogen cyanamide (Dormex®) and winter oil are commercially used to alleviate challenges associated with insufficient winter chilling. A previous project (*Using the shoot assay to screen combinations and sequential application of existing and possible new rest breaking agents in apples. (2014-2017)*) demonstrated that treating excised shoots with nitric oxide showed rest breaking potential equal to that of Dormex® and oil. The same study also indicated that Promalin® (combination of synthetic cytokinin and gibberellin 4+7 (GA_{4+7}) used with Dormex®) increased vigour in spring when used in combinations with Dormex® and oil. Testing the Promalin® application thereof at different times during the winter period in apple trees may lead to improved bud break in warm winter regions plagued by low bud break and vigour in spring. The aim of the project is thus to test alternative rest breaking and growth-promoting agents on apple trees to improve bud break and vigour.

Methods

Experiment 1: To evaluate the effect on bud break in Fuji apple trees at Cortina Farm, 42 individual trees planted at 4.0 × 1.8 m on M.7 rootstocks in 2011 will be sprayed with 8 treatments: 3% Dormex®, 3% Oil, 0.5% Dormex® + 3% Oil (control), 0.5% Dormex® + 3% Oil + 100 mg/l Promalin®, 3.4% $NaNO_2$ + 3% Oil, 3% Oil +100 mg/l Promalin®.

Experiment 2: To evaluate the effect on bud break in Rosy Glow apple trees, 42 individual trees will be sprayed with 4% Oil, 1% Dormex®, 1% Dormex® + 4% Oil (control), 1% Dormex® + 4% Oil + 100 mg/L Promalin®, 3.4% $NaNO_2$ + 4% Oil, and 4% Oil +100 mg/l Promalin®.

Experiment 3: To examine the concentration and timing of Promalin® on enhancing bud break and flowering, about 42 Fuji apple trees will be sprayed at 3 application times (7, 6 and 5 weeks before full bloom) with the following treatments: 3% Dormex®, 0.5% Dormex® + 3% Oil (control), 3% Oil +100 mg/l Promalin®, 0.5% Dormex® + 3% Oil + 50 mg/l Promalin®, 0.5% Dormex® + 3% Oil + 100 mg/l Promalin®, and 0.5% Dormex® + 3% Oil + 150 mg/l Promalin®.

Key Results

The first treatment application was done on 20 August 2019. There are no results or observations to present at this stage of the project.

Conclusion and Discussion

The rest-breaking treatments are still being applied to the trees. Therefore, there is no data to be presented.

Leaf defoliation of Cripps' Pink and Granny Smith apples in the EGVV – effect on vegetative and reproductive development

X Siboza, K Theron and D Craven

Objectives and Rationale

Apple scab is the most serious disease in apple fruit trees, limiting fruit production, with symptoms commonly observed on the leaves and fruit. Control of apple scab can be a challenge in Mediterranean-type climates, associated with protracted leaf abscission. In this study, we are investigating the effectiveness of various chemicals to induce condensed leaf abscission. We are also assessing the effect of the treatments on leaf decomposition rate, bud break, leaf area, flower quality, fruit set, fruit yield, fruit quality and return bloom in apple trees.

Methods

A total of 168 individual trees were selected and allocated to a randomised complete block design of 8 leaf defoliation treatments that were applied on 7 blocks at 3 different application times to a 'Rosy Glow' and two 'Granny Smith' orchards of which one was under shade netting. The following leaf defoliation treatments were applied during the first and third weeks of June as well as the first week of July: control (no spray), hand-defoliation, 5% Urea, 3% Urea plus 2% $ZnSO_4$, ABA (ProTone™) 500 ppm, ACC 500 ppm, and ABA 500 ppm + Urea 2%.

Key Results

The chemical defoliation applications appeared to be effective in all three orchards. Based on visual observations, the trees under shade net dropped their leaves much earlier than trees in the open orchards. The effectiveness of these chemical defoliation treatments was cultivar dependent. The effect of defoliation treatments on bud break and subsequent development of the trees still needs to be determined.

Conclusion and Discussion

3% Urea and 2% $ZnSO_4$, 5% Urea, ABA 500 ppm + Urea 2%, and ACC 500 ppm all resulted in high leaf drop rates in all trials compared to the control, with 3% Urea plus 2% $ZnSO_4$ the most effective. It is however too soon to make any accurate conclusions without further statistical analysis.

Evaluate rest breaking programmes for warm winter regions

(X Siboza and D Craven)

Objectives and Rationale

Rest breaking agents (RBAs) are applied to alleviate the symptoms of delayed foliation in apple production areas with warm winters where insufficient chilling accumulates. The potential benefits of RBA application include yield increase, greater fruit size (by facilitating thinning), more uniform fruit maturity and the alleviation of delayed foliation symptoms. The objectives of this study were to determine the effect of RBA application on vegetative and reproductive buds, yield and fruit quality.

Methods

Individual apple trees of 'Golden Delicious Reinders', 'Fuji', and 'Rosy Glow' planted in commercial orchards in the EGGV regions were selected according to a randomised complete block design and treated with various RBAs. The vegetative and reproductive bud break percentages were determined on a weekly basis.

Key Results

Experiment 1: Applying 3% Dormex® on 'Golden Delicious Reinders' improved bud break.

Experiment 2: The 3% Dormex® was too strong a treatment on 'Fuji' in the wet 2013 season.

Experiment 3: Treatment with 3% Dormex® had a fruit thinning effect on 'Fuji'. The 2% LB Urea + 2% KNO_3 and 7 days later 0.5% Dormex® + 3% Oil was as an effective rest breaking treatment.

Experiment 4: Treatment with 3% Dormex® gave good fruit size and advanced bud break on 'Golden Delicious Reinders'. The 1% Dormex® + 4% Oil was the most effective rest breaking treatment but had a thinning effect.

Experiment 5: Treatments were equally effective in inducing bud break in 'Fuji'. Applying 3% Dormex® had a negative effect on fruit size.

Experiment 6: The bud break progression was poor and not affected by the rest breaking agents in 'Golden Delicious Reinders'.

Experiment 7: Applying 0.5% Dormex® + 3% Oil + 100 mg/L Promalin® enhanced bud break in 'Fuji' compared to other treatments.

Experiment 8: The best bud break was induced either by 1% Dormex® + 4 Oil + 100 mg/L Promalin® or 1% Dormex® + 4% Oil in 'Rosy Glow'.

Experiment 9: Treatment with 3% Dormex® induced more vegetative buds than reproductive buds in 'Fuji'. The return bloom percentage was higher on trees sprayed with 3% Dormex® than on trees sprayed with the other rest breaking agents.

Experiment 10: The greatest reproductive bud break percentage was obtained with 1% Dormex® + 4% Oil + 100 mg/L Promalin® in 'Rosy Glow' apple trees.

Conclusion and Discussion

The high dosage of 3% Dormex® often promoted more vegetative bud break than reproductive bud break because of the phytotoxic effect this chemical has on floral tissues. Adding 100 mg/l Promalin® to the common 0.5% Dormex® + 3% Oil or 1% Dormex® + 4% Oil treatments seemed to have had a positive effect on bud break and requires further investigation. In some of the trials, treatment mixtures of various "softer" rest breaking products equaled the results obtained with Dormex® + Oil and this also requires further evaluation.

Quantifying the impact of insufficient winter chill on apple fruit quality

(E Louw and A van Lingen)

Objectives and Rationale

Insufficient winter chill is a reality in most of the apple producing areas of South Africa but little scientific data is available to quantify the effect that this has on the quality of the fruit. This study aims to quantify the variability in fruit quality in two climatically contrasting areas and to locate the origin of the possible variability. As a second objective it aims to determine if the variability on fruit quality can be mitigated by rootstock choice as well as investigating the rootstock effect on dormancy progression.

Methods

For the first objective, 'Golden Delicious' orchards (Elgin and Koue Bokkeveld) were harvested by selecting 6 trees and removing the fruit from 2 branches into six categories: position on the tree (top and bottom), bearing position (spur and shoot) and degree of sun exposure (full sun and shaded). Destructive and non-destructive quality parameters were measured before and after storage (0.5˚C, RA for 3 months) and statistical analysis was performed to determine the variability. Similar methods were applied in a randomised block design with seven rootstocks grafted with 'Reinder's Golden Delicious'. Dormancy progression of the rootstock/scion trial was also determined using one-year-old shoots exposed to standard forcing conditions.

Key Results

Fruit maturity and quality parameters are influenced by several pre-harvest factors such as orchard and tree differences as well as position within the canopy. Mass, starch breakdown, firmness and TSS are reported on and discussed in detail showing variability on various levels including seasonal differences. The dormancy progression of an apple tree is influenced by its rootstock with the Geneva® rootstocks showing a deeper maximum dormancy level compared to the Malling rootstocks.

Conclusion and Discussion

At the time of the report, the data analysis was not yet complete and no conclusions could be made. However, preliminary results give insight into the variability of 'Golden Delicious' fruit produced under different climatic conditions. Dormancy progression is altered by the rootstock choice, but whether it mitigates fruit variability is still to be determined.

Physiological dynamics of dormancy in apple buds grown in areas with insufficient cold

(E Louw, L Möller and M Inamahoro)

Objectives and Rationale

We investigated physiological aspects (respiration, lipid content, oxidative stress and hormone concentration) of apple buds produced under inadequate winter chilling to gain fundamental knowledge on the changes brought about by typical South African conditions. The current report discusses results relating to the dynamics of four different respiration pathways as well as the changes in abscisic acid concentrations and its respective catabolites.

Methods

Dormant apple buds from two contrasting climatic regions, Elgin (insufficient winter chill) and Koue Bokkeveld (sufficient winter chill) are compared in terms of their chill accumulation and dormancy levels during three consecutive winter periods (2015-2017). The respiration rate of the four biochemical pathways contributing to respiration (tricarboxylic acid cycle (TCA), pentose phosphate pathway (PPP), alternative pathway (ALT) and cytochrome c (CYT) pathway) were measured and compared as well as the concentration of abscisic acid (ABA) and its catabolites i.e. abscisic acid-glucosyl ester (ABA-GE), dihydrophaseic acid (DPA) and phaseic acid (PA) .

Key Results

Apple buds from the Elgin region failed to increase their TCA and CYT respiration pathways after the dormant period and maintained higher levels of the PPP and ALT compared to buds from the Koue Bokkeveld. ABA assays indicated that although buds from Elgin have higher ABA levels during dormancy in some years, they had higher ABA-GE levels and consistently low DPA levels compared to Koue Bokkeveld buds.

Conclusion and Discussion

Both the respiration dynamics and the ABA catabolism of dormant apples buds changed when they did not receive sufficient winter chill. In the case of the respiration pathways it seemed as if hydrogen cyanamide and oil mixture can compensate for the loss in energy production due to insufficient chill, but possibly at a cost of prolonged oxidative stress. The lack of cold also prevents the complete inactivation of ABA to DPA. This work is in progress.

Investigating the effects of different autumn temperatures on endodormancy progression

(E Louw and L Allderman)

Objectives and Rationale

The aim of this project is to investigate different temperature treatments on the induction (late summer/autumn) of endodormancy and the effect this has on dormancy progression in order to increase our understanding of how temperature influences the early stages of dormancy.

Methods

'Royal Beaut' shoots from two different climatic areas were collected weekly and exposed to temperatures varying from 4 to14˚C for different time periods (1 – 14 days) and then forced (25˚C, continuous light) to grow while monitoring the bud break pattern. The effect of harsh environmental conditions were repeated three times during endodormancy progression by exposing 'Cripps' Pink' shoots from both climatic areas to two days of either 30˚C, 4˚C or -4˚C forcing (25˚C, continuous light) and monitoring the bud break pattern.

Key Results

Preliminary results showed that buds from different climatic areas differ in their sensitivity to additional chill treatments. During the dormancy induction period, buds are able to sense additional cold and adjust their dormancy levels accordingly. Buds from Elgin tend to be more sensitive and have more fluctuating results compared to buds from the Koue Bokkeveld. Sudden, short changes in temperature are interpreted differently by different cultivars and their reaction depends on their state of dormancy at the time of treatment. Although general patterns could be seen, seasonal variation made it difficult to draw conclusions.

Conclusion and Discussion

No final conclusion has been made on any of the findings. Further data mining and statistical analysis is currently in progress.

ROOTSTOCKS AND NURSERY TREE QUALITY

Evaluation of pear rootstocks for the South African industry. Packham's Triumph in Grabouw. (X Siboza and I Labuschagne)

Objectives and Rationale

Pear rootstocks, like any other rootstocks, vary in their adaptation to various soils, climatic conditions and pest and disease resistance. Therefore a selection of appropriate rootstocks is crucial to the South African pear industry. This study will generate new knowledge on precocity, vegetative and reproduction performance of these new rootstocks under our marginal winter chilling conditions, poor soils, low water availability, high temperatures and the presence of pests and diseases. This information will then be used by the industry to advise growers on rootstock selection and planting of future pear orchards with higher productivity and commercial value.

Methods

'Packham's Triumph' trees on selected rootstocks were planted at the Jackal River Farm on the following 9 rootstocks: BP1, BP3, OHF40, OHF217, QC51, Pyriam, BA29/BH, QC51/BH, and QA/BH. Rootstocks were planted in a randomised block design with 10 blocks of 2 trees per plot. The experimental trees were planted at 4.5 m × 2 m (1111 trees ha^{-1}).

Key Results

The trees were planted in 2016 and have not started bearing. The rootstocks did not have a significant effect on most of the important horticultural traits including trunk cross-sectional area (TCSA) increase from 2016/19 and in the 2018/19 season, tree height increase from 2016/19 and in the 2018/19 season, and on tree survival. According to the TCSA, the trees on OHxF 217, QC 51, BA 29/BH, QC 51/BH, BP1, BP3, Pyriam, and QA/BH rootstocks were larger than the trees on OHxF 40 rootstocks. All trees have reached a similar height during the 2019 season.

Conclusion and Discussion

The rootstock evaluation is still in preliminary stages. Therefore, it is too early for any conclusions.

Evaluation of pear rootstocks for the South African industry. Forelle in Wolseley (Mostertshoek)

(X Siboza and I Labuschagne)

Objectives and Rationale

Pear rootstocks, like any other rootstocks, vary in their adaptation to various soils, climatic conditions and pest and disease resistance. Therefore a selection of rootstocks is crucial to the South African pear industry. This study will generate new knowledge on precocity and vegetative and reproduction performance of these new rootstocks under our marginal winter chilling conditions, poor soils, low water availability, high temperatures and of pests and diseases. The industry will then use this information to advise growers on rootstock selection and planting of future pear orchards with higher productivity and commercial value.

Methods

'Forelle' pear trees were planted on the following selected rootstocks at the Mostertshoek farm in Wolseley: OHF40, OHF217, QC51, BA29/BH, QC51/BH, BP1, QA/BH and Pyriam. All rootstocks were planted in a randomised complete block design with 10 blocks of 2 trees per plot. The experimental trees were spaced at 4.5 m × 1.5 m (1481 trees ha^{-1}).

Key Results

Rootstocks had a great influence on the tree trunk cross-sectional area (TCSA). Trees on BP1, QC 51, and OHxF 40 rootstocks increased most in diameter since planting followed by QC 51/showed the smallest diameter increases.

Conclusion and Discussion

The influence of rootstocks on tree growth was significant during the 2019 season. However, it is still early days for a solid conclusion. The first crop is expected during the 2019/20 season.

Evaluation of pear rootstocks for the South African industry. African Rose in Wolseley (Mostertshoek)

(X Siboza and I Labuschagne)

Objectives and Rationale

Pear rootstocks, like any other rootstocks, vary in their adaptation to various soils, climatic conditions and pest and disease resistance. Therefore a selection of rootstocks is crucial to the South African pear industry. This study will generate new knowledge on precocity and vegetative and reproduction performance of these new rootstocks under our marginal winter chilling conditions, poor soils, low water availability, high temperatures and of pests and diseases. The industry will then use this information to advise growers on rootstock selection and planting of future pear orchards with higher productivity and commercial value.

Methods

The African Rose pear cultivar was planted in 2016 in a pear rootstock trial at the Mostertshoek farm in Wolseley on the following rootstocks: BP1, OHF40, OHF217, BA29/BH, QC51/BH, QA/BH, and Pyriam. Rootstocks were planted in a randomised complete block design with 10 blocks of 2 trees per plot.

Key Results

According to tree height during the 2019 season, the trees on QC 51/BH, OHxF 217, OHxF 40, BA 29/BH, BP1, QA/BH rootstocks were taller than the trees on Pyriam rootstock. According to tree height increase from 2016 to 2019, trees on OHxF 40, BP1, OHxF 217, and QA/BH rootstocks increased more in height compared to the trees on BA 29/BH, and Pyriam rootstocks, which were the shortest.

Conclusion and Discussion

The preliminary results suggest that the trees on OHxF 40, BP1, OHxF 217, and QA/BH rootstocks are more vigorous compared to the trees on BA 29/BH, and Pyriam rootstocks which are more dwarfing. However, it is still early days for final comparison. Most of the horticultural characteristics including TCSA in 2019, TCSA increase 2016/19, TCSA increase 2018/19, and tree height increase 2018/19 were not significantly affected by the rootstocks. During the following season first fruits are expected that will be harvested and evaluated.

Evaluation of peach rootstocks for the South African fruit industry at Vaalwater, Limpopo

(P Stassen and I Labuschagne)

Objectives and Rationale

The main objective for this project is to evaluate high potential imported and local rootstocks on two different soil types in the Vaalwater growing region.

Methods

Two trials have been planted during 2015 in the Vaalwater region. One with 'Snow Angel' as scion, using 8 rootstocks on a sandy (79%) soil and the second planting with 'Snow Angel' on 12 rootstocks on high clay soil (42% clay). The trial layouts are randomised complete-block (10) designs with 10 replications.

Key Results

During the second harvest, 'Snow Angel' trees on sandy soil, on the rootstock Okinawa gave the highest yield, but not significantly better than trees on OSM 99-3. Trees on Rootpack 70 and Kakamas seedling had the lowest yields. Fruit of trees on Flordaguard had the best fruit weight, but not significantly better compared to fruit of trees on OSM 99-3. Trees on Kakamas seedling had the lowest fruit weight. On high clay soil, trees on Barrier gave the highest yield, but trees on Flordaguard, Okinawa, Earligrande, Kakamas seedling, OSM 99-3 and Rootpack 70 did not differ significantly in yield. Trees on Viking gave the lowest yield, but not significantly lower compared to trees on Earliblush. No significant differences at P=5% between rootstocks were found on fruit weight of trees.

Conclusion and Discussion

This is a low chill growing region and 'Snow Angel' is a very early cultivar (end September) and that puts pressure on fruit growth and development of this cultivar. After two harvesting seasons, trees on Okinawa, OSM 99-3 and Flordaguard performed well in terms of average yield and fruit weight on both sites. Trees on Kakamas seedling are semi-dwarfing and easily stressed on sandy soils, resulting in poor yield and fruit weight.

Evaluation of peach rootstocks for South African fruit industry: Rawsonville planting (Slanghoek)

(P Stassen and I Labuschagne)

Objectives and Rationale

The main objective for this project is to evaluate high potential imported and local rootstocks on high risk sandy soil in a low-lying area in the Slanghoek, Rawsonville region.

Methods

Trial done with 'Earliblush' as scion, using 12 rootstocks on a sandy soil infected with *Xiphinema* spp, (dagger nematodes). The trial layout consists of a randomised complete-block designs with 10 replications.

Key Results

During the first harvest 'Earliblush' trees on Barrier gave the highest yield, but differences between rootstocks were not significant at 5% test level. Fruit weight was generally good. Fruit weight of trees on Viking was superior (151.93g), but not significantly better compared to trees on Barrier. Fruit weight of trees on Flordaguard and Kakamas seedling was the smallest. Trees on Kakamas seedling and Rootpack 70 are semi-dwarfing whilst trees on Barrier, Flordaguard and Garnem are strong growers.

Conclusion and Discussion

t is too early for any conclusions at this stage. This trial must provide information of the influence of sandy soils, dagger nematodes and fluctuating water tables on especially the rootstocks Guardian, Garnem, Rootpack 70, OSM 99-2 and OSM 99-3.

Evaluation of plum rootstocks for the South African industry at Simondium (Keunenberg)

(P Stassen and I Labuschagne)

Objectives and Rationale

The main objective of this project is the evaluation of high potential imported and local rootstocks on different soil types and under different climatic conditions to make recommendations that can complement yield and fruit quality of plum cultivars.

Methods

At the Simondium trial site, 13 rootstocks were planted in a complete randomised trial lay-out in 10 blocks. Trial trees and side row trees were included in a commercial orchard. The new ARC bred rootstock selections OSK99-6, 7B-25-21 and 5A-05-34 were pre-selected for root-knot and ring nematode resistance. According to results obtained during pre-screening trials, these selections were highly recommended for phase 3 evaluation by the Rootstock Evaluation Committee.

Key Results

Poor fruit set occurred due to climatic conditions during the spring of 2018 that affected all main growing areas, including Simondium. Trees yielded poorly with those on GF 677 significantly higher than on all other rootstocks except Marianna. Due to huge variation no significance occurred in fruit weight. In this high risky sandy soil, trees on all rootstocks showed die-back symptoms except those on Atlas and Kakamas seedling.

Conclusion and Discussion

Poor climatic conditions during the bloom period in October 2018 resulted in poor yield of 'Ruby Star' trees planted in this evaluation plot. Results of the 2018/19 season are therefore not trustworthy for recommendation purpose.

Evaluation of plum rootstocks for South African fruit Industry: Robertson planting (Roodehoogte) **(P Stassen and I Labuschagne)**

Objectives and Rationale

The main objective is the evaluation of high potential imported and local rootstocks on different soil types and under different climatic conditions and to make recommendations that can complement yield and fruit quality of plum cultivars.

Methods

At the Robertson trial site, 9 rootstocks were planted in a randomised complete-block trial lay-out using 10 replications included as part of a commercial orchard. The new ARC bred rootstock selections OSK99-6 and 8B-35-10 were included. These selections were highly recommended for phase 3 evaluation by the Rootstock Evaluation Committee.

Key Results

On this high potential soil (43% silt and clay) with moderate high pH (KCl 6.7), trees on GF 677 yielded significantly higher compared to all other rootstocks during the first harvesting season. The second crop was lower than expected and was harvested before yield and no fruit data could be measured.

Conclusion and Discussion

No yield and fruit measurements were taken during the second harvesting season. It is too early to draw any substantial conclusions from one year's results.

Evaluation of new apple rootstocks and interstem combinations in Grabouw (Oak Valley)

(X Siboza and I Labuschagne)

Objectives and Rationale

The objective of this project is to assess various new apple rootstocks (most of the Cornell Geneva® range) that have recently become available against the industry standard M.793, M.7 EMLA and MM.109. The use of G.222 and M9. EMLA as potential interstems will also be assessed.

Methods

The more dwarfing (M.9 EMLA, M.9 Nic® 29, G.222, M.7 EMLA, MM.109/M.9 EMLA, MM.109/G.222, M.793/M.9 EMLA, M.793/G.222, G.778/M.9 EMLA, G.778/G.222) and more vigorous rootstocks (M.7 EMLA, G.202, G.778, M.793, MM.109, and G.228) were grouped together in two adjacent, but separate 'Fuji' plantings. With hindsight, G.202 should have formed part of the more dwarfing planting. Trees were planted during spring 2013 using randomised complete block designs for both plantings. All tree scion diameters were measured at 50 cm above the soil level.

Key Results

Vigorous site: The trees on MM.109 rootstocks grew vigorously from 2013 to 2019 followed by the trees on M.793, G.778, G.228, and M.7 EMLA rootstocks while the trees on G.202 rootstocks are dwarfing. According to the cumulative yield efficiency from 2016 to 2019, the trees on G.202, and G.228 rootstocks were most efficient followed by the trees on G.778 rootstocks while the industry standards, MM.109, M.793, and M.7 EMLA rootstocks were least efficient. Rootstocks had a significant effect on fruit red colour percentage, red colour intensity, colour background, and firmness but did not influence fruit mass, diameter, sunburn and total soluble solids during the 2019 season.

Dwarfing site: The trees on M.7 EMLA rootstocks induced greater growth followed by the trees on G.778/G.222, MM.109/G.222, M.793/M.9 EMLA, M.793/M.9 EMLA, G.778/M.9 EMLA, M.793/G.222, G.222, and MM.109/M.9 EMLA rootstocks while the trees on M.9 Nic® 29 and M.9 EMLA rootstocks were the smallest. The trees on G.778/M.9 EMLA and G.778/G.222 rootstocks had the greatest cumulative yields from 2016 to 2019 while the trees on M.7 EMLA, M.793/M.9 EMLA, M.9 Nic® 29, and M.793/G.222 rootstocks had the lowest cumulative yields. The most cumulative yield efficient trees were on G.778/M.9 EMLA, G.778/G.222, and M.9 EMLA rootstocks while the least cumulative yield efficient trees were on MM.109/G.222, M.793/G.222, M.7 EMLA, and M.793/M.9 EMLA rootstocks. Rootstocks had a significant effect on fruit quality including mass, diameter, red colour percentage, red colour intensity, colour background, and firmness but not on total soluble solids.

Conclusion and Discussion

On the vigorous site, the G.778, G.228 and G.202 rootstocks produced the greatest cumulative yields and cumulative yield efficiencies. On the dwarfing site, the G.778/G.222 and G.778/M.9 EMLA rootstocks are more productive and yield efficient than the industry standard M.7 EMLA.

Evaluation of new apple rootstocks and interstem combinations in Grabouw (Breëvlei)

(X Siboza and I Labuschagne)

Objectives and Rationale

The objective of this project is to assess the various new apple rootstocks (most of the Cornell Geneva® range) that have become available against the industry standard M.793, M.7 EMLA and MM.109. The use of G.222 and M.9 EMLA as potential interstems will also be assessed.

Methods

The more dwarfing (M.9 EMLA, M9 Nic® 29, G222, M.7 EMLA, MM.109/M.9 EMLA, MM.109/G.222, M.93/M.9 EMLA, M.793/G.222, G.778/M.9 EMLA, and G.778/G.222) and more vigorous rootstocks (M.7 EMLA, G.202, G.778, M.793, MM.109, and G.228) were grouped together in two adjacent, but separate 'Fuji' plantings. Trees were planted during spring 2013 using randomised complete block designs for both plantings. Tree scion diameter, fruit production and fruit quality were evaluated during the following seasons.

Key Results

Vigorous site: according to the 2019 trunk cross-sectional area (TCSA), the trees on MM.109 rootstocks were most vigorous followed by the trees on M.793, G.778, M.7 EMLA, and G.228 rootstocks. The trees on G.202 were the most dwarfing on this site. The greatest cumulative yield was on G.778 rootstocks but not statistically different from the trees on G.228 rootstocks from 2017 to 2019. However, the greatest cumulative yield efficiency was with trees on G.202 rootstocks followed by the trees on G.228, and G.778 rootstocks.

Dwarfing site: The trees on M.7 EMLA rootstocks were vigorous with the largest TCSA but not statistically different from the trees on G.778/G.222, G.778/M.9 EMLA, G.222, and M.793/G.222 rootstocks. The trees on G.778/M.9 EMLA, and M.9 Nic® 29 rootstocks were highly efficient but not statistically different from the other trees except the trees on M.7 EMLA rootstocks which were least efficient.

Conclusion and Discussion

The trees on G.202, G.228, and G.778 rootstocks appear to be more productive than the trees on M.7 EMLA, M.793, and MM.109 rootstocks. The trees on G.778/M.9 EMLA, and M.9 Nic® 29 rootstocks appeared to be more yield efficient than the trees on M.7 EMLA rootstocks.

Evaluation of new apple rootstocks and interstem combinations in the Langkloof (Helderwater)

(X Siboza and I Labuschagne)

Objectives and Rationale

The objective of this project is to assess the various new apple rootstocks (most of the Cornell Geneva® range) that have recently become available against the industry standard M.793, M.7 EMLA and MM.109. The use of G.222 and M.9 EMLA as potential interstems will also be assessed.

Methods

The more dwarfing (M.9 EMLA, M.9 Nic® 29, G.222, M.7 EMLA, MM.109/M.9 EMLA, MM.109/G.222, M7.93/M.9 EMLA, M.793/G.222, G.778/M.9 EMLA, and G.778/G.222) and more vigorous rootstocks (M.7 EMLA, G.202, G.778, M.793, MM.109, and G.228) were grouped together in two adjacent, but separate 'Fuji' plantings. Trees were planted during spring 2013 using randomised complete block designs for both plantings. Tree scion diameter, fruit production and fruit quality were evaluated during the 2017 season. Trees have reached the optimum height. Central leaders were cut back. Therefore, tree height measurements were omitted during the 2017 season and onwards to avoid biases.

Key Results

Vigorous site: The trees on MM.109 rootstocks were growing vigorously followed by the trees on M.793, and G.778 rootstocks while the trees on G.228 and M.7 EMLA rootstocks were semi-vigorous; and those on G.202 rootstocks were dwarfing. The greatest cumulative yields were with trees on G.778, and G.228 rootstocks followed by those on MM.109, G.202, and M.7 EMLA while the lowest cumulative yields were with trees on M.793 rootstocks. The trees on G.202, G.228, and G.778 rootstocks were highly efficient followed by the trees on M.7 EMLA rootstocks while the trees on MM.109 and M.793 rootstocks were least yield efficient.

Dwarfing site: The trees on G.778/G.222, M.7 EMLA and G.778/M.9 EMLA rootstocks were semi-vigorous; the trees on MM.109/M.9 EMLA, G.222, MM.109/G.222, M.793/G.222 and M.793/M.9 EMLA rootstocks were semi-dwarfing while the trees on M.9 EMLA and M.9 Nic® 29 rootstocks were dwarfing. The greatest cumulative yield was with trees on G.778/G.222, G.778/M.9 EMLA, and G.222 rootstocks. However, the greatest cumulative yield efficiency was with the trees on M.9 EMLA, M.9 Nic® 29, G.222 and G.778/G.222 rootstocks. The lowest cumulative yield efficiency was with the trees on M.793/M.9 EMLA, M.793/G. 222, and M.7 EMLA rootstocks.

Conclusion and Discussion

The greatest cumulative yield efficiency was with trees on G.202, G.228, and G.778 rootstocks on the more vigorous site. The greatest cumulative yield efficiency was with trees on M.9 EMLA, M.9 Nic® 29, G.222 and G.778/G.222 rootstocks on the dwarfing site. The lowest cumulative yield efficiency was with the trees on M.7 EMLA, M.793 and MM.109 rootstocks.

Evaluation of new apple rootstocks representing two vigour classes in two growing areas (Bokveldskloof and Molteno)

(X Siboza and I Labuschagne)

Objectives and Rationale

Continuous evaluation of newly released rootstocks will always stay relevant for a well organised and prosperous apple industry. The aim of this project is to evaluate new apple rootstocks representing two vigour classes in two separate trials each planted in two main apple-growing areas in South Africa.

Methods

A semi-vigorous planting and a dwarfing planting were made at both Molteno farm in Grabouw Bokveldskloof in the Koue Bokkeveld. The semi-vigorous planting included G.778, G.969, G.222 with MM.116 and M.7 EMLA while the dwarfing planting included G.41, G.202 G.757 and G.13 with M.9 EMLA and M.9 T-337. Where necessary, the experimental areas were treated with Telopic (1,3-Dichloropropene: Chloropicrin 60:35, Dow AgroSciences, Paarl, South Africa).

Key Results

Semi-vigorous site at Molteno: The trees on G.222 rootstocks were larger than the trees on MM.116, G.778, M.7 EMLA and G.969 rootstocks. The trees on G.969 rootstocks were the smallest.

Dwarfing site at Molteno: The dwarfing trees planted at Molteno performed poorly and the entire orchard was removed during the 2019 season. A 'Bigbucks' trial also planted in 2018 on dwarfing rootstocks at Oewerzicht farm has been nominated to replace the uprooted dwarfing rootstock trial at Molteno.

Semi-vigorous site at Bokveldskloof: The most vigorous trees were on G.778 rootstocks but not statistically different from the trees on G.222 and MM.116 rootstocks. The trees on M.7 EMLA rootstocks were of intermediate size while the trees on G.969 rootstocks were dwarfing.

Dwarfing site at Bokveldskloof: The trees on G.202 rootstocks grew more vigorously than the trees on G.757, M.9 T-337, G.41, and M.9 EMLA rootstocks. The trees on G.13 rootstocks were the most dwarfing trees during the 2019 season.

Conclusion and Discussion

The trees were planted during the 2018 season. The rootstock influence on most of the horticultural attributes was not significant at this early stage.

Evaluation of new apple rootstocks representing three vigour classes at Môrester and Oak Valley

(X Siboza and I Labuschagne)

Objectives and Rationale

Continuous evaluation of newly released rootstocks will stay relevant for a well organised and prosperous apple industry. The aim of this project was to evaluate new apple rootstocks representing three vigour classes in three separate trials.

Methods

The trials were planted with 'Bigbucks' as scion in three randomised block plantings in two commercial orchards on two farms i.e., Môrester in Koue Bokkeveld and Oak Valley in Grabouw. Trees were prepared for planting during the 2017 season on rootstocks representing the following vigour classes.

Group A: G.228, G.778, M.793, MM.109 planting at 'Oak Valley'

Group B: M.7 EMLA, G.890, G.222, G.757 and Supporter 4 planting at 'Môrester'

Group C: G.202, M.9 EMLA, Nic® 29 planting at 'Môrester'

Groups B and C were planted at 3.5 m x 1.25 m in 10 randomised blocks with 3 trees per treatment plot. Group A was spaced at 4 m x 1.5 m in 10 randomised blocks with 3 trees per treatment plot. Granny Smith apple trees were planted to serve as cross-pollinators in this orchard. Trees will be trained to single leaders.

Key Results

Group A: The G.778 and MM.109 rootstocks induced more vigour than the G.228 and M.793 rootstocks. The trees on G.778 and MM.109 rootstocks had a larger trunk cross-sectional area (TCSA) than the trees on G.228 and M.793 rootstocks. Rootstocks did not have a significant effect on tree height increase during the 2018/19 season and tree survival percentage.

Group B: The trees with the largest TCSA were on G.890, M.7 EMLA, and G.222 rootstocks, while the trees with the smallest TCSA were on G.757 and Supporter 4 rootstocks. The trees on G.890 and M.7 EMLA rootstocks were the tallest followed by the trees on G.222 and G.757 rootstocks while the trees on Supporter 4 rootstocks were the shortest. Rootstocks did not have a significant effect on tree survival percentage.

Group C: According to the TCSA, the trees on G.202 rootstocks were the largest while the trees on M.9 EMLA and M.9 Nic® 29 rootstocks were the smallest. The trees on G.202 and M.9 EMLA rootstocks were taller than the trees on M.9 Nic® 29 rootstocks.

Conclusion and Discussion

These are preliminary results. Therefore, no solid conclusions can be made at this early stage.

Sensitivity of various apple rootstocks to water stress

(S Midgley and L Muchena)

Objectives and Rationale

The apple industry needs a better understanding of tree responses to irrigation deficits. Rootstock choices are critical to achieving high yield and fruit quality, but little is known on differential sensitivities to water stress between rootstocks. The objective of this study is to assess the influence of rootstocks of varying vigour on tree performance under water stress.

Methods

Two drought cycles were imposed on full-bearing field-grown 'Rosy Glow' trees on five rootstocks and on non-bearing potted 'Rosy Glow' trees on five rootstocks. We assessed changes in soil water content, stem/leaf water potential, leaf gas exchange, tree transpiration, shoot growth and biomass partitioning, including roots, and water productivity. This was done continuously (e.g. sap flow) or before, during and after each drought cycle (e.g. water potential).

Key Results

In mature trees, daily and seasonal water use decreased with decreasing vigour. The drought treatments did not reduce transpiration, although physiological measurements indicated that water stress was developing. Following re-watering, two rootstocks (RN29, M.793) showed an ability to increase transpiration beyond normal recovery. This was confirmed in young potted trees. Drought treatments reduced transpiration in potted trees - rapidly in G.202 and M.7 and more slowly in G.222. M.7 and G.222 recovered after a longer period of re-watering. G.202 showed only a small partial recovery.

Conclusion and Discussion

Most of the milestones for the first two seasons have been met. Some final field work (amendment request) will allow for all data analysis to be completed during 2019/2020.

Evaluate methods to produce and handle containerised nursery trees

(K Theron and W Truter)

Objectives and Rationale

The aim of the project was to investigate the feasibility of growing apple nursery trees in bags in a sterile medium and potentially planting trees already in autumn rather than the normal spring planting in order to attenuate transplant shock and preclude the need to cold store trees.

Methods

'Golden Delicious' and 'Bigbucks' on M.9 rootstock were grown in bags in a shaded tunnel in a commercial nursery. Different treatments were evaluated to try and induce growth cessation and enhance hardening-off during autumn. Treatments to chemically defoliate trees in autumn, reduce reproductive bud formation and increase nitrogen reserve status were also evaluated. In addition, trials were done to compare autumn to spring planting of containerised trees in the orchard, evaluate cold storage versus chemical restbreaking and different planting methods in establishing containerised trees in the orchard.

Key Results

Prohexadione calcium and abscisic acid showed no significant effect on growth cessation during the nursery phase, and no significant effect in spring bud break and new growth in the orchard. Trees planted in autumn showed earlier bud break whereas trees planted in spring had a higher bud break percentage. Foliar nitrogen (urea) during the nursery phase did not significantly affect spring bud break and new growth. At the rates applied, foliar copper, in comparison to 1-aminocyclopropane-1-carboxylic acid proved to be a more successful chemical defoliant in the nursery with no significant negative effect on the subsequent performance in the orchard. Dormancy management practises improved bud break in spring as well as the architecture of young trees planted in a commercial orchard. It is recommended that trees receive a six-week 6 ˚C cold storage period and a chemical rest breaking treatment to improve establishment. Different planting methods of containerised nursery trees did not significantly influence bud break in spring, but planting containerised trees with an undisturbed growing medium or only slightly loosening the growing medium before planting improved new lateral shoot growth and apical extension growth.

Conclusion and Discussion / Recommendation

No clear conclusion could be made on the use of PGRs to harden-off trees or chemical defoliants in our trials. Trees planted during autumn, in a warm winter region, did not accumulate sufficient chilling, which resulted in reduced bud break during spring. This time of planting resulted in a basal dominant tree architecture. As trees were probably not managed ideally in the orchard, the treatment effects could have been masked by a lack of tree vigour during the first growing season in the orchard. A period of a six-week cold storage at 6 ˚C as well as a chemical rest breaking treatment are important dormancy management practices, regarding spring bud break and tree architecture, when trees are planted in warm regions. Because containerised nursery tree propagation is a new concept in South Africa, further research is needed on propagation and subsequent management of these trees.

GROWING SEASON CLIMATE

Scientific and practical guide to climate change and pome/stone fruit production in South Africa **(S Midgley)**

Objectives and Rationale

The future sustainability of the pome and stone fruit industries in view of climate change is threatened in regard to yield and fruit quality and irrigation water requirement. Long-term adaptation planning is vital for perennial fruit crops with an expected economic lifetime of 25-30 years. The project objective is to compile a science-based, relevant and practical guide (practitioners' handbook) to pome and stone fruit farmers in South Africa on climate change risks, impacts and adaptation responses.

Methods

The modelling and mapping of key climate-related parameters (soil, water, climate, pests) was based on existing databases and knowledge, with additional modelling of fruit quality parameters such as sunburn and red colour. Five Global Climate Models (GCMs) were used. The spatial scale is national but cut out for the Western Cape, focusing on seven production regions, and the future timeframes are either 2030s or 2050s. Industry experts guided the choice of parameters to be included in the Guide.

Key Results

A large set of parameters was modelled and mapped, showing present and future conditions and the change between the two periods. The key maps include those for mean, minimum and maximum temperature, heat (days >35˚C), chill unit accumulation, potential evaporation, risk of dry and wet spells, groundwater recharge, stream flow, and red colour development.

Conclusion and Discussion

Although the project is behind schedule, the milestones are being achieved. The modelling and mapping component is almost complete, and the results have been validated and fine-tuning suggested by technical experts.

Determining 'Forelle' pre-harvest mealiness / cavity development stage, due to environmental factors and exploring prevention of mealiness developing after storage and ripening

(E Crouch, L Schoeman and L-M Dippenaar)

Objectives and Rationale

According to previous trials it seems that outside canopy 'Forelle' pears have a high risk of becoming mealy and are associated with a lower neck density. This study aims to understand when outside canopy fruit develop cavities, by shading them over time and determining differences in their cellular structure.

Methods

Outer canopy pears were shaded through bi-weekly application of shade nets from 13 weeks before harvest. Fruit surface temperature (FST) and irradiance were measured at each interval. X-ray CT was performed to determine tissue density and cellular structure. Fruit were harvested at commercial harvest and evaluated after 8 weeks of cold storage at -0.5 ˚C, plus 0, 4, 7 and 11 days of ripening at 20 ˚C. Standard maturity indexing and cell wall alcohol insoluble residue (AIR) extractions were performed.

Key Results

Fruit shaded closer to harvest showed improved fruit size and blush colour. A higher netting percentage severely reduced blush colour. Lower fruit firmness coincided with higher mealiness. X-ray micro-CT demonstrated density differences between shading treatments. This can be attributed to the significantly higher porosity detected in fruit (5.97%) exposed to 4 weeks of shading, compared to fruit (1.99%) exposed to 14 weeks of shading.

Conclusion and Discussion

A link exists between time exposed to sunlight and mealiness development based on an accumulation effect due to prolonged exposure to extreme irradiance and FST. Ripening and firmness proved to be crucial in mealiness expression, highlighting the need to include ripening time intervals rather than a snap-shot at one ripening time.

Effect of nets on growth, yield and fruit quality as well economic feasibility in plums

(K Theron and N van Rensburg)

Objectives and Rationale

The South African plum industry has experienced heat damage and sunburn on fruit in recent seasons. Especially the 2015/16 season has resulted in high percentages of fruit being down-graded due to sunburn and heat damage. The latter is often only noticed when fruit are cut when pit burn becomes noticeable. As predictions are that the South African summers will become even warmer and heat wave scenarios can become more extreme, it is expected that the problem might become even worse in future. This has induced some producers to already start covering some plum orchards with shade netting. Orchards that were covered in the 2015/16 season have however shown excessive vegetative growth.

Currently no suitable dwarfing rootstocks are available for plums that could combat the excessive growth observed. The aim of the project was to evaluate the effect of shade nets on plum fruit quality at harvest and after cold storage, as well as to evaluate methods to reduce vegetative growth using various plant growth regulators (PGRs).

Methods

Foliar or soil applications of the PGRs were made either at petal drop (PD), PD plus 4 weeks later or after harvest depending on the product. Effect on fruit set, summer pruning and yield and fruit quality were determined. A comparison of fruit quality from untreated trees in full sun were compared to fruit quality from trees grown under shade net, at harvest, after cold storage and after cold storage and subsequent shelf-life.

Key Results

The data is currently still being analysed and results written up and compiled into an MScAgric thesis.

Conclusion and Discussion / Recommendation

Conclusions will only be made once the data analysis is completed.

Heat damage in plums

(W Steyn, M Jooste and B Makeredza)

Objectives and Rationale

Heat waves hamper production of premium quality plums in the Western Cape Province by causing sunburn in the presence of high irradiance. In addition, high respiration rates initiated by high temperatures are thought to deplete internal fruit oxygen and trigger anaerobic respiration with subsequent accumulation of ethanol, resulting in internal damage that manifests in cold storage. No information is available on temperature thresholds for thermal damage of the skin and flesh of plums. In apples, maintaining high stem water potential (SWP) and applying shade netting were reported to alleviate sunburn. Research in this regard as it pertains to plums is lacking.

Methods

Various trials were conducted and the word limitation of the abstract doesn't allow the detailed description of all methodology.

Key Results

Fruit under shade net received 83.5% of full sunlight and this decreased the fruit surface temperature (FST) by average 1-2 °C resulting in a slight reduction in sunburn. As the shade net was installed quite late (22 January), some sunburn might have occurred before then and earlier installation might further reduce sunburn.

The plant's capacity to utilise light in carbon assimilation is reduced under low plant water potential. This causes excess light in the system, which can overwhelm the photoprotective measures, causing oxidative damage. Well-watered trees had lower canopy temperatures due to maintaining higher transpiration rates. Low water potential triggered stomatal closure which in turn decreased transpiration. Increasing canopy temperature decreases potential for radiative heat loss from fruit to the environment, further increasing the FST. Increasing irrigation beyond the general normal agronomic practice did not further reduce sunburn.

We were not successful in inducing pitburn but did observe gel breakdown in response to heat treatments. An increase in temperature and duration of exposure to high temperature generally increased metabolic processes such as respiration and ethanol evolution. Further increases

to 45 °C were, however, inhibitory to varying extents among the cultivars. Pre-storage heat exposure at this apparent threshold temperature initiated tolerance to cold storage-induced internal heat damage through curing.

Conclusion and Discussion

Further research over the entire growing season and a wider range of cultivars will indicate the full value and shortcomings of shade nets. We tested shade nets on African Delight, a cultivar not susceptible to internal heat damage. Shade nets should be able to reduce internal heat damage. Further studies in this area using sensitive cultivars such as Laetitia could be worthwhile.

It is important to note that fruit on trees with low water potential have increased sunburn risk and farmers should strive to attain optimal water level to avoid predisposing fruit to sunburn. They should note thought that additional irrigation beyond normal agronomic practice will not further reduce sunburn.

Fruit exposed to high temperature treatments can potentially store longer. However, we are not sure that curing will be a commercially viable treatment option for plums considering that it sometimes resulted in external damage. It might also prove difficult to apply to large volumes of fruit in practice.

IRRIGATION AND NUTRITION

The effect of irrigation on the performance of young apple trees in newly established orchards (E Hoffman, J van Zyl and A Stofberg)

Objectives and Rationale

Apple trees in newly established orchards must fill their allotted space as soon as possible in order to be profitable. Soil water status and root growth are believed to be major determining factors in achieving such a favourable effect. The objective of this study is therefore to determine the most effective irrigation schedule for the optimum performance, including root growth and root distribution, of young apple trees in newly established orchards on gravelly soils which are wide-spread in apple-growing regions of South Africa.

Methods

The irrigation treatments were continued in the trial apple orchard which was in its third leaf during 2018/19 and soil water data have been captured throughout the season. Midday stem and leaf water potentials were employed to determine tree water stress. Aboveground measurements of tree response were conducted in June 2019 followed by root mapping according to the profile wall method while root growth periodicity was measured by root scanning in the plexiglass rhizotrons.

Key Results

During the third year of the field trial, aboveground response to the irrigation treatments namely, stem circumference, new shoot growth and internode length, did not differ significantly. This result is in agreement to findings after the first season, but not a continuation of second season results when trunk circumferences of T1 trees (high irrigation frequency) were significantly better than those of both the other two treatments. Root studies in the rhizotrons confirmed that more roots penetrated deeper into the soil with larger quantities of water applied less frequently. Root number increased substantially in all treatments compared to the studies done after the first growing season. The evapotranspiration of the three-year old trees was 646 mm for the season of which 49% was supplied by rainfall and the rest by irrigation. Irrigation quantities did not differ substantially among treatments. Midday stem water potentials confirmed tree water stress as a result of longer irrigation cycles.

Conclusion and Discussion

At the end of the third season after planting, aboveground growth of the three irrigation treatments was still similar. Better root distribution of the drier treatments probably compensated for periods between irrigations when trees on long irrigation cycle plots experienced stress. Midday stem water potential confirmed such an increase in tree water stress in the case of long cycle irrigations compared to short cycle irrigation. The evapotranspiration of the young non-bearing trees remained low at 646 mm on average during the growing season. The irrigation trial should continue to allow investigation of the effect of irrigation cycles on yield and fruit quality. The trial orchard is also an ideal platform to determine how evapotranspiration and root distribution of young trees entering their cropping phase, will further increase with the concomitant effect on water requirement.

Water use of pome and stone fruit: knowledge status, relevance and gap analysis

(C Jarmain, N Tayler, A van Niekerk and N Shongwe)

Objectives and Rationale

Selective and limited information is available on the crop water use and requirements of various stone and pome fruits produced across South Africa. Further, little is known about the ranges in crop and region-specific water use and water requirement and the factors influencing it, are not well understood. No "reference" or summary document exists listing these. This project aims to assess the available information related to crop water use and irrigation requirements of pome and stone fruit. The final product of this project will be a quick reference guide on pome and stone fruit water use.

Methods

This project will be executed as a desktop study, whether through summarising knowledge, collating producers' information, extracting statistical information, or performing a survey. The project will involve engagement with producers and the fruit industry as well as crop water use and deciduous fruit crop experts.

Key Results

Thus far literature relating to crop water use and irrigation requirements has been reviewed and documented. In addition, crop irrigation requirements used by water management authorities in South Africa have been obtained, as well as long term crop water use data generated through the FruitLook initiative. These datasets need to be integrated, analysed and then summarised in a summary document.

Conclusion and Discussion

Progress has been made with most of the milestones listed. However, none have been completed. A new work plan will be drafted and submitted.

Establishing quantitative relationships between water relations, growth, yield and quality of high performing commercial apple orchards

(S Midgley and S Zirebwa)

Objectives and Rationale

The objective was to assess the effects and interaction of varying crop load and irrigation volume in 'Golden Delicious' on tree physiology, fruit, shoot and root growth, and fruit yield and quality. This will provide information on the yield-water-growth relationships which can be used to optimise water use in apple production.

Methods

We established treatments of two crop loads and three irrigation volumes in a 'Golden Delicious' orchard in 2015/2016 and 2016/2017. Monthly measurements were performed of midday stem water potential, leaf gas exchange, stem/fruit diameter fluctuations, and fruit/shoot/root growth. Soil water content was monitored. Fruit number, yield, and fruit quality and maturity were determined at harvest.

Key Results

High crop load led to lower midday stem water potential (MSWP) compared to medium crop load, especially later in the season. Irrigation treatments did not significantly affect MSWP and there was no interaction with crop load. In season one, there were no treatment effects on gas exchange parameters. In season two, gas exchange parameters decreased with decreasing irrigation volumes, but in interaction with crop load – highest values were measured for the combination of medium crop load with high irrigation volume. This treatment also showed the highest shoot growth rate. In both seasons high crop gave smaller fruit and lower shoot growth rates. Shoot growth rates were reduced under medium and low irrigation volumes, especially early in the season.

Conclusion and Discussion

Further analysis is required to assess the water relations of the different treatment combinations. This will include the analysis of daily stem and fruit diameter changes and seasonal root growth patterns.

NEMATOLOGY

Control of the obscure mealybug, Pseudococcus viburni, using entomopathogenic fungi and nematodes in deciduous fruit orchards

(N Stokwe and L Mathulwe)

Objectives and Rationale

Pseudococcus viburni (Signoret) (Hemiptera: Pseudococcidae), obscure mealybug, is an important polyphagous insect pest of deciduous fruits, including apples and pears, and it affects fruit production both in South Africa and globally. The mealybug has developed some level of resistance against a wide range of chemical insecticides, including organophosphates and carbamates, previously used for its control in agricultural ecosystems. The objectives of this study are:

1. To screen local and commercial EPF and EPN isolates for pathogenicity against *P. viburni* using laboratory bioassays, to select the most promising candidates;
2. To evaluate an additive or synergistic effect of using EPF in combination with EPN in the laboratory for pathogenicity against *P. viburni*;
3. To mass culture and to formulate the selected EPF candidate by optimising standard techniques for the selected EPF isolate,
4. To assess the efficacy of the formulated fungi and of the *in vitro*-cultured and formulated EPN for mealybug control in semi-field trials.

Methods

A colony of *P. viburni* consisting of nymphs, adult females and ovisacs, was collected from infested granadilla and apple fruits, and maintained on potatoes and butternuts to initiate a laboratory colony. Molecularly identified EPN and EPF, obtained from the Stellenbosch University collection were cultured for laboratory bioassays. Pre- screening bioassays using two EPF isolates (*Beauveria bassiana* and *Metarhizium pinghaense*) and two EPN isolates (*Steinernema yirgalemense* and *S. jefferyense*) were used to assess their virulence against *P. viburni*.

Key Results

Both EPF and EPN isolates have shown to be pathogenic when used against *P. viburni.* Screening, concentration dose-response and exposure time-response bioassays are scheduled to be done soon.

Conclusion and Discussion

The literature review and laboratory studies are progressing as planned.

Screening of apple rootstocks for resistance against the most prevalent Pratylenchus species affecting orchards in South Africa

(R Knoetze)

Objectives and Rationale

Lesion nematodes (*Pratylenchus* spp.), are difficult to control once stablished. None of the current commercially available apple rootstocks in South Africa are known to be tolerant or resistant to nematodes. Screening newly imported, promising high potential apple rootstocks for resistance against prevalent species of root lesion nematodes occurring in SA will help to identify the most promising rootstocks for release to the industry. Results from several ongoing projects are now enabling us to prioritise this research, which is of major importance to the industry. A project on the distribution and identity of *Pratylenchus* species in SA apple orchards will identify the most widespread lesion nematode species, which should be used when evaluating these rootstocks. Methodology for the culturing of lesion nematodes has been optimised during the screening of cover crops, enabling us to produce large numbers of nematodes for use in screening protocols. The aim of this project is to evaluate new rootstocks with potential value to the industry, including promising new Geneva® rootstocks, for their comparative susceptibility, resistance or tolerance to the lesion nematodes prevalent in SA apple orchards.

Methods

Populations of lesion nematode species will be obtained from the collections of ARC Infruitec-Nietvoorbij and cultured using the *in vitro* carrot disc method. Plants will be inoculated with nematodes by distributing 2 ml of a predetermined nematode concentration into two holes made in the soil, approximately 1.5 to 2.0 cm from the plant stem. At 180 days after inoculation, final nematode populations (Pf) and numbers of nematodes per gram of root will be assessed for each experiment. The reproductive potential of lesion nematodes in each rootstock will be calculated using Oostenbrink's reproduction factor (Rf = Pf/Pi), where Rf > 1 indicates susceptibility. In addition to this, the percentage of the nematodes g^{-1} roots of each rootstock in relation to the nematodes g^{-1} roots of the most susceptible rootstock will be calculated and used as an additional parameter (%R) to classify the level of resistance, where%R < 10% indicates resistance.

Key Results

The project commenced in April 2019, and as yet there are no results on which to report.

Conclusion and Discussion

The project commenced in April 2019, and as yet there are no conclusions to be drawn.

Host status of certain cover crops for the root lesion nematode, a major pest of economic importance in apples

(R Knoetze)

Objectives and Rationale

Currently the most preferred method of orchard management is to plant a cover crop in the work row to improve fertility and soil structure, and reduce erosion. However, in choosing a cover crop it is important to ensure that it is not a good host for lesion nematodes (*Pratylenchus* spp.), the main nematodes of economic importance on apples in South Africa. The aim of the study is to assess the susceptibility of selected cover crops to different lesion nematode species by estimating nematode reproduction on these crops.

Methods

To successfully culture the lesion nematodes, it was necessary to optimise an *in vitro* culturing method using carrot discs. After propagation of the cover crops, they were inoculated with lesion nematodes that were harvested from the carrot discs. After 13 weeks, the crops were evaluated for their susceptibility to lesion nematodes. To do this, the reproductive potential (Rf) of the nematodes in each crop as well as the percentage of the nematodes g^{-1} roots of each crop in relation to the nematodes g^{-1} roots of the most susceptible crop (%R) was calculated.

Key Results

The reproduction of the lesion nematodes on the susceptible crops were poor in all cases. Although it was possible to calculate relative reproduction potential by means of %R, based on nematodes per gram roots, the low reproduction rates casts doubt over these results and these experiments will need to be repeated. It is for this reason that alternative measures for growing conditions, inoculation methods and extraction methods were explored in the second experiment. The second experiment indicated that nematodes are more viable when delivered in a carrot disc to the plant as compared to pipetting nematode suspension into the soil. Also, plants grown in a temperature controlled glasshouse promoted the reproduction of the lesion nematodes on a favourable host, while in the first trials, it seems like the combination of inoculation method and fluctuating temperatures lead to poor reproduction of the nematodes.

Conclusion and Discussion

Although a simulation of natural field conditions suits the cover crops in terms of growth, the fluctuating temperatures are not conducive to nematode reproduction. Utilising alternative inoculation and extraction methods will increase the success of nematode reproduction on susceptible hosts. Because of poor nematode reproduction on the susceptible hosts in the screening trials performed in this year, repeats of these experiments are necessary.

Control of woolly apple aphid using entomopathogenic fungi

(N Stokwe and L Mathulwe)

Objectives and Rationale

The main aim of the current study was to survey for EPF in local apple orchards and to screen them for their ability to control woolly apple aphid (WAA). The first objective was to survey for the presence of EPF in local apple orchards, and to identify isolates to species level using molecular techniques while the second objective was to screen selected identified EPF isolates for their virulence against WAA under laboratory conditions. The last objective was to apply the most virulent EPF isolate to apple bark, so as to be able to determine the degree of persistence and contact infection attained under laboratory conditions.

Methods

The field survey was conducted in the Grabouw and Vyeboom areas located in the Western Cape Province, South Africa. A total of 48 soil samples, comprised of 240 soil subsamples, were collected across six apple farms. In the laboratory, soil samples were baited for EPF using wax moth and mealworm larvae. DNA was extracted from the 12 selected morphologically different EPF isolates.

Six EPF isolates were evaluated for their potential as biological control agents for WAA in the laboratory, using a 24-well bioassay protocol screening method. The lethal dose and time of the most promising isolates were also tested in the laboratory.

Persistence of fungal conidia on apple bark was also evaluated. The apple barks were sprayed with conidial suspensions and the persistence of the fungal conidia was determined. Natural infections and the mortality of WAA, following exposure to the apple tree bark treated with conidial suspensions over time were also determined.

Key Results

Six EPF were isolated and identified both morphologically and molecularly.

Screening bioassays identified *Metarhizium pinghaense* (70.83% ± 5.14%) and *M. brunneum* (65.00% ± 5.71%) as the most virulent against WAA. The LT_{50} for *M. pinghaense* and *M. brunneum* were found to be 4.77 and 9.43 days, respectively.

Metarhizium pinghaense was shown to have better persistence on the apple bark over a period of 3 weeks than *M. brunneum*. Further analysis of persistence showed that *M. pinghaense* was capable of inducing mortality of about 39-82% in colonies of WAA under optimum laboratory conditions, when exposed for a period of 10 days.

Conclusion and Discussion

The current study concludes that EPF offer a good chance of managing WAA in apple orchards. The study has indicated that *M. pinghaense* is the best local fungal candidate for the integrated management of WAA. Future studies should test *M. pinghaense* against WAA under glasshouse or field conditions with the fungus either being applied directly to the root system of apple trees to control the root colonies, or applied to the arboreal parts (e.g. the tree trunks) of the apple trees. Another option requiring investigation is the use of conidia-infected barriers, to target WAA crawlers as they move up the tree trunk to the arboreal parts of the tree.

Incorporating entomopathogenic nematodes and fungi in an integrated pest management system for the control of codling moth

(A Malan and D Odendaal)

Objectives and Rationale

The codling moth (CM), *Cydia pomonella*, is one of the most successful insect pests in the world, due to its extreme adaptability, with it being a major pest in apple-growing areas around the globe. The main aim of this study is to build on the previous research undertaken with CM and entomopathogenic nematodes (EPNs), and to provide insight into how to incorporate EPNs and entomopathogenic fungi (EPF) individually, and in combination, into an integrated pest management (IPM) system, directed towards the effective control of diapausing CM populations. The objectives of the study include the following: to identify indigenous EPF and EPN isolates from apple orchards in the Western Cape province, and to test their pathogenicity towards diapausing CM larvae; to determine the compatibility of selected EPNs with adjuvants, and their effect on the control of CM larvae and pupae under both laboratory and field conditions; to determine the effect of the separate and combined application of EPF- and EPN-selected strains on diapausing CM larvae, under controlled and field conditions; and to compare the performance of *in vivo*- and *in vitro*-cultured nematodes, in both the laboratory and the field.

Methods

After isolation, the efficacy of EPNs and EPF was tested against various stages of the CM life cycle. The EPNs and EPF were evaluated in the laboratory, with the most effective isolates being tested in the field. The EPN and EPF concentrations were calculated in the laboratory, prior to them being applied, with handheld sprayers, to wire-mesh cages, replicating the conditions of an infested apple tree (20 CM larvae together with apple tree bark) in the field. After 24 h, the cages that were field-tested were removed from the field, whereupon the larvae were rinsed off and placed on moist filter paper in Petri dishes, which were kept in a growth chamber at 25˚C. From 2-7 days after treatment, the trials were monitored, and the results recorded.

Key Results

Of the isolated EPF, the most abundant species isolated were found to be *Metarhizium pinghaense* (45%) and *Metarhizium robertsii* (33%). The most effective EPF isolates were determined to be *M. pinghaense* DO8, *M. robertsii* DO3 and DO36, *M. anisopliae* DO4, and *Beauveria bassiana* DO40. The local EPN isolate, *Steinernema jeffreyense*, proved most effective and reliable of the isolates tested. As the EPF mode of action takes longer than does the EPN, the former must be applied first. When the EPF are applied 48 h to 72 h before the EPN, the result is the additive or synergistic control of the CM larvae concerned, resulting in higher CM mortality than might otherwise be achieved if either of the entomopathogens were to be applied alone.

Conclusion and Discussion

EPN and EPF have been underestimated in the past, and, thus, underappreciated as pest control agents. The organisms involved should be able to become the nucleus of an IPM strategy, if they are properly utilised. A specialised strategy needs to be followed regarding their introduction to the pest control market, as they are live organisms, whose biology requires understanding on a fine scale, demanding the application of a skill that is only possible for professionally trained nematologists to apply.
To head up the current market, companies specialising in such products must be established, with them applying the EPNs within the ambit of IPM programmes.

Nematode community structure and function as a bio-indicator of the effects of soil amendments on soil health in deciduous fruit orchards

(S Storey and C Kapp)

Objectives and Rationale

The nematode community structure and function was determined in various localities, under different environmental conditions and different treatments to determine the effectiveness as a bio-indicator of soil health. Through the series of treatments, it was determined that the soil nematode community and inferred soil health is strongly influenced by time and various factors including soil moisture.

Methods

Soil samples in orchards were collected from the root zone of each treatment, in the work and tree row when required. The nematodes were extracted using the Cobb's decanting and sieving method followed by 48 hours in a modified Baermann funnel. Nematodes were counted and identified to genus level, categorised into feeding groups according to Yeates et al. (1993) and assigned cp-values as defined by Bongers (1990).

The results were used to determine the nematode community structure, function and associated soil health status of these orchards. The nematode faunal analysis was used to evaluate the function and structure of the soil food web.

Key Results

Nematode communities present in organic stone and pome fruit orchards differed in structure and function and were not significantly affected by mowing and mulching treatments. The pome fruit orchards (quince) revealed a unique nematode community structure compared to that of the stone fruit (plum, peach and apricot).

Nematode communities in apple orchards under shade net were influenced by soil preparation techniques and rootstock. Low numbers of plant-parasitic nematodes, especially ring nematode (*Criconemoides xenoplax*) and lesion nematode (*Pratylenchus* sp.), were present in the orchard. The areas planted to G.222 rootstock were more enriched than the areas planted to M.7 and M.9 rootstock. Areas planted to G.222 had the highest level of soil food web structure. The calculated nematode Maturity Index indicated that the entire orchard is disturbed and/or enriched.

The nematode community structure and function was determined annually over a four-year period in a site where five different cover crop treatments were applied. Results revealed that the enrichment and structure of the work and tree row for each of the five treatments deteriorated over the four-year period to such an extent that all data points indicated stressed conditions by the time the trial was suspended.

Nematode feeding groups in an orchard inundated with entomopathogenic nematodes (EPNs), indicated a similar pattern in their distribution, indicating that changes in population could be due to external effects rather than EPN treatment. Multiple regression analyses using specific indicator nematode families indicated no significant differences in the nematode populations for the duration of the experiment. No succession in the soil food web could be determined.

Conclusion and Discussion / Recommendation

Nematodes are effective as a bio indicator. Sampling should occur at least twice a year for more than two years, preferably for 5 years to accurately determine the effect of management practices on soil health. Climate change will influence nematodes and the soil food web, therefore management practices such as the utilisation of cover crops and mulches need to be implemented to buffer the soil environment against such harsh climatic conditions. The host status of cover crops needs to be evaluated for susceptibility to plant-parasitic nematodes, which negatively influence the cash crop. Climatic data including soil temperature and humidity, would give valuable information regarding the soil environment and possible outbreaks of plant-parasitic nematodes and other pests and diseases. Information regarding the management practices followed in the orchard is likely to form a crucial part of the interpretation of the sampling analysis.

SOIL HEALTH

Orchard floor management and soil health in deciduous fruit orchards

(M Addison)

Objectives and Rationale

The development of integrated orchard floor management methods is critical as they will allow for more sustainable fruit production. Current information on orchard floor management is limited. It is proposed that various combinations of cover crops be planted and assessed in order to determine the basic information needed.

Methods

Objective 1: Establish four cover crop treatments in tree rows and work rows in two climatic areas

Objective 2: Assess cover crop performance and the long term effects of the various management practices on soil ecology and yield.

Objective 3. Assessment of additional cover crop species at a small scale in two climatic areas.

Key Results

Cover crops were planted in May 2018. Various performance and biological parameters have been measured and assessed. The overall performance of the various treatments was deemed satisfactory; however, all treatments experienced competition from weeds. Results of soil analyses, soil fauna and nematode assessments appear to be similar to the previous season's results. Small scale cover crop plantings were established and plant performance of the various species assessed. Of the floral crops planted *Matricaria recutita* (Chamomile), *Coriandrum sativum* (Coriander), *Anethum graveolens* (Dill) and *Lobularia maratima (*Alyssium) performed well. Species that performed well in the work row plantings included *Trifolium fragiferum* (Strawberry clover) and *Trifolium incarnatum* (Crimson clover).

Conclusion and Discussion

Cover crops have established well and assessments are underway. Small scale assessment of various plant species planted in autumn were successful. The various analyses are complete and the data collected. Various assessment methods proved problematic, for example, the assessment of cover crop growth and production over time. An assessment method to measure vertical vegetation growth using image analysis was developed and used.

PRECISION AGRICULTURE

Spray application techniques on pome and stone fruit trees to improve spray deposition parameters for the control of late season red spider mite, mealybug and scale insects

(G van Zyl)

Objectives and Rationale

Spray deposition quantity, uniformity and quality was evaluated through spray application of a yellow fluorescent pigment, fluorometry and digital image analysis at various spray volumes in a current representative 4m apple orchard with a tree row volume of lower than 2000 L/ha to determine benchmark deposition values and the optimal spray volume (L/ha) (when applied with a optimally set up sprayer and spray methodology *i.e.* forward speed and air volume) for controlling cryptic pests such as red spider mite in pome and stone fruit.

Methods

Field trials were sprayed with a rovicLeers Evenflow tower sprayer at various spray volumes (250, 500, 750, 1000, 1250, 1500, 1750 and 2000 L/ha) with a yellow fluorescent pigment at 1ml/1L. To keep the VMD (volume median diameter) (<= 160 µm) of droplets similar throughout the different spray volumes applied, different sets of Albuz ATR 80 nozzles were used at the relevant pressure (Bar) Spray speed (4.5 km/h), air volume (36 100 m^3/h) and air speed (10 m/s) was kept constant throughout the trial to minimize treatment effects. No concentrate sprays were applied due to a shortage of pigment. Concentrate spray data is needed to conclude determining benchmark spray volumes. Leaves were sampled and analysed through macrophotography and image analysis determining deposition quantity, quality and uniformity.

Key Results

As expected, deposition quantity (FPC%) increased with an increase in spray volume. Sprayer setup and height is very important to achieve similar deposition parameters throughout the canopy profile (inside/outside; top/middle/bottom). Deposition quantity, quality and uniformity data indicates a possible point of run-off between 750 and 1250 L/ha for the 2000 L/ha TRV orchard sprayed with the spray mythology when using a constant dose of product per 100L of water (droplet density/coverage evaluation). However, this needs to be confirmed with concentrate sprays this season to evaluate the effect of concentrate sprays on deposition parameters.

Conclusion and Discussion

Spray volume plays a critical role in achieving optimal deposition together with optimal machine use, setup and methodology. Optimal spray volume cannot achieve optimal deposition parameters alone. Concentrate sprays are at the same spray volumes are needed to validate current dataset. Current dataset needs to be validated before bi-seasonal trials can progress.

Artificial intelligence for managing economic fruit pest efficiently

(P Addison and F Bekker)

Objectives and Rationale

The aim of this project is to use this technology to 1) determine sensitivity of trap configurations for fruit flies to improve monitoring efficacy; 2) to conduct a spatial-temporal analysis of fruit fly trap catches in relation to fruit damage; 3) assess multiple biotic and abiotic factors to determine the spatio-temporal distribution of codling moth; and 4) to test automated identification techniques against fruit fly adults, and potentially also fly and moth immature stages. This will enable more accurate monitoring and identification, better estimation of crop damage of fruit flies, and a better idea of the environmental drivers behind codling moth hot spots (areas where high catches cluster in space).

Methods

Monitoring data were obtained from various sources for codling moth. Data are being cleaned and formatted for spatio-temporal analysis. A pilot trial is being conducted to assess automated identification tools, whereby images of mouth hooks of various economically important fruit fly species are being tested against different machine learning algorithms in order to classify each species correctly.

Key Results

Trap monitoring data and associated trap attribute data are currently being incorporated into a GIS.

The pilot study is underway to test automatic identification of fruit flies using mouth hooks of the third instar larvae. Results are pending.

Conclusion and Discussion

No conclusions to date.

Integration of GIS and spatial analysis with monitoring data of major pests for the purposes of area-wide management

(P Addison and F Bekker)

Objectives and Rationale

To incorporate area-wide fruit fly monitoring data and its corresponding environmental variables, from various sources into a geographic information system (GIS), in order to manipulate, explore, analyse and spatially display the data. The rationale is to investigate the spatial distribution of fruit flies on an area-wide basis, in terms of the main geographic factors driving their spatial distribution. This will lead to decision-making tools for area-wide fruit fly managers.

Methods

Using a geographic information system (GIS), spatial analysis and machine learning to analyse and explore fruit fly trap and associated geographic data on a local and area-wide scale.

Key Results

Ceratitis capitata (Medfly) and *Ceratitis quilicii (Cape fly)* share the same resources in a heterogeneous orchard environment.

Fruit fly alternative hosts play a major role in the overall fruit fly populations in orchard environments.

Spatial analysis and machine learning proved to be very useful additional tools to analyse large fruit fly trapping datasets.

Fruit fly population drivers are area-specific.

Rainfall seems to play a major role in the EGVV in determining the spatial distribution of fruit fly hot and cold spots, where hot spots occur in warm dry areas, while cold spots occur in cold and wet areas.

Fruit fly hosts in urban areas contribute to early season fruit fly population pressures in commerciaL orchards.

Conclusion and Discussion / Recommendation

This study provides the deciduous fruit industry of the Western Cape with a toolset to quantify the spatio-temporal distributions of *C. capitata,* on an area-wide scale, but also on orchard level. The information gained improves our understanding of how *C. capitata* spatio-temporal distributions are

driven by stable geographic variables within heterogeneous fruit producing regions. This information will assist the deciduous fruit industry in improving its management of *C. capitata*, by more precise application of fruit fly management actions. It is recommended that this research be extended to include more precise and up to date pest monitoring data, and that an effort should be made to establish a real-time weather database for the Western Cape. Furthermore, real-time data on the cultivar phenology is also important. Although this type of data is easily obtainable on an orchard level, the challenge is to obtain this information on an area-wide scale, for entire production regions. Having access to real-time *C. capitata* trapping data, weather data, cultivar information and cultivar phenology, would enable the establishment of real-time seasonal spatio-temporal distribution models (Sciarretta & Trematerra 2014), not only for *C. capitata,* but many other pests, whose spatio-temporal distributions are mainly driven by these factors. Although there is currently a coordinated approach toward management of *C. capitata* in the Western Cape, data capturing and data handling are still aspects which can enjoy more resources, as most management decision-information is locked up in the data.

Evaluation of the MABO dosing model for pesticide spray application in modern high-density apple orchards

(A McLeod and P Rebel)

Objectives and Rationale

In modern high density apple orchards in South Africa, the currently used pesticide dosing model (tree row volume [TRV]) together with axial fans without turrets are likely not optimal. The MABO dosing model has been developed for modern orchards in Germany and Austria. Spray deposition must be correlated with biological efficacy, i.e. pest and disease control. No biological efficacy model is available for any disease on apple. The objectives of the study were to (i) evaluate the efficacy of the MABO dosing model in high-density apple orchards in South Africa, (ii) develop a spray drift sampling and quantification protocol and (iii) develop a biological efficacy model for mancozeb and apple scab caused by *Venturia inaequalis*.

Methods

Evaluation of the MABO dosing model was done using orchard trials along with fluorescent pigment sprays, photomicrography, and digital image analyses. Although spray drift orchard trials were not conducted due to unfavourable weather conditions, suitable spray drift collectors and a quantification method for the drift collectors were developed. This was done using a fluorescent pigment and photomacrography. The biological efficacy model was developed using apple seedlings sprayed with mancozeb, spray deposition quantification and *V. inaequalis* inoculations. Lesions were quantified using infrared thermal photography, image analyses, and qPCR analyses.

Key Results

In 4m-row-width apple orchards, deposition parameters achieved with the MABO dosing model did not differ significantly from those of the TRV model. Deposition parameters in the orchards were furthermore not significantly affected by using a high (36000 m^3/h) versus a low (28000 m^3/ha) volumetric airflow rate (VAR) produced by a high profile axial fan sprayer. Evaluations in two 3.5m-row-width orchards indicated that, depending on the orchard, deposition quantity with the MABO model at a high VAR was significantly better at the top canopy position or overall dewposition positions (top, middle, bottom, inside and outside canopy sampling positions) than the TRV (low and high VAR). Savings in spray costs of 40 to 28.5% (depending on spray volume) can be achieved when using the MABO dosing model versus the TRV model on a typically large scale high-density apple farm.

Black polyvinyl spray drift collectors were identified as suitable drift collectors. Spray deposition on the collectors can be quantified using macrophotography of yellow fluorescent pigment depositions.

Development of a benchmark model first showed that quantitative real-time PCR (qPCR) was a more suitable quantification method than thermal infrared imaging (TIRI) for fusi lesion quantification. TIRI overestimated the percentage of disease control. Both benchmark models showed that mancozeb yielded high levels of disease control at very low concentrations; for the qPCR benchmark model, the FPC% value of the FPC_{90} (90% control) corresponded to 0.15 times that of the registered mancozeb concentration in South Africa, i.e. 85% lower than the registered dosage.

Conclusion and Discussion / Recommendation

The MABO model has potential for pesticide application in high-density apple orchards in South Africa; it is more user-friendly than the Unrath model and can also reduce spray costs. Based on the developed laboratory benchmark model, lower mancozeb dosages may be required for fusi control than the currently registered dosage. This will have to be evaluated further under orchard conditions.

INTEGRATED PEST MANAGEMENT

Implementation of biological control options against false codling moth in laboratory and field trials (P Addison and F du Preez)

Objectives and Rationale

Resistance to insecticides has been reported in FCM. Egg parasitoids occur naturally in citrus orchards and can parasitise up to 80% of FCM eggs. Entomopathogenic fungi (EPF) previously resulted in significant mortality against FCM, while EPN were found to control >90% pupae and emerging adults in laboratory bioassays. Most control measures for FCM are targeted towards citrus orchards, and information on alternative management in deciduous fruit and grapevine is lacking. The main aim of this project is to determine the efficacy and the application of biological control agents under small-scale field experiments against the false codling moth.

Methods

Objective 1

Five EPN and five EPF species will be evaluated against FCM larvae and pupae, using laboratory screening bioassays. The LD50 of the two best performing EPN and EPF species against larvae and pupae will be determined by means of a logarithmic-dose probit-analysis. EPN and EPF combination bioassays against larvae and pupae will be carried out at different application intervals to assess interactions.

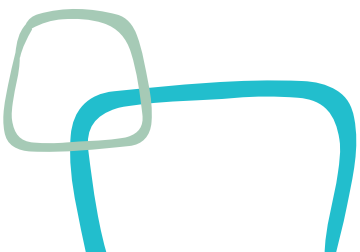
The LD50 of the two best performing combination treatments will be determined using above-mentioned methodology.

Key Results

Results will be available at the conclusion of Objective 1 in November 2019. Preparations for laboratory bioassays (treatments) were done, and FCM will be inoculated during August 2019. Inoculation will take place twice a week, weekly, for 13 weeks. Data will be analysed continuously.

Conclusion and Discussion

None to date.



Assessment of management methods against pome fruit mites

(T Platt and P Addison)

Objectives and Rationale

Mites are an increasing problem in certain pome fruit growing regions in the Western Cape Province, South Africa due to a combination of factors such as drought/climatic conditions, acaricide resistance, incorrect application of monitoring protocols and management practices, or a breakdown in biological control. The aim of this project is to investigate potential contributing factors in the Ceres, Villiersdorp and Elgin areas to determine the reasons for these mite outbreaks over two seasons. The project will allow for the current integrated management recommendations to be objectively reviewed and amended where needed.

Methods

A questionnaire will be distributed to farmers to assess awareness of, and adherence to, correct mite monitoring and control protocols in orchards.

Monitoring and spray application data will be obtained, where available, to assess relevant drivers of spatio-temporal mite distributions.

Mite populations will be monitored both on trees and in surrounding cover crops, to determine correlation between percentage cover and type of cover crops to mite infestations.

Bioassays will be performed to determine the susceptibility of both phytophagous and predatory mites to registered acaricides.

Data will be analysed via machine learning to determine interactions between the different patterns and draw overall conclusions.

Key Results

The trial was originally scheduled to begin in August 2018 but was not approved to begin until mid-summer 2018. Site scouting was performed in early 2019 but no naturally-infested sites were discovered in any of Ceres, Villiersdorp or Elgin, and subsequently no action was able to be taken.

Conclusion and Discussion

No suitable trial sites were able to be identified in late 2018/early 2019 (at sites such as Windermere and Oak Valley) and as such no milestones have been completed as of June 2019. The low recorded rainfall and drought conditions may have contributed to the difficulties in mite infestation identification. It is suggested that sites be re-scouted in early/mid-summer of 2019, just prior to serious mite infestations.

Sequencing the genome and transcriptome of false codling moth, Thaumatotibia leucotreta, for pest management

(J Terblanche and M Karsten)

Objectives and Rationale

The development of novel control methods for false codling moth (FCM), *Thaumatotibia leucotreta* (Meyrick) is an urgent priority for several fruit kinds to maintain current and emerging market access. Here we aim to develop a new genomic and transcriptomic toolkit for FCM in order to support novel population control methods and better understand the rapid evolution of, and constraints on, pesticide resistance and environmental stress adaptation and potential interactions between these.

Methods

FCM larvae were obtained from XSIT (Citrusdal) to initiate full-sib families and to use as starting material for DNA extractions. DNA was extracted using the QIAGEN DNeasy Blood & Tissue kit and sent to MACROGEN. Laboratory rearing of full-sib families was initiated by mating moths received from XSIT with their siblings for multiple generations.

Key Results

DNA sent to MACROGEN last year failed their rigorous quality control tests for Illumina mate-pair library construction. Sufficient DNA has been obtained for shotgun library construction to initiate sequencing of the FCM genome. To obtain sufficient DNA for mate-pair sequencing, protocols have been modified and additional reagents procured. Multiple attempts to rear full-sib families have failed. This is largely due to secondary microbial infections and discussions with XSIT has provided information for successful rearing with attention given to sterilization of equipment and switching to artificial diet provided by them.

Conclusion and Discussion

Despite major setbacks with regards to DNA extraction and laboratory rearing of moths which was unexpected, new methods and protocols should get us back on track to deliver milestones.

Exploration of orchard sanitation and the potential of parasitic wasps for the biological control of fruit flies in South Africa

(P Addison and B Stead)

Objectives and Rationale

The objectives of this project are to i) identify (morphologically and molecularly) the diversity of parasitic wasp species in South Africa and their relative importance in controlling fruit flies; ii) search for biocontrol agents in the area of origin of fruit flies (rest of Afrotropical region) in view of future introductions; iii) highlight the trophic associations between fruit flies and their parasitoids (utilizing a DNA metabarcoding approach), and iv) perform initial testing of augmentoria, which could greatly assist with orchard sanitation.

Methods

Subsequent to extensive surveys, all samples will be subject to DNA extraction, PCR amplification and sequencing the mitochondrial Cytochrome Oxydase 1 to construct a DNA barcode database using conventional molecular methods. Lastly, an augmentorium (orchard sanitation method) will be tested to optimize and adapt the technique according to optimal size of netting to match size of local parasitoids.

Key Results

Two main Opiinae wasps (biological control agents) of fruit flies have been identified in SA: *Fopius ceratitivorus* and *Psyttalia humilis*.

70 morphospecies of Opiinae from the Afrotropical region have been identified and sequenced for the standard COI gene. They are candidates for potential future introductions in SA.

A substantial contrast was observed in the distribution of fruit fly parasitoid species between the regions studied and between fruit types.

In appropriate locations and for specific fruits, augmentoria allow a mass-release of Opiinae biological control agents of fruit flies.

Conclusion and Discussion

South Africa shows two main species of Opiinae that are efficient biocontrol agents and that can be used via augmentative techniques. However, we found an important variation of the abundance of these parasitoids among the localities and fruit types considered.

Determining the contribution of wild honey bees (pollination ecosystem service) to commercial deciduous fruit production

(R Veldtman and M Allsopp)

Objectives and Rationale

Deciduous fruit orchards found in landscapes with a high percentage of semi-natural areas may receive a pollination service from wild honey bees. If their contribution is significant it would have implications for industry recommended hive stocking rates, as well as in the maintenance of these semi-natural areas for the ecosystem service they provide. At present, however, there is no method to determine what percentage of honey bees active on a crop are from managed and introduced colonies, and what percentage are from wild colonies.

We aim investigate the contribution of wild versus managed honey bees as pollinators in a deciduous fruit crop under different landscape contexts in the Western Cape. Seeing as field observations alone cannot determine if observed honey bees are wild or managed, we propose to determine this ratio by manipulating introduced honey bee hives.

Methods

By using hive boxes that can regulate the foraging of the colony, counting foraging bees when the colonies are closed compared to when they are open, we can determine the percentage of honey bees from introduced versus wild colonies. We will use early flowering plums as our study crop. This experimental approach is novel and no device has been developed to allow for the easy separation of returning honey bee foragers from outgoing foragers, without disruption.

Key Results

None as yet. The first device failed to adequately separate the incoming from the outgoing foragers, while the second device succeeded in this purpose but only at the cost of causing unacceptable levels of disruption around the entrance of the colony. A third improved device also failed to result in natural foraging levels, as both departing and returning foragers continued for more than a week to circumvent the device, thereby disrupting foraging.

Consequently, the 'two-way device' plan has been discontinued for the present, and a simple hive closure + recess chamber system has been designed and tested, which results in colonies stopping foraging when closed, and without significant disruption to the colonies as the returned foragers remain in the recess chamber until the hive is re-opened. Thereafter, normal foraging is quickly resumed.

Conclusion and Discussion

The two-way entrance without foraging disruption system has been concluded to not be the best option for this project, and has been discontinued. However, a simple modified hive closure system has been designed that meets the objectives and will allow for the determination of wild versus managed bees in any setting. This new system will be thoroughly tested under field conditions in October 2019, and will be tested on commercial plums in various settings in the 2020 season.

False codling moth population genetics: gene flow in agricultural environments

(J Terblanche, M Karsten and E Huisamen)

Objectives and Rationale

The false codling moth (FCM), *Thaumatotibia leucotreta* (Meyrick), is a polyphagous pest attacking many crops of economic importance and is listed as a quarantine pest for most of our export markets. Here we aim to investigate the gene flow of FCM in orchards and non-orchards across South Africa to identify potential movement pathways and possible host races. In addition, the possibility of refugia will be explored in the Western Cape Province and kinship analyses will be used to track moths and provide estimates of dispersal

Methods

Fruit infested with FCM were procured by field collections around the Western Cape Province as well as by contacting relevant stakeholders and farmers. Fruit or larvae collected from other provinces were couriered to Stellenbosch University. All samples were stored in alcohol for genetic analyses.

Key Results

Fruit infested with FCM have been collected from two provinces (Western and Eastern Cape) from 12 locations and multiple hosts (navels, plums and pomegranates) and several additional areas have been identified for future collections focussing also on other provinces. Collections of FCM from orchards and home gardens, as well as other alternative host plants have also started in a demarcated area around Stellenbosch and will continue until mid-2020.

Conclusion and Discussion

No conclusions can be made at this stage, and is typical of this type of molecular work, but the project is on-track for completion within the proposed timeframe.

Maintaining and rearing of insect cultures (M Addison and T Asia)

Objectives and Rationale

The objective of this project is to establish and maintain different insect species in a laboratory environment to assist researchers and currently enrolled post-graduate students in developing integrated pest management technologies. These studies are all current and cannot be completed without the supply of suitable insects.

Methods

The following insects were reared in the laboratory in 2018/2019: codling moth (*Cydia pomonella),* trichogramma wasp (*Trichogramma lutea*), Mediterranean fruit fly (*Ceratitis capitata*), banded fruit weevil (*Phlyctinus callosus*), wax moth larvae (*Galleria mellonella*) and *Lobesia vanillana*. All of these insects were reared on different artificial mediums except the banded fruit weevil which was reared on carrots using a new rearing method.

Key Results

An average of 15 000 codling moths and 1 000 Mediterranean fruit flies were reared weekly. A total of 951 banded fruit weevil larvae and 250 adults were reared. An average of 200-250 Lobesia moths were reared weekly. In addition, a Trichogramma wasp species was maintained in culture.

Conclusion and Discussion

A medium-scale, multi-rearing system was successfully maintained. There was an increasing demand for rearing and maintaining a variety of insects, and the facility was able to supply researchers with adequate material.

Pest and disease monitoring in orchards under shade net

(M Addison)

Objectives and Rationale

The use of shade netting in apple orchards is becoming common place. The effects on the pest and disease complex in covered orchards is poorly understood. This study is aimed at determining the effects of shade netting on the pest and disease complex. In addition, aspects such as soil health and orchard floor management practices will be assessed where possible.

Methods

Orchard A23 on Oak Valley Estate in Elgin was selected for the purpose. The orchard is fully enclosed with 20% white shade cloth. The orchard is 2.45 ha in extent and is planted to Granny Smith on a range of rootstocks (CG.222, M.7, M.9, M.109). The orchard was planted in 2012 and extended in 2013. The orchard is contiguous and no untreated (trees without nets) area is available for comparative purposes.

Standard pest and disease monitoring protocols were followed in the orchard. Pre-harvest fruit damage assessments were carried out by inspecting 10 fruit per tree on 25 trees per block. In addition on farm monitoring data were collected. Additional soil sampling was conducted where possible according to standard protocols.

Key Results

Pest monitoring data indicates the orchard remains codling moth free, woolly apple aphid and banded fruit weevil appear to be an increasing problem. A geometrid moth, *Cleora tulbaghata* has been "captured" in the orchard and causes extensive leaf and shot damage.

Fruit damage assessments indicate that woolly apple aphid and banded fruit weevil are problematic in the orchard despite routine control measures being applied. Soil sampling to determine the nematode populations and the status of soil health indicate that the soils remain disturbed and unbalanced. In addition, root lesion nematode species are increasing both in the tree and work row.

Conclusion and Discussion

Pest and disease monitoring should continue in the orchard. The project should be extended to assess the effects of shade netting on orchard floor management including cover crops in additional orchards.

Using biological control (fungi and nematodes) against two sporadic pests in vineyards and orchards

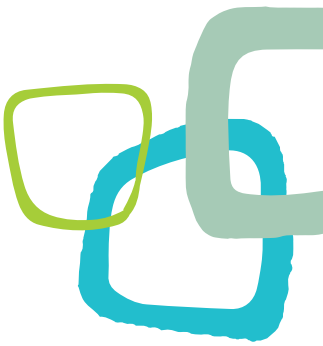
(P Addison and B Dlamini)

Objectives and Rationale

Katydids (*Plangia graminea*) and weevils (*Phlyctinus callosus*), BFW, are sporadic pests of vineyards and orchards in the Western Cape province of South Africa. They primarily feed on foliage, which during pest outbreaks, may result in reduced vigour and stunted development. An increase in their density and distribution have been reported, and no agrochemicals are currently registered for their control. Previous research identified possible biological control agents, including entomopathogenic fungi (EPF) and parasitic wasps. The aim of this study was to (i) evaluate the efficacy of EPNs and EPF against katydids and weevils; (ii) to determine an estimate of katydid geographical distribution and to (iii) record observations made in field and laboratory populations.

Methods

Field collected insects were screened against 12 in vivo-cultured EPN species at 200IJ / insect, in a laboratory environment, incubated at 25˚C and >95% RH for 48 h, after which mortality was assessed. Geographical distribution was estimated by plotting reported and verified katydid occurrence sites. In total, 70 soil samples were collected from deciduous fruit orchards and vineyards in the Western Cape. The soil samples were baited with mealworms, Tenebrio molitor (*Coleoptera: Tenebrionidae*) to trap EPNs and EPF. A field trial to determine the performance of *Steinernema yirgalemense*, applied at different concentrations, followed. The EPF were either applied alone, in simultaneous combination with *S. yirgalemense*, or 1 and 2 weeks after fungal application; the EPNs were also applied alone.



Key Results

Seven locally isolated EPN species achieved significant mortality, of which *H. zealandica*, *H. indica*, *S. jeffreyense* and *S. yirgalemense* performed the best (> 90% mortality). Katydids were reported from 36 locations, primarily in the Cape Winelands region of the Western Cape, of which 12 were confirmed by site visitation. EPNs were isolated from 17% (12) of the samples, with *Heterorhabditis bacteriophora* and *H. safricana* as the only two EPN species isolated. *Steinernema yirgalemense, H. noenieputensis,* and *Steinernema feltiae* resulted in significantly higher ($p < 0.05$) control of BFW larvae at a concentration of 100 IJs/insect, compared to the other EPNs, with no significant difference between each other. In the field trials, *S. yirgalemense*, at 20 and 40 IJs/cm2, gave 69% and 78% mortality for BFW larvae, respectively. The results showed that all EPNs screened controlled the different life stages of the BFW. Results showed that 100% larval and adult mortality was obtained when S. *yirgalemense* was applied 1 or 2 weeks after Eco-Bb and BroadBand®.

Conclusion and Discussion/ Recommendations

Katydid nymphs have proven susceptible to EPN infection. The efficacy of in vitro-cultured EPNs in field trials, in combination with adjuvants and as part of an IPM program, would further provide clarification on the value of EPNs as biological control agents.

Both entomopathogens have shown outstanding potential to control the BFW when used alone, and in combination, could provide an economically viable control strategy against the BFW. Laboratory trials have shown the viability of using alternative control methods to chemicals. The next step would be to field test these products on a larger scale to assess the practicality and efficacy.

Integrated management of the control of false codling moth, Thaumatotibia leucotreta, on stone fruit and table grapes

(P Addison and V Steyn)

Objectives and Rationale

False codling moth (FCM), which is a priority pest on stone fruit, has recently become a problem on table grapes, posing phytosanitary restrictions in terms of export fruit, as well as direct crop damage. This project aims to investigate the use of biological control and mating disruption as alternate control methods for FCM.

Methods

Soil surveys were conducted in the Western Cape, so as to establish what pathogens (nematodes and fungi) are present. Newly collected and known species/strains were tested in bioassays against FCM eggs, larvae and pupae. Mating disruption experiments were executed in stone fruit and table grape blocks to determine the level of disruption for six doses (0,1/3FD,2/3FD,1FD,4/3FD,8/3FD) and for five densities of Isomate™.

Key Results

Soil survey

Entomopathogenic fungi – nematodes isolated from soils.

Bio-assays

EPN collected (*H. indica, H. bacteriophora, H. zealandica*) from soil.

EPN caused mortality in eggs (first record,30-70%), larvae (70-100%) and pupae (8-27%)

EPNs caused high mortality and persisted 4 weeks after application in field trials.

EPF caused larval mortality (20-77%), strains require identification.

Mating disruption experiments

Field work complete total of 94 releases.

Mating disruption works against FCM in stone fruit and table grapes.

0.33xField dose to 1xField dose=83% disruption, 1.33-2.66xField dose=96% disruption.

800 dispensers/ha or its equivalent release rate is the optimal dose.

36 clusters of dispensers similar disruption to 800 single dispensers.

Conclusion and Discussion

It is evident that the alternate control methods tested to date against FCM work well and should form part of an integrated control program against FCM. Control of FCM entering orchards from neighbouring areas may become important to consider.

The effects of biotic and abiotic factors on the distribution of economically important weevils in the deciduous fruit industry

(P Addison and M Magagula)

Objectives and Rationale

The objectives of this project will include: 1) determination of the influence of soil type on weevil distribution, 2) determining the influence of orchard floor management practices (eg, cover crops), 3) establishing the relative abundance of economically important weevil species and user-friendly keys for the identification of the species involved. The aim of this study will be to yield valuable information in developing improved weevil management related to both soil texture and cover crop variability (cultural control methods), as well as prioritizing the species that should be targeted for management purposes.

Methods

Farms with a history of weevil infestations will be selected in two or three regions (e.g. Ceres, Elgin and a coastal region). Monitoring will take place once per month, using weevil bands (double-sided cardboard bands) and plant (buds, leaves, stems and fruit) damage assessments. Collection of geographic and biological attributes will include: soil, slope, location, orchard design (number of trees/vines/ha, row spacing, irrigation, fertilization etc.), cover crop assessment (type, estimation of% cover, ratio between broad leaf and grass species).

Key Results

There were nine weevil species found to occur in apple orchards and vineyards, all belonging to the family *Entiminae* (root weevils). A peak in adult populations were reached between November and December, after which the population dropped drastically from January up to May. *P. callosus* was the most abundant weevil species and it accounted for 82% of all the weevils collected during the survey. Most damage took place during the pre-thinning assessment and to a lesser extent in the pre-harvest assessment. Most of the damage in apple orchards and vineyards was attributed to *P. callosus*, with the remaining weevils contributing to some damage. The results further indicated that there was no significant (P = 0.05) relationship between either soil chemistry, soil bulk density, soil texture, ground cover percentage and weevil population.

Conclusion and Discussion/ Recommendations

This study identified and recognized nine weevil species causing damage in vineyards and apple orchards in the Western Cape Province, South Africa, of which one was recorded for the first time in vineyards, as well as assessing the effect of abiotic and biotic attributes towards the population of weevils on these crops. Monitoring should take place starting in early October and control should be applied as soon as weevils are noticed. Abiotic factors were not found to play a role in this study, but should be assessed over a larger area, for a longer time period.

PHYTOSANITARY AND MARKET ACCESS

Confronting Climate Change Initiative **(A Blignaut)**

Objectives and Rationale

The CCC carbon emissions calculator not only provides the fruit and wine industry with a method to calculate and report on their carbon emissions but also ensures the continued monitoring of emissions which provides opportunities to raise awareness on appropriate mitigation and adaptation techniques within the agricultural sector. The overall objective of the Initiative is to assist the fruit and wine industries in enhancing their competitive position, to proactively protect market access, to proactively respond to the challenges of climate change and to enhance the sustainability of farms, packhouses, wineries and the industry as a whole.

Methods

Carbon emissions and consumption data on farm, packhouse, cold store and winery level is collected through submission by the producer via an on-line data entry interface. The carbon footprint is calculated in the background using the data entered by the user and a PDF report is generated for the user. Training through workshops as well as telephonic and email support is offered to users. Communications takes place via a bulk email list, the website, industry websites and communication channels and twitter. Data quality is managed through a benchmarking process of sense-checking of the data.

Key Results

The user numbers, number of completed carbon footprints as well as the number of data points within the benchmark reports continues to grow year-on-year. The coverage within the table grape- and wine industry (specifically cellars) has significantly increased. Progress has been made with Grain-SA in a joint project with Blue North Sustainability. Two projects have been initiated with the Wintergrain Trust and the Maize Trust via Grain-SA. It follows three phases of which the first and second phase provides a snapshot carbon footprint and carbon sequestration respectively under different management regimes. Phase three involves a more practical approach with farmers in the form of workshops to raise awareness and train them on the use of the tool. The tool is excel based and can therefore not be distributed at this stage. Phase 3 has almost been completed for the Wintergrain Trust and Phase 1 for the Maize Trust. Approval has been obtained for Phase 2 of the Maize Trust project.

Conclusion and Discussion

The CCC project has reached the goals and targets set as per the approved business plan up to date. The CCC project continues to be an important resource to both industry and the producer to measure and manage inputs and to determine carbon emissions. The CCC project remains strategically important and allows for:

1. Better managed and more sustainable businesses
2. Enhanced industry competitiveness
3. Regulatory and Standards readiness & compliance

The Grain-SA projects are considered as very successful first steps towards potentially rolling out this carbon calculator tool in the grain sector. The project will continue throughout Phase 4: Year 3 with focus of broadening the reach of the project to other commodities and growing its commercial potential.

Ethyl formate fumigation technology – upscaling application towards commercialisation (S Johnson and R Smit)

Funded by the Post-Harvest Innovation (PHI) Programme

Objectives and Rationale

Ethyl formate fumigation is the most promising alternative to replace methyl bromide fumigation as a postharvest treatment for a wide range of phytosanitary pests. Also, ethyl formate is highly effective against a key phytosanitary pest of South African export fruit, the grain chinch bug, *Macchiademus diplopterus*, a pest that until now, has been very difficult to control. The aim of this project is to develop technology for large scale fumigation of export fruit using ethyl formate, as opposed to Vapormate® (a formulation of ethyl formate with some challenges for large scale application).

Methods

We visited international research centres where other scientists are also working on the development of ethyl formate fumigation technology for postharvest use, to gain insight and knowledge from their experiences and expertise. We have contracted engineers to design and build an ethyl formate dispensing system for application of the fumigant in a modified shipping container.

Key Results

The research visits provided valuable networking opportunities with relevant postharvest research scientists, and contributed to the design and decision-making around the dispensing system and protocols for fumigation. A nozzle system to introduce liquid ethyl formate into the fumigation space was designed and tested. Effective control of grain chinch bug was achieved using this system.

Conclusion and Discussion

We have successfully developed a dispensing method for liquid ethyl formate into a shipping container under safe conditions, using a N_2 generator and gas sensors (O_2 and ethyl formate) to monitor levels throughout the process. We are now in a position to use this system to obtain efficacy data for various insects, conduct fruit quality assessments, and ultimately upscale the system for application in cold room capacity.

PRE-AND POST-HARVEST PATHOLOGY

The influence of climatically different seasons on the reproductive strategy of Venturia inequalis and the RIMpro disease forecasting model

(A McLeod and E Froneman)

Objectives and Rationale

Apple scab (fusi), caused by *Venturia inaequalis* is a destructive disease of apple. Previous research (*Evaluating an ascospore release forecasting model and orchard disease monitoring methods for improving apple scab management. (2015-2018)*) suggested that conidia, instead of ascospores, may be an important source of primary inoculum during dry and warm autumns. This information is important for evaluating the RIMpro disease forecasting model. The objectives of the study are (i) to re-evaluate the primary inoculum source/s of fusi using a population genetics approach and (ii) to evaluate the RIMpro prediction model.

Methods

Laboratory-based pre-spring evaluation of ascospore production was conducted by collecting fusi leaf lesions one month after leaf fall in five orchards, using a published protocol. RIMpro was evaluated in the 2018/19 season using spore samplers and trap trees. Fusi lesions were collected from the trees for a population genetic study using published simple sequence repeat (SSR) markers. A technique for direct genotyping from leaf lesions was optimized. Grower based potential ascospore dosage estimates were made in three orchards in May 2019 and leaves were overwintered for biofix estimates for evaluating RIMpro in the 2019/20 season.

Key Results

Laboratory-based pre-spring evaluation of ascospore production showed that no ascospores were present in any of the samples. Evaluation of RIMpro based on trap trees was only conducted in one orchard, which showed that the predictions were in general accurate, but that the last predicted infection event did not occur. Ascospore quantification from spore samplers must still be conducted. Fusi lesions from the trap trees have been SSR genotyped, but the data have not been analysed.

Conclusion and Discussion

A more accurate assessment of RIMpro for the 2018/19 season will be possible once ascospores have been quantified from spore samplers. Pre-spring ascospore analysis suggests that autumn was unconducive for pseudothecium development. However, since the positive control (lesions incubated in the cold room) also did not produce ascospores the methodology that we used may have been incorrect.

The effect of organic amendments on the severity of apple replant diseases in subsequent apple orchard replantings

(A McLeod and R Janse van Rensburg)

Objectives and Rationale

Apple replant disease (ARD) is a phenomenon where the growth of young apple trees is reduced when replanted into soil previously cultivated with apple, due to the long-term build-up of a complex of ARD causative agents. Currently, there is no known strategy to prevent this pathogen build-up, but compost and mulch applications may have potential. The main aim of the project is to determine whether the long-term application of mulches and/or compost can reduce ARD in subsequent re-plantings. Sub-aims are to determine whether there are (i) specific soil quality factors associated with ARD suppressive orchard treatments and (ii) if *P. cactorum* inoculum builds up in orchards through colonization of tree debris.

Methods

Bioassays will be conducted with the orchard soils in glasshouse trials to evaluate the ARD suppressiveness of treatments by applying soil pasteurization or semi-selective chemicals (fluopyram, phosphonates and mefenoxam) to determine the increase in apple seedling growth relative to untreated soil. The dosage of semi-selective chemicals will have to be optimized for the glasshouse trials. The build-up of *P. cactorum* inoculum in apple tree debris will be investigated using baiting and qPCR approaches.

Key Results

Progress with the project is not up to date since a PhD student could not initially be identified. Subsequently, a student was identified but she could not start working until September 2019 due to her MSc thesis reports being outstanding. Apple seedlings for the glasshouse trial have been produced, and the first glasshouse trials will start in September 2019.

Conclusion and Discussion

The lack of progress to date will be made up for once the PhD student starts working on the project. Furthermore, a post-doctoral fellow, funded by Thrip, will also start working on the project in January 2020 to further assist in achieving the project goals in a timely manner.

Evaluation of pruning wound protectants on nursery apple trees

(L Mostert and G Gatsi)

Objectives and Rationale

Wounds made when rootstock shoots are pruned back on nursery trees can get infected by canker and wood rot pathogens. These infections can develop into cankers causing dieback of young apple trees. Alternatives to current wound protectants need to be investigated to improve the protection provided on these wounds.

Methods

The evaluation of fungicides for their efficacy towards mycelial growth inhibition of three canker pathogens and one wood rot pathogen were done. Potted M.793 plants were used to evaluate the same pruning wound treatments on rootstock wounds exposed to artificial inoculum of *Diplodia seriata*.

Key Results

The fungicide sensitivity assays showed that isolates of *Diaporthe eres* (B), *Didymosphaeria rubi-ulmifollii*, *Diplodia seriata* and *Trametes versicolor* were sensitive towards tebuconazole and guazatine. Isolates of *Didymosphaeria rubi-ulmifollii* and *Diplodia seriata* were sensitive towards carbendazim. The best pruning wound protectants when challenged with *Diplodia seriata* conidia over the two time periods (challenged 1 and 7 days after application of the pruning wound protectant) were carbendazim and MT1+carbendazim. The industry standard (ABE Tree Seal) inhibited infections by 68% at 1 day and 86% at 7 days, though higher levels of inhibition were obtained with Neocil-plus, prochloraz, carbendazim and MT1+carbendazim.

Conclusion and Discussion

The results of the artificial inoculation trial give an indication of the fungicides that can be used for pruning wound protection (namely carbendazim and prochloraz), however, the field trials allowing a longer time of natural infection is needed to make final recommendations.

Alternatives for the management of apple replant disease

(A McLeod and D de Villiers)

Objectives and Rationale

Apple replant disease (ARD) is caused by a complex of biological agents that reduce tree growth on replanted apple soils. Semi-selective chemicals, which also include fenamiphos, have potential for managing ARD. Fenamiphos will likely be removed from the market soon. The objectives of this project are to (i) evaluate cost effective and sustainable alternatives for the management of ARD, (ii) determine if fluopyram controls ARD pathogens in addition to lesion nematode and (iii) develop quantification methods for additional ARD causative agents.

Methods

Five orchard trials were established from 2017 to 2018 to evaluate various treatments by measuring tree growth. Root samples were obtained for analysing ARD causative agents. Three apple seedling glasshouse trials were conducted with the orchard soils for determining the ARD status of the soils, and the efficacy of fluopyram.

Key Results

Based on glasshouse bioassays, two of the orchard soils likely do not have ARD or have a very low ARD severity. This was supported by the lack of significant increase in tree growth in the orchard trials due to fumigation. In two of the other orchards, although being ARD soils based on bioassay data, none of the treatments significantly increased orchard tree growth relative to the controls. In the fifth orchard, significant increases in tree growth were obtained with fumigation and with a treatment combining compost, mulch and semi-selective chemicals. Only two of the five orchard soils had high *Pratylenchus* spp. numbers. In a glasshouse trial, no significant increases in seedling growth were obtained in response to fluopyram in the one orchard soil; the other orchard soil must still be analysed statistically. Two of the glasshouse trials must still be evaluated. Two new qPCR assays for ARD agents have been optimized.

Conclusion and Discussion

Conclusions regarding the efficacy of alternative ARD treatments in the orchard trials might be hampered due to the selection of orchards that are not ARD orchards, and due to suboptimal cultural practices having been used for managing ARD. Compost, mulch and semi-selectives may have potential for managing ARD.

Determine fungicide efficacy using qRT-PCR for detection and quantification of Botrytis cinerea inoculum and viability on pear leaves as a substrate, before and after fungicide application

(P Louw)

Objectives and Rationale

The efficacy of fungicide control is dependent on the efficacy of the fungicide and effective application. The optimisation of these aspects has been identified by the fruit industry as a need to address. To identify the correct fungicides and application, it is important to determine fungal growth and fungicide application. Molecular biology has made it possible to accurately and sensitively quantify fungal inoculum levels. The aim of this project is to determine the efficacy of fungicidal treatments based on fungal growth dynamics after treatment using qPCR.

Methods

Leaves will be harvested for trials. The leaves will be surface sterilised and inoculated with *Botrytis cinerea*. Different fungicide treatments, time intervals (2h, 24h and 48h) and application efficacies will be evaluated. Samples (snap frozen) will be submitted for molecular processing (DNA extraction and qPCR) and analysis to determine the efficacy of the fungicide treatments and application methods based on fungal growth and reproduction (increase) after treatment.

Key Results

Fungicide treatments were obtained. An initial trial was conducted but abandoned. A new partnership (NDA drawn up and signed by both parties) was made with a company that specializes in plant genetics (CenGen). A new primer and probe set was identified and will be ordered once an initial test proves that the fungicides will not interfere with the DNA extraction process.

Conclusion and Discussion

Based on the new partnership, primers and probe set, and design, trials will be repeated / start in the 2019/20 season.

Screening apple rootstocks for tolerance to Phytophthora crown rot

(A Vermeulen)

Objectives and Rationale

This project aimed to test apple rootstocks for tolerance to crown rot (*Phytophthora cactorum*) as part of an integrated disease management strategy.

Methods

Two methods were tested as a screening technique for tolerance to crown rot.

Tissue culture plants of rootstocks were planted in *Phytophthora cactorum* inoculated soils and grown for four to six months. Total, root and shoot weight along with shoot length were measured.

Excised stem inoculations were also made to determine tolerance to crown rot.

Key Results

Isolations from soils after planting showed that the inoculation procedure worked as *Phytophthora* was isolated from the soil samples. Isolation from the roots was done on all the plants and only a few isolates were recovered from the rootstocks.

Statistical differences obtained could not be claimed to be tolerance to crown rot as the results differ too much over seasons.

Conclusion and Discussion / Recommendation

No visual differences in plant growth were noted in any of the seasons. When comparing percentage growth of the different rootstocks with each other, significant differences were obtained but it varied from season to season. The differences are thus more likely to be due to factors such as vigour and coping with the growing conditions than the influence of the pathogen. No definite conclusions can be made from these results.

It is clear that there is still no reliable screening technique that gives a clear reliable result for rootstock susceptibility or resistance to *Phytophthora catorum*.

Survey of stem canker pathogens on stone fruit propagation material and young stone fruit trees

(L Mostert and V Jacobs)

Objectives and Rationale

A wide variety of canker and Cylindrocarpon-like fungi were isolated from stone fruit nursery trees and propagation material. To establish their relevance, pathogenicity trials were conducted for i) possible stem canker pathogens and ii) Cylindrocarpon-like fungi.

Methods

Canker and wood rot species (66 isolates) were inoculated with mycelial plugs on two to three year old wood of two plum orchards, African Rose and Sunkiss. Shoots were harvested after 4 months, re-isolations made and the lesions measured. The Cylindrocarpon-like fungi (20 isolates) were plug inoculated on one year old detached dormant rootstock shoots of two cultivars (Maridon and Mariana). After 7 weeks, shoots were split, re-isolations made and lesions measured.

Key Results

All of the canker and wood rot species formed lesions significantly longer than the controls for both orchards. Brown to black lesions were seen, typical of canker pathogens. The longest lesions were formed by *Lasiodiplodia theobromae* isolates. For the detached shoot assay, all the Cylindrocarpon-like isolates formed lesions that were significantly different from the controls for both cultivars tested. The lesions formed on the rootstock shoots were brown to pale brown. The two *Ilyonectria liriodendri* isolates were the most virulent, forming the longest lesions.

Conclusion and Discussion

The pathogenicity testing of the canker and wood rot causing species confirmed their pathogen status. The role of the Cylindrocarpon-like isolates in stone fruit tree decline and dieback is still uncertain and would need to be confirmed with field observations.

Identification of inoculum sources of oomycetes, a major contributor to apple replant disease, and the management thereof

(A McLeod, M Nyoni and S Moein)

Objectives and Rationale

The major apple replant disease (ARD) causative agents in South Africa consist of oomycetes, with plant parasitic nematodes occasionally being involved. A selected group of fungi (Cylindrocarpon-like and Rhizoctonia spp.) can also play a role. The aims of the study were to determine (i) whether apple nursery trees and irrigation water are external inoculum sources of ARD, (ii) whether ARD can be managed using semi-selective chemicals (phenylamides, fenamiphos, imidacloprid and phosphonates) and to compare the efficacy of fumigants differing in chloropicrin content and (iii) to increase knowledge on the translocation and efficacy of phosphonates in apple trees when used to manage Phytophthora root rot.

Methods

The methodology for the first aim consisted of quantifying ARD causative agents from nursery trees and orchard irrigation water using traditional isolation methods and qPCR analysis. The second aim was investigated through three orchard trials where various soil treatments were applied, followed by tree growth evaluations (stem diameter, shoot length and yield) over a 4- to 5-year period, and the quantification of ARD causative agents in roots. For the last aim, five orchard trials were conducted; two trials to investigate phosphite (breakdown product of phosphonates in trees) translocation in trees and three trials to investigate the management of Phytophthora root rot when different phosphonate application methods (stem spray, stem paint and foliar sprays) were used. The latter five trials were evaluated by measuring phosphite concentrations and *P. cactorum* quantities, whereas tree growth and yield evaluations were conducted in three trials.

Key Results

Apple nursery trees were identified as a source of ARD causative agents, with the most prominent being *Pratylenchus spp*. and *Pythium irregulare*. ARD causative agents were rarely found in irrigation water.

In ARD orchard trials, the higher dosage chloropicrin fumigant was in general more effective than the lower dosage chloropicrin fumigant. The semi-selective chemicals combined with the low chloropicrin fumigant was also an effective treatment. These two treatments increased yields (14 to 122%) over a 3-year period. Although the independent use of semi-selective chemicals increased tree growth to a manner similar than the fumigants, yields were only significantly increased relative to the control in one of the trials.

Translocation of phosphite to roots is highly effective when phosphonates are applied as foliar sprays. In Phytophthora root rot symptomatic orchards, phosphonates increased yield meaningful ($P = 0.0631$) and in general irrespective of application method. Trunk diameter was increased over 2-years in two of the three trials. *P. cactorum* root DNA concentrations were significantly reduced in two of the three trials, irrespective of application method.

Conclusion and Discussion / Recommendation

The use of a higher chloropicrin containing fumigant (57% chloropicrin and 38% 1,3-di chloropropene) is recommended for fumigation of ARD trials. Due to the potential contamination of apple nursery trees with ARD causative agents, the application of semi-selective chemicals is recommended at planting.

Phosphonates have potential for managing *Phytophthora* root rot in apple orchards. Data have been generated for the registration of phosphonates against *Phytophthora* root rot on apple, but more trials may be required for registering the product in South Africa.

The role of stress factors in predisposing plum trees to invasion by bacterial pathogen Pseudomonas syringae pv. syringae

(T Coutinho, K Bophela and M Modiba)

Objectives and Rationale

There is anecdotal evidence that abiotic factors such as drought, soil conditions, extreme temperatures, etc., impact on bacterial canker outbreaks caused by *Pseudomonas syringae* pv. *syringae* on stone fruit trees. The project objectives were: i) to determine the link between ring nematode infestation and bacterial canker outbreaks, ii) to determine the link between *Phytophthora*, and bacterial canker outbreaks, iii) to study the effect of drought and ring nematode stress combination in predisposing plum trees to *Pseudomonas syringae* infection, and iv) to study the effect of *Phytophthora* or other Oomycetes as a biotic stress factor in predisposing trees to infection. Circumstantial evidence supports the hypothesis that abiotic and other biological factors have an impact on bacterial canker of stone fruit trees. The reason for the inclusion of *Phytophthora*/other Oomycetes is that when visiting plum orchards, typical symptoms associated with this pathogen were noticed.

Methods

Four disease surveys were conducted in September/October 2016, March 2017, October 2017 and March 2018 in the major plum-producing farms in the Western Cape Province to assess disease prevalence and severity as well as to collect plum rhizospheric soil samples for estimating the population of ring nematodes and *Phytophthora* present in the soil.

Bacterial isolations were performed from plum trees displaying symptoms of bacterial canker from all farms visited. A semi-selective (King's B) and general medium (Nutrient agar) was used. Identification of strains was achieved by sequencing *cts*, *gapA*, *gyrB* and *rpoD* genes.

Baiting technique was used to isolate Oomycetes from the rhizospheric soil, followed by the transfer of lesions from the baiting material onto selective media NARPH. Oomycetes from infected plant material (inner bark) were plated directly onto the selective media.

The effect of water stress on predisposing plum trees to infection by bacterial canker-associated pathogens, *Pseudomonas syringae* and/or *P. viridiflava* was investigated under greenhouse conditions using varieties 'Songold' (tolerant) and 'Sapphire' (susceptible).

Key Results

Severe wilting and death of plum trees was observed in the majority of the surveyed plum orchards which is indicative of high levels of water stress. Thirteen to 22% of trees surveyed displayed symptoms of bacterial canker. Additionally, the ring nematode populations in rhizospheric soils were low in 2016 and much higher in 2017 in the majority of the farms surveyed. This change in the population density is probably due to weather pattern shifts from cool conditions at the start of summer to very hot conditions at the end of summer.

Fifteen pseudomonad isolates were delineated to two phylogenetic groups within the *Pseudomonas syringae* species complex, namely, *P. syringae sensu stricto* and *P. viridiflava,* the latter not previously reported to be associated with bacterial canker of plum trees.

Phytophthora and other Oomycete species recovered from the rhizospheric soil were *Phytophthora multivora*, *Phytopythium vexans*, *Pythium coloratum*, *P. diclinum*, *P. irregulare*, and *P. ultimum*. The only species that was recovered from infected plant material was *Phytopythium vexans*.

Results from the greenhouse trial indicated that water stress did not have a significant effect on disease development; however co-inoculation of *Pseudomonas syringae* and *P. viridiflava* yielded larger lesions on both varieties tested.

Conclusion and Discussion

From our surveys, we found that bacterial canker in the Western Cape was caused by both *Pseudomonas syringae* pv. *syringae and Pseudomonas viridiflava.* Of the abiotic factors playing a role in plum tree decline, drought proved to be the most significance factor. The presence of ring nematodes had little to no effect on the incidence and severity of bacterial canker outbreaks. A *Phytophthora* sp. and other Oomycetes were isolated from rhizopheric soil surrounding symptomatic trees. Only *Phytopythium vexans* was isolated from symptomatic plant material. To determine if this biotic agents played a role in bacterial canker outbreaks in still in the process of being determined.

Thermal and non-thermal treatments of stone and pome fruit: Towards efficient phytosanitary measures

(O Caleb, Z Belay and N Nyamende)

Objectives and Rationale

Postharvest phyto-sanitary measures predominantly involve the use of fungicides. This contributes to the development of bactericide/fungicide resistant pathogen populations (Rahman et al., 2014), which in turn results in either the use of higher fungicide dosages and the consequent increase in toxic residues on fresh produce or the outbreak of resistant foodborne pathogens. Hence, there is a negative perception towards the use of synthetic preservatives and phyto-chemical measures in fresh produce (Munhuweyi et al., 2017). Conventional postharvest treatments based on thermal treatments, ensure microbiological safety via sterilization however at the cost of partial loss in nutritional and sensory qualities (Lado and Yousef, 2002). Thus, the aim of this project is to investigate the efficacy of cold plasma technology and electrolyzed/ionised water washing combined with appropriate packaging systems as effective phyto-sanitary measures. These technologies will be applied to different stone and pome fruits depending on applicability.

Methods

Electrolyzed water (EW) will be generated with different acidity and alkalinity strength using an Agrilyt-Generator (Schulz Systemtechnik GmbH, Visbek, Germany) equipped with a DEA-30 electrolytic cell (Elliod GmbH, Berlin, Germany), and with separating membrane between the anode and cathode. The following treatments will be investigated; a) EW with sodium chloride, and b) EW with potassium chloride on: (i) fungal spore infected fruit, (ii) non-infected fruit, while, (iii) fruit washed with chlorine water and (iv) fruit samples that are not exposed to any treatment or washing step will serve as controls). Each fruit batch (plums and peaches) will be exposed to one of the treatments for different duration of time (1, 5, 10, and 15 min) prior to packaging and storage at 0 ˚C for six weeks (4 months). Four batches representing the four treatment (consisting of 150 fruit per batch) will be used, and a minimum of three replicate for each batch per treatment will be taken on the sampling day.

Key Results

No report at this stage as we are in the final phase of setting up the electrolyte water system

Conclusion and Discussion

A review of the existing literature on the use of electrolyte water as an alternative treatment has been completed to date.

Pursuit of sanitiser products for potential use in the apple and pear industry

(P Louw)

Objectives and Rationale

Only a few fruit sanitation products are registered and currently available to the South African pome fruit industry. Exporting countries are continually placing restrictions on products available and residues allowed for sanitisers and other chemicals. The industry is thus in need of new products to be used as sanitisers. This study aims to test potentially new sanitation products for use in the pome fruit industry of South Africa.

Methods

New sanitiser products were identified. The efficacy of the products to sanitize water containing spores (*in vitro* trial) and other impurities (packhouse water) will be evaluated. Based on efficacy results, the most promising products will be identified for use on apples and pears.

Key Results

Bestcure, Hypercide, Wondercide and potassium sorbate were selected and sourced for evaluation. Initial trials are in progress.

Conclusion and Discussion

Numerous factors caused a delay in the project. Hand-over and selection / sourcing of products took longer than expected. Four products were identified. Some products will be combined with low concentrations of chlorine or other product if control efficacy proves to be below the required levels (initial tests).

Purification of antimicrobial lipopeptides produced by Bacillus spp. for biological control of postharvest phytopathogens in the perishable fruit industry

(R Pott, J van Johannides and G Teke)

Objectives and Rationale

The focus is separation and purification of LPs produced in Bacillus fermentations. The work investigates acid precipitation, solvent extraction, adsorption and aqueous two phase extraction for product recovery and purification, and builds on this to develop a process for LP production

Methods

A variety of methods used.

Key Results

Aqueous Two Phase Separation (ATPS) is proving effective for LP purification, and separation of homologues: Iturin and Fengycin reported to the polymer phase, separating out the surfactin. Recoveries of up to 90% have been seen. This is the first demonstration of this effect in the literature, and works surprisingly well – this work continues, with extension into eutectic ATPS. (This separation of homologues may not be necessary, from toxicology results).

Bacillus grown under high salt conditions showed equal LP production rates. A reactor has been designed which will take advantage of this for continuous LP production.

A chromatography column has been built, in order to purify large quantities of LP homologues, for use in the Plant Pathology work.

Conclusion and Discussion

ATPS is a good route for LP separation and purification, and continuous production in a new reactor is being tested. Chromatography is being used to produce testable quantities of Iturin and Fengycin.

The ATPS milestone from objective 2 continues (tied in with objective 4); the project remains ahead of schedule. The work has tied well with parallel projects in plant sciences, showing good anti-fungal efficacy from the crude extracts, and no toxic effects under usable concentrations.

Lipopeptides Fengycin and Iturin A as postharvest fungicide on pome fruit

(C Lennox, J Meitz-Hopkins and S Magwebu)

Objectives and Rationale

Cyclolipopeptides (CLP) produced by the biocontrol agent *Bacillus amyloliquefaciens* ,such as Fengycin and Iturin A have been identified as potential biological fungicides due to their direct growth inhibiting action against plant pathogenic fungi and their low toxicity to non-microbial organisms such as plants, fish and mammals as well as environmentally friendly characteristics. The aim of this study is to evaluate the efficacy of CLPs on fruit infected with *Botrytis cinerea* (causing grey mould on pears) and *Penicillium expansum* (causing blue mould on apples),and investigate the feasibility of using CLP as fresh fruit application.

Methods

The efficacy of fruit application of CLP to control *B. cinerea* and *P. expansum* was tested using acid precipitate of *Bacillus* culture filtrate. 'Packham's Triumph' pears or Golden Delicious apples were inoculated with three fungal isolates per pathogen species (curative application). Wounds were treated with Fengycin and Iturin A; and fludioxonil treated fruit was used as control. A microtiter assay was optimised to determine optimal spore germination time for the two fungal pathogens in presence of the CLP technical grade actives.

Key Results

Preliminary results from a fruit trial to control *B. cinerea* on pears showed efficacy of the lipopeptides at crude extract concentrations of 10 g/L. No phytotoxicity was observed on the CLP treated fruit. Fruit trials on apples showed that the highest dose of 10x CLP (2.79 g/L Fengycin, 0.63 g/L Iturin A) inhibited *B. cinerea* between 13-41%. While *P. expansum* (one of the three isolates tested) causing blue mould had 53% inhibition. HPLC results showed high concentrations of Iturin A and Fengycin can be obtained after 48 h incubation. The microtiter results for *B. cinerea* showed reduction when using Iturin A technical grade after 15 h of incubation which means there is potential efficacy at higher concentrations.

Conclusion and Discussion

Samples of CLP acid precipitate were prepared and confirmed the presence of Fengycin and Iturin A cyclolipopeptides in the supernatant of the *B. amyloliquefaciens* culture filtrate at adequate concentrations of 93.397g/L Fengycin and 26.543 g/L Iturin. From previous results, it was noted that lipopeptides do have an inhibitory effect on the pathogens, with *P. expansum* showing a 26% reduction in lesion diameter and *B. cinerea* a 32% reduction in lesion diameter.

The development of an integrated management strategy for Bull's Eye rot of apples

(C Lennox, J Meitz-Hopkins and A Russouw)

Objectives and Rationale

Neofabraea vagabunda infection on apples (c.o. Bull's Eye rot of apples; syn. *N. alba*) can result in significant levels of fruit decay in storage. The sporadic occurrence of this disease, and the absence of routine management strategies makes this disease a phytosanitary risk to export markets. In 2013 and 2018 China temporarily closed off its apple import market from Chile and New Zealand due to Bull's Eye rot infected apples. The aim of this project is to identify the components of a potential integrated management strategy for Bull's Eye rot

Methods

Isolates were obtained from Bull's Eye rot symptomatic fruit and identified with species-specific PCR. Pathogenicity testing of *Neofabraea* sp., were conducted on cv. Cripps' Pink, Golden Delicious and Fuji. Fungicide efficacy (fludioxonil and pyrimethanil) as a dip, drench and thermofog application were tested on artificially inoculated apple cv. Cripps' Pink and Fuji.

Key Results

Neofabraea sp. isolates (N=112) were collected and identified as *N. vagabunda*. Cultivars Fuji and Cripps' Pink were found to be highly susceptible to *N. vagabunda* in the pathogenicity test. Fludioxonil effectively reduced Bull's Eye rot incidence (>80%) as a dip treatment. Fludioxonil drench significantly reduced incidence on both cultivars (Cripps' Pink and Fuji). Better efficacy was achieved with cv. Fuji. Pyrimethanil as a drench, although significant, only reduced incidence on cv. Fuji by 26%. Thermofog treatment of both fungicides produced moderate control. Pyrimethanil efficacy was reduced significantly when artificially inoculated fruit are treated with a delay of 24 hours.

Conclusion and Discussion

Bull's Eye rot causal organism in the Western Cape is *Neofabraea vagabunda*. Cultivars Cripps' Pink and Fuji are highly susceptible to *N. vagabunda*. Fludioxonil can effectively reduce Bull's Eye rot incidence when applied as a dip and has moderate efficacy as a drench or thermofog treatment. Thermofog application of pyrimethanil could potentially serve as a control of Bull's Eye rot on cultivar Fuji. However, to conclude, testing of post-harvest fungicide efficacy on Bull's Eye rot is required on natural infected fruit in the orchard in order to present a definitive answer.

Lipopeptides for the biological control of postharvest phytopathogens

(R Pott, G Teke, D Baloyi, J Marais and S Magwebu)

Funded by the Post-Harvest Innovation (PHI) Programme

Objectives and Rationale

There is a need to develop new and alternative phyto-control agents, for use in post-harvest fruit protection. The aim of this project was to extend previous PHI projects on lipopeptides (LPs), produced *Bacillus* spp., as a bio-fungicide product. Within this aim three separate workpackages were developed: i) Production and testing of the LP product at scaled-up volumes, ii) Investigation of the efficacy of LPs against single spored isolates of *Botrytis cinerea*, causing grey mould on pears and *Penicillium expansum* causing blue mould on apples and iii) examine the toxicology of the product using zebrafish as models.

Methods

1. Scaled-up production of LPs

Bioflo110 1L and 5L reactors were used to cultivate *Bacillus* spp., under conditions optimised in previous PHI projects. LP product was recovered using acid precipitation. HPLC analysis determined purity and composition of the product.

2. LP product optimisation

Extractive fermentation using Aqueous Two-phase Separation (ATPS) was developed for LP purification (specifically Iturin and Fengycin purified from surfactin) using a PEG-salt system. Product partitioning and effect on organism growth was determined using spectrophotometric and HPLC analysis. Reactor development was conducted using a continuous extraction, backextraction fermentation system was developed and tested.

3. E50 measurement

Twenty key phytopathogens isolates of blue mould were isolated from symptomatic apples. PCR-RFLP and confirmation sequencing of selected isolates using a partial beta-tubulin gene region was used to determine species ID. A range of concentrations of LP product was used to amend liquid media containing resazurin dye indicating respiration. The EC50 of the two fungicidal compounds was determined in Statistica V. 13 from the growth curve.

4. Toxicology

Zebrafish embryos were exposed to various LP concentrations (against a control of zero concentration). Mortality, heart rates, length measurement, apoptosis and gene expression measured at various times post-fertilization.

5. In vivo testing

A 'challenge inoculation' method was used where fresh fruit were scored, inoculated with phytopathogen culture and various amounts of LP product. Rot was monitored over approximately 10 days, and an in vivo efficacy of our product against each phytopathogen determined.

Key Results

LP product was successfully produced under scaled-up conditions in 1L and 5L reactors. However, limitations with current reactor configurations were noted – a significant outcome of this project. In order to circumvent these issues, an extractive fermentation methodology was instituted, to recover the LP product in situ. This result significantly enhances the product, through removing the need for expensive further downstream processing steps. Further, a partitioned bioreactor system was developed in which this extractive fermentation can be done was developed and tested. LP product of consistent composition was produced and recovered using acid precipitation. This product was tested on HPLC to determine purity and composition (of the LPs: 72% Fengycin, 17% Iturin and 11% surfactin). The methodology of the resazurin-based microtiter assay was successfully optimised for *P. expansum*. *Botrytis cinerea* assay conditions had been optimised for other fungicides in a previous study. Both Fengycin and Iturin A did not sufficiently inhibit the two pathogens in vitro at the tested concentrations. High variation was observed, possibly due to an interaction of potato dextrose broth with the resazurin dye. A higher range of lipopeptide concentrations is currently also being investigated. Using a conventional methodology of amending potato dextrose agar with lipopeptide acid precipitate from the culture filtrate of *B. amyloliquefaciens*, it was shown that the higher concentrations of 2.79 mg/L Fengycin and 0.63 mg/L Iturin A

effectively inhibited mycelial growth of one *P. expansum* in vitro. Toxicology testing showed no toxic effect on zebrafish embryo development even up to surfactin concentrations of 100ppm. This significantly improves our understanding of the applicability of LP products, since it is the first study to examine this.

Conclusion and Discussion

The project successfully demonstrated the scale-up and production of LP product, even though it was identified that for industrial application, non-traditional bioreactor configurations will be needed. Steps towards developing appropriate reactor and separation technologies were made in this project, despite the short time frame. Encouragingly toxicology tests showed to toxic effects even under concentrated conditions, indicating that the product falls within safe consumption limits. In vitro testing showed some efficacy of the product against a number of phytopathogenic organisms, however, further testing will be needed to determine optimal product concentrations.

Evaluating the relationship between quantified Botrytis cinerea levels in pear fruit at harvest and the Botrytis rot incidence and severity at the end of storage: Towards the development of a Botrytis rot management model

(S Ferreira and I Wilson)

Objectives and Rationale

Post-harvest rot of pears is of major concern to the industry. *Botrytis cinerea*, causal agent of Botrytis rot, is the most important. Earlier studies have shown that there is likely to be a minimum inoculum threshold level required for rot symptom development, and it was thus important to determine the relationship between inoculum level and eventual decay symptoms. Molecular biology-based detection techniques have made it possible to accurately detect and quantify inoculum levels before visual symptom development, making it possible to investigate this relationship in more detail. The aim of this project was to create a standard curve which correlated the amount of inoculum on artificially inoculated fruit at harvest with eventual decay. A further aim was to determine whether samples collected from a variety of orchards fit into this standard curve.

Methods

Pear fruit were harvested from orchards and artificially inoculated with a variety of defined spore amounts, or kept uninoculated. Thereafter the *B. cinerea* inoculum level and decay incidence was measured after different periods of storage. Subsequently the data was analysed to investigate the relationship between spore amount present and eventual decay.

Key Results

The selected range of artificial inoculation spore amounts, method of application and conditions selected for incubation resulted in a decay data with high resolution over a large dynamic range.

The artificial inoculation experiment was representable of natural inoculum measured in orchards.

There was a strong relationship between *B. cinerea* DNA content and eventual disease incidence over a large dynamic range.

The project provides high quality, reproducible data in terms of the relationship between inoculum levels and eventual decay symptoms.

Conclusion and Discussion

The results provide strong support not only that the inoculum levels in the pear calyx-end can be accurately measured, but also that this measurement provides insight into the eventual decay levels that can be expected after storage, in relation to the level *B. cinerea* DNA measured in samples.

Develop a storage protocol for plums stored for 6 weeks in bins prior to packing - decay control using alternative gas regimes of CO_2 and O_2 manipulation, fungicides and GRAS products by drenching and Ozone treatment

(P Louw)

Objectives and Rationale

Decay control is an ongoing problem in the stone fruit industry. There are still too few postharvest treatments available for stone fruit. Numerous technologies are available in other industries [i.e. controlled atmosphere (CA) storage, drenching / dipping, UV, Ozone]. The aim of this study is to test different technologies to reduce decay of plum.

Methods

Different inoculation methods (spray and droplet inoculation) and spore concentrations of *Botrytis cinerea* and *Monilinia laxa* were evaluated on Angeleno plum following treatments to reduce decay development during storage. Three CA storage regimes (6 O_2/ 15 CO_2, 9 O_2/ 12 CO_2 and 12 O_2/ 9 CO_2) were tested, as well as six dip treatments (Bestcure 1X and 2X, Hypercide 1X and 2X, Teacher, Teacher + Support). Fruit were stored for 6 weeks at -0.5 ˚C and 5d at 10 ˚C (shelf life) before evaluated.

Key Results

Regime 1 (15% O_2 and 6% CO_2) and 2 (12% O_2 and 9% CO_2) significantly reduced decay, however not totally eliminating decay development. In some instances, up to 65% (regime 1) and 50% (regime 2) control (decay severity) was accomplished. Bestcure was ineffective and Hypercide showed low levels of decay reduction (depending on method and concentration). The benchmark set by the fungicide Teacher, exhibiting almost 100% control, will be difficult to equalise by GRAS products.

Conclusion and Discussion

Although dipping is less applicable to bins, it holds less of a risk for resistance build-up due to more complete and even treatment coverage than drenching. Combining dipping or drenching with CA storage (regime 1 or 2) can help to prevent resistance build-up and prolong storage. Combining GRAS products with CA storage can likely provide reduction in decay development for a stringent market (low or no MRLs). More research is needed to expand decay control measures.

Quantification of the presence of Botrytis cinerea, Monilinia laxa and Penicillium expansum in blossoms and plums at harvest, and correlation of relative pathogen presence to decay after shelf-life: Potential application of diagnostic information early in the season to use as a management tool of plum decay post storage and shelf life

(S Ferreira and I Wilson)

Objectives and Rationale

Post-harvest decay of plums results in significant economic losses to the stone fruit industry. The most prominent fungal species leading to decay is *Botrytis cinerea, Monilinia laxa* and *Penicillium expansum*. No method to monitor and quantify inoculum levels exist. The development and implementation of a tool to detect early infections could greatly assist in decay management. The aim of the project was to detect and quantify the levels of the three most prominent fungal species in blossoms and fruit at harvest, and correlate the levels to decay development after storage.

Methods

Blossoms were harvested from orchards and processed for qPCR analysis. Fruit were harvested from the same orchards and either processed for qPCR analysis for quantification of fungal DNA, or assessed for visual decay development at end of storage.

Key Results

1. *B. cinerea* could be detected by multiplex qPCR assay in all blossoms sampled and in some fruit samples prior to storage. The results were repeatable over the two seasons of the trial.
2. *M. laxa* could be detected by multiplex qPCR assay in some fruit samples, but not *P. expansum*.
3. A strong correlation was found between *B. cinerea* DNA in blossoms and decay development after storage. The decay was, however, described as "brown rot".
4. The correlation between *B. cinerea* in blossoms and overall decay at the end of storage was not observed in the second season of this trial.

Conclusion and Discussion / Recommendation

A relatively high correlation was observed between *B. cinerea* DNA content in blossoms and total decay at the end of storage (R^2= 0.75) during the first season of this project. The majority of the decay observed in the fruit was characterised as "brown rot", caused by *M. laxa*. *M. laxa* DNA was not detectable in blossoms, but was detectable in low levels in fruit prior to storage. It needs to be noted that decay development during storage was extremely slow, requiring an extended storage period of almost 60 days before adequate decay was observed. This correlation was not observed in the second season of the study.

Factors that influence the retention of fungicide residues on plums

(A de Kock)

Objectives and Rationale

Export countries regulate traces of chemicals legally tolerated on fruit. Maximum residue limits (MRL's) dictate the permissible residues. Non-compliance results in rejection of fruit upon arrival at export destinations, with concomitant financial loss. Variation in residues on fruit subjected to post-harvest fungicide application is sometimes experienced. To assist Growers and Packers, this study was initiated to determine the effect of cultivar, fungicide exposure time, fruit maturity, fruit temperature and fungicide solution temperature on residue retention, following post-harvest fungicide dip applications.

Methods

In 2018, Songold and Laetitia plums, each sampled at two harvest maturities were dipped in fungicide solutions with Fludioxonil the active ingredient. The variables included for testing, on the basis of resultant residue levels achieved, were: exposure time, fruit pulp temperature and fungicide solution temperature. In 2019, African Delight and Flavour Fall plums were also tested in addition to Songold and Laetitia.

Key Results

In 2018, plum cultivars reflected different residue levels following post-harvest fungicide dip applications. Residues were approximately 20% higher on Songold than Laetitia. Exposure times of 10 and 30 seconds, gave similar residues and these were significantly lower compared to 3 and 4 minutes exposure. Residues related to fruit and solution temperatures varied between cultivars. With Songold, temperatures influenced residues, but with Laetitia it had no effect. Similarly, harvest maturity affected residue levels on Laetitia, with higher residues on fruit of more advanced maturity. With Songold, harvest maturity influence on residue was inconclusive. In 2019, most of the parameters, namely cultivar, exposure time and fruit temperature had little or no effect on fungicide residues. Results associated with exposure times of 10 and 30 seconds were similar to 2018, and did not differ from each other at these durations. High fungicide solution temperatures resulted in higher residue levels.

Conclusion and Discussion / Recommendation

Special attention to cultivar, harvest maturity, fungicide exposure time and fruit temperature, within reason, is not required as the effect on residue loading on plums is minimal. High solution temperatures (± 40˚C) may result in higher residues. While this research was conducted using dipping, it is postulated that with atomizers, other factors such as calibration and solution concentration are likely to have a bigger effect on residues than the other parameters tested in this study.

Survey and investigation on the impact of various fungicide application methods and technologies on decay control of plums in the pack-house

(A de Kock and I Wilson)

Objectives and Rationale

Application of fungicides may be highly efficient for control of post-harvest decay of plums. However, successful control, without exceeding maximum residue limits, relies on appropriate and optimized fungicide application, dosages and methods. The aim of this study was to conduct a survey at various packing lines in plum pack-houses in the Western Cape to determine and review the specifications at which fungicide application technologies are used.

Methods

In the first year, atomiser systems of seventeen plum packing lines were surveyed to determine which fungicide application technologies were prevalent, and to gather information on system specifics. In the second year, selected packing lines were re-surveyed to establish if improvements had been made as a consequence of the first year's findings and recommendations.

Key Results

It was established that three fungicide atomising systems were in use:

a) Atomisation by nozzles driven by compressed air (60% of packing lines)

b) Atomisation by nozzles driven compressed (hydraulic) fluid (10% of packing lines).

c) Atomisation by spinning disks (30% of packing lines)

Factors critical for successful fungicide application using the atomizers were identified as:

a) Condition of the pumps

b) Mixing of the fungicide product

c) Condition of the pipes transporting the fungicide product

d) Concentration of the fungicide product

e) Spray deposition of the fungicide product on the fruit (number of heads, spacing, etc.)

Conclusion and Discussion

Fungicide cost cannot be considered a major driver in decisions regarding fungicide application, when application methods do not deliver the product effectively. Despite the certain problems identified, it was pleasing to establish that all the atomiser systems surveyed were capable of delivering adequate coverage of fungicide product to fruit. Focussed management of the critical factors influencing atomiser efficacy, as identified in first year of the study, was shown to improve fungicide spray deposition as evidenced in the second year. Good information to assist pack-house users to optimize atomisers for post-harvest fungicide application is provided in the report, with graphic illustrations to assist. In addition, a guide to assist optimization of atomiser systems on plum packing lines has been drafted.

QUALITY MANAGEMENT

The effect of a water deficit on fruit tree phenology, fruit production, fruit quality and storability of 'Fuji' and 'Cripps' Pink' apples

(S Midgley and S Daiber)

Objectives and Rationale

The current study aims to investigate outcomes of postharvest and preharvest water deficits on apple production in a pre- and postharvest context. More specifically the impact of water stress on bud break, flower quality, yield and postharvest storability; will be determined. Cultivars such as Fuji and Cripps' Pink, which exhibit water stress related disorders during drought, will be focused on.

Methods

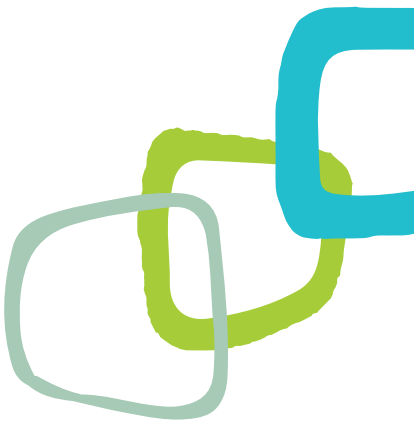
The apple trees were stressed after harvesting, by cutting irrigation lines of "treated" rows and covering the orchard floor with a thick tarp cover sheet to prevent rain from penetrating. Stem water potential readings were taken predawn during this period after trees were harvested, to quantify tree stress, as well as manual soil water potential readings.

Key Results

There are no results that can be reported during the current reporting period.

Conclusion and Discussion

The trial is on track to achieve its stated goals. 'Fuji' apples were successfully stressed postharvest, which can also be seen from current ongoing assessments, indicating delayed bud break.



Revision of FEMA release standards when fruit do not make FEMA firmness or sugar criteria

(D Viljoen)

Objectives and Rationale

Apart from the outstanding success of the FEMA Programme, there is still pressure from producers to release orchards as early as possible. One of the major challenges with this cultivar is that in many instances the two major release parameters, flesh firmness and sugar levels may remain constant and do not change over 2 or 3 weeks. In other instances one of these parameters may move while the other remains constant. This study will therefore determine whether fruit harvested with TSS values below 14%, or flesh firmness values above 6 kg will be of acceptable eating quality after a storage period of 5 to 6 weeks.

Methods

Fifteen 'Forelle' orchards were selected from maturity data obtained from Hortec. Orchards were selected using the following firmness and TSS levels: firmness 6.0 – 6.5 kg and TSS > 14.0%, firmness > 6.5 kg and TSS > 14.0%, firmness < 6.0 kg and TSS 13.0 - 14.0%, firmness < 6.0 kg and TSS 11.0 - 13.0%, and firmness < 6.0 kg and TSS > 14.0% (Normal FEMA release). Fruit were subjected to a FEMA rate SmartFresh^{SM} within 7 days after harvest and cold stored for 5 weeks in RA. Fruit were evaluated after end of cold storage and after a 7 day shelf life. Fruit were subjected to a taste assessment after shelf life.

Key Results

All milestones and all laboratory work were successfully met and are now complete. Interpretation of the data obtained from the taste panel will be discussed with staff from the Department of Food Science at the University of Stellenbosch as the data sets are quite complex.

Conclusion and Discussion

No conclusions to date.

To develop marketing protocols for FEMA designated orchards that are harvested two to three weeks after normal release but do not qualify for FEMA release

(D Viljoen)

Objectives and Rationale

Currently almost 50% of all South African 'Forelle', representing about 2 million cartons, are marketed under the FEMA programme.
As FEMA fruit can demand premium prices, producers identify an excessive number of orchards to ensure that they make their quota. FEMA released orchards arriving in the market early give the highest returns. Producers therefore often push a large number of orchards so that they stand the best chance of qualifying for the FEMA release standard. This often results in some orchards being harvested for standard release at a compromised maturity, especially in terms of colour break. The problem that needs to be addressed is how to best handle these fruit to ensure best eating quality either on the local or the export market. The aim of this project is to develop a marketing protocol for fruit that do not meet FEMA release criteria, but were from orchards designated for FEMA release.

Methods

Three 'Forelle' orchards in the Villiersdorp region were selected. These orchards have a history of flesh firmness's not lowering to an acceptable level for FEMA release in time. Fruit were harvested at normal 'Forelle' release and again two weeks later. Fruit were subjected to a pear rate and FEMA rate SmartFresh^{SM} and stored for 8 and 12 weeks at -0.5 ˚C in RA. After cold storage fruit were subjected to a 7 day simulated shelf life and a taste assessment.

Key Results

All milestones and all laboratory work were successfully met and are now complete. Interpretation of the data obtained from the taste panel will be discussed with staff from the Department of Food Science at the University of Stellenbosch as the data sets are quite complex.

Conclusion and Discussion

No conclusions to date.

Integrated post-harvest ethylene management along the value chain: From the farm to the consumer

(O Caleb, Z Belay and M Nkohla)

Objectives and Rationale

Accumulation of ethylene along the supply chain from farm to consumers could exert numerous detrimental effects on the desired postharvest quality attributes and shelf life of horticultural commodities. In order to identify suitable management strategies, a comprehensive study was conducted to establish possible concentration hotspots of ethylene through the fresh produce handling chain. The rationale of this project is to determine the impact of ethylene and to investigate the effectiveness of using photocatalytic oxidation techniques for ethylene removal.

The objectives for this period were:

a. To finalize the research proposal for approval by the university's Higher Degrees Committee.
b. To develop a proof of concept - Development of large scale system for photocatalytic oxidation of ethylene during postharvest storage of fruit.
c. To investigate pack-houses practices and to take into account the influence of exogenous ethylene originating from other sources besides the fruit itself.

Methods

The reactor is a flat plate type consisting of box type reaction vessel into which a TiO2 (catalyst) coated stainless steel plate and a LEDs (UV light source) mounted aluminium sheet will be inserted. Preliminary experiments will be conducted to test its effectiveness in reducing ethylene concentration. In the pack-houses, routine ethylene measurements were taken.

Key Results

Based on preliminary data, ethylene hotspots differed across the various pack-houses based on facility operations. Ethylene concentrations were significantly ($p < 0.05$) higher in RA pallet rooms with apples in comparison to those with pears. Storage rooms without fruit (empty) had moderately high to very high residual ethylene concentrations.

Conclusion and Discussion

A review of the existing literature indicates that at ethylene concentrations as low as 1 ppb, physiological stress could be induced in specific horticultural commodities. Therefore, the management of ethylene concentrations in pack-houses is crucial to maintaining quality attributes of fruit and vegetables, thus reducing postharvest losses. Photocatalytic oxidation of ethylene during postharvest storage of fruit tests has not been concluded.

The use of Harvista™ (pre-harvest 1-MCP) application to prevent green colour loss and reduce blush of 'Granny Smith' apples

(D Viljoen)

Objectives and Rationale

Many 'Granny Smith' apples are harvested at a maturity not suitable for the export market due to loss in green colour (white 'Granny Smith'). This is due to other, more lucrative cultivars such as Fuji and Braeburn apples reaching optimum harvest maturity at the same time that Granny Smith apples need to be harvested to satisfy the market need, or to seasons of high yield resulting in delayed harvest. Other seasonal and geographic factors may also play a role in loss of green skin colour in 'Granny Smith' apples, and the exact causative factors are not still fully understood and require further investigation. Certain 'Granny Smith' orchards may also experience pink blush on the fruit resulting in reduced export pack out. The aim of this project is to determine if the use of pre-harvest Harvista™ sprays (1-MCP) can prevent green colour loss and pink blush on 'Granny Smith' apples.

Methods

A 'Granny Smith' orchard in the Koue Bokkeveld region was subjected to a 1x and 2x Harvista™ application 28, 14 and 3 days before spray application. Maturity and efficacy samples were harvested at each spray application and 7, 14 and 21 days after commercial harvest. Untreated control fruit and fruit sprayed with 1x Harvista™ 28 days before commercial harvest were harvested to obtain commercial pack out data.

Key Results

All sprays were done successfully. Maturity and efficacy samples were harvested as planned. Commercial pack out data still needs to be obtained. Storage samples from the untreated control and from the treatment where 1x Harvista™ was applied 28 days prior to harvest still needs to be assessed.

Conclusion and Discussion

No conclusions to date.

The effect of DPA on fruit quality in pome fruit

(A Botes)

Objectives and Rationale

Previously, the South African apple and pear industry relied on diphenylamine (DPA) for controlling superficial scald disorder; however, increasing consumer concerns and reduction in maximum residue levels (MRLs) resulted in the industry rather using alternative control strategies. Since DPA is not used on fruit exported to the EU, it may lead to other fruit quality problems. The past few seasons a lot of internal browning issues occurred. The aim of this project is to determine the effect of DPA on fruit quality. These results may lead to a re-evaluation of the current recommended CA regimes for South African pome fruit.

Methods

Optimum harvested 'Cripps' Pink' apples from three sites from two production areas were subjected to five postharvest treatments. The trial was repeated over two seasons. Fruit quality evaluations were done after three storage periods.

Key Results

In 2017, fruit from the three sites in Grabouw had diffuse browning after 3 months of storage in all the treatments. In two of the sites, the DPA+RA and RA stored fruit tended to have the lowest percentage of diffuse browning after 6 and 9 months. In all the sites, the DPA+RA and RA fruit had soft scald after 6 months followed by 14 day shelf-life. In two of the sites all the treatments had soft scald after 9 months followed by 7 day shelf-life. Fruit from the three sites in Ceres had diffuse browning after 3 months storage which increased during the longer storage periods. Soft scald was found on RA and DPA+HCA stored fruit in all the sites at various storage periods. In 2018, all the treatments from all the sites from Grabouw resulted in diffuse and radial browning from 3 months storage. In two of the sites the DPA+RA and RA treatments tended to have the lowest percentage of internal browning. Soft scald was found on DPA+RA and RA stored fruit. 6 months RA is academic and not for commercial practice.

Conclusion and Discussion

The application of DPA did not prohibit the development of internal browning, neither diffuse nor radial browning. No CO_2 injury was found at DPA plus 2.5% CO_2. The trial included variables that we knew would induce browning such as farms with a historic internal browning problem and storing of apples at -0.5˚C. The importance of step-wise cooling is evident since the SF+CA treatment at 1˚C also had internal browning. The fact that the industry is currently having internal browning issues is probably related to a combination of factors.

Quantifying the effect of bag perforations on forced-air cooling cycles and post storage quality of apples

(D Viljoen)

Objectives and Rationale

The pome industry is under pressure to reduce the forced-air cooling (FAC) cycle time of commercial pallets after packing and prior to shipment. It is likely that the forced-air cycles can be shortened if perforated liner bags are used in place of the non-perforated bags typically used as standard for apples.

Objectives:

1. To quantify the improvement in cooling rates/shorter forced-air cooling cycles for apples packed in perforated bags.

2. To determine the ability of liner bags, perforated to the extent that a significant reduction (>20% - 40%) in forced-air cooling (FAC) rates is achieved, can still maintain post storage quality during simulated export of apples.

Methods

Each season, three populations of fruit that had been cold stored in bins under controlled atmosphere were packed into bags with small perforations and bags with large perforations and subjected to FAC. Fruit stored in standard non-perforated bags served as controls. After cooling, fruit were stored for 5 and 9 weeks in regular atmosphere (RA). Cultivars used in this trial were Granny Smith, Top Red, Cripps' Pink, Golden Delicious, Fuji and Braeburn.

Key Results

2016

High levels of superficial scald were detected on the 'Granny Smith' apples tested. However, no trend could be observed relating to a specific treatment. Fruit in bags with small and large perforations had a shorter 90% cooling rate compared to fruit in non-perforated bags.

2017

High lenticel spot incidence occurred on 'Golden Delicious' apples packed without bags and in perforated bags, while this problem was less pronounced on apples in non-perforated bags.

2018

Large perforations resulted in FAC times decreasing by more than 40%. Marginal differences were detected regarding lenticel related defects on fruit stored in bags with different perforation dimensions.

Conclusion and Discussion/ Recommendations

2016

Marginal differences in post storage quality occurred between 'Granny Smith' apples stored in regular non-perforated bags, no bags, and fruit stored in bags with small and large perforations. A decrease in FAC time occurred for fruit stored without bags, or in bags with small and large perforations, compared to fruit stored in non-perforated bags.

2017

Fruit packed in bags with small perforations did not cool as efficiently as was the case with large perforations. With Reds and 'Cripps' Pink' apples, the shorter cooling time had no significant negative effect on fruit quality. 'Golden Delicious' apples exhibited significantly more lenticel damage when packed and forced-air cooled in perforated bags or without bags, compared to the standard non-perforated bag.

2018

Packing fruit in bags with large perforations resulted in more efficient FAC. No differences were noted regarding fruit quality between the different bag treatments.

Bag liners with large perforations enabled 30-45% shorter cooling times depending on carton type, while bags with small perforations resulted in 5-20% shorter cooling times. Care should be taken with sensitive cultivars such as Golden Delicious which developed lenticel related disorders after being forced-air cooled without a plastic bag liner, or in perforated liner bags. Further trials should be conducted to understand the factors causing this disorder and to develop a strategy to lower the risk of it developing during shipping.

The use of Harvista™ (pre-harvest 1-MCP) application to control superficial scald on 'Packham's Triumph' pears

(D Viljoen)

Objectives and Rationale

The postharvest application of SmartFresh℠ was investigated for superficial scald control on 'Packham's Triumph' pears and although this product showed good control of superficial and senescent scald on 'Packham's Triumph' pears, fruit may experience delayed ripening issues, especially if the product is applied shortly after harvest. DCA storage may also control superficial scald development. However, not enough rooms are available and alternatives are urgently sought. Therefore the aim of this trial was to evaluate the use of pre-harvest Harvista™ sprays (1-MCP) to control superficial scald on 'Packham's Triumph' pears during extended storage.

Methods

Harvista™ was applied to 'Packham's Triumph' pears at release (early optimum), optimum (7 days after release) and late optimum (7 days after optimum). Fruit were harvested ± 3 days after spray application and stored for 3, 5 and 7 months at -0.5° C in RA. Fruit were evaluated after cold storage and a 7 day simulated shelf life at 20° C.

Key Results

2016

Untreated control fruit stored for 7 months were generally softer after cold storage compared to other treatments and storage times. Unacceptable levels of superficial scald occurred on untreated control fruit from the pre optimum and optimum harvested fruit stored for 7 months. Low levels to none occurred on Harvista™ treated fruit. High incidence of superficial scald also occurred after shelf life on untreated control fruit from the first two harvests stored for 5 and 7 months. Unacceptable levels also occurred on Harvista™ treated fruit, but to a much lower extent.

2017

Regardless of concentration, harvest time and storage duration, Harvista™ treated fruit were significantly firmer after shelf life compared to untreated fruit. Superficial scald occurred only on fruit stored for 5 and 7 months. Shelf life results showed reduced levels of superficial scald on Harvista™ treated fruit.

2018

After 5 months cold storage no superficial scald was detected on any fruit. Only after the 7 day shelf life, untreated control fruit developed superficial scald levels of up to 38.7%. Except for fruit from one treatment from one harvest, Harvista™ treated fruit had superficial scald levels below 10%. After 7 months cold storage

reduced levels of superficial scald were detected on Harvista™ treated fruit (≤ 11.8%) compared to untreated control fruit (≥ 18.7%). Following the shelf life period after this storage duration, unacceptable levels of superficial scald occurred on all fruit (≥ 54.7%).

Conclusion and Discussion / Recommendation

Harvista™ reduced superficial scald after cold storage and shelf life. However, it did not control the disorder completely. Harvista™ treated fruit were also prone to not ripen during shelf life and it is advised not to spray Harvista™ near harvest (≤ 4 days). This, however, can be alleviated by increasing the days between spray and harvest.

Determine the CO_2 sensitivity of the four main plum cultivars

(A de Kock)

Objectives and Rationale

The effect of carbon dioxide (CO_2) on quality after cold storage on four plum cultivars was tested. The aim was to determine if elevated levels of CO_2, in the range of 2%, 4% and 6% would have a negative effect on plum quality. This information is vital if the current vent setting procedure for plums, by opening the vents in shipping containers if threshold CO_2 levels are reached, is considered. The effect of this procedure on relative humidity (RH) in containers is unknown and will have to be determined at some stage. The ultimate aim is to utilise knowledge generated to increase RH in shipping containers and in this way reduce shrivel on plums.

Methods

'Fortune', 'Laetitia', 'Songold' and 'September Yummy' plums were cold stored at modified atmospheres (MA) of 2%, 4% and 6% CO_2. O_2 levels were 19%, 17%, and 15% respectively. 'Songold' plums were treated with the commercial concentration of 1-MCP (SmartFresh℠) before cold storage. The plums were stored at MA for 20 days to simulate the shipping period to the EU. 'Fortune', 'Laetitia' and 'September Yummy' were stored at single temperature while a dual-temperature regime was used for 'Songold'. Overall quality was evaluated after cold storage of 42 days and after shelf life.

Key Results

The MA regimes tested had no negative effect on 'Fortune', 'Songold' and 'September Yummy' plums. Positive effects with elevated CO_2 occurred in terms of flesh firmness ('Fortune') and reduced internal disorders ('Songold' and 'September Yummy'). The MA regimes tested had a negative effect on flesh firmness and internal disorders with 'Laetitia' plums. No off tastes were noted in any of the cultivars. It therefore appears as if a blanket recommendation regarding the effect of the particular MA regimes on plum quality will not be possible. No conclusive trends could be identified for CO_2 level effects on shrivel development. This will require testing in shipping containers.

Conclusion and Discussion / Recommendation

CO_2 levels of up to 6% and the balance of O_2 (to a total of 21%) had varying effects on plum quality dependent on cultivar. A blanket recommendation for plums regarding venting of shipping containers based on CO_2 build-up in the containers is therefore not possible. However, the results indicated that there could be positive effects of elevated CO_2 levels in combination with relatively high O_2 levels and this could be explored to improve fruit quality of selected cultivars

Evaluation of the 8 mm penetrometer plunger to determine harvest maturity on plums

(A de Kock)

Objectives and Rationale

The objective of this trial was to establish if an 8 mm penetrometer plunger can accurately determine flesh firmness as a harvest maturity parameter and also as an indicator of flesh firmness after arrival in the market place. The standard 11.2 mm plunger as currently used in South Africa was used as reference. The ultimate aim is to standardise the method used to determine flesh firmness in South Africa, with other stone fruit producing and importing countries.

Methods

Flesh firmness was determined on 'Fortune', 'Laetitia' and 'African Delight' plums with penetrometer plungers of 8 mm and 11.2 mm diameters. Firmness was determined, at harvest, after cold storage (SOS) and after shelf life (EOS). At each of these evaluations, firmness was determined on the same fruit with an 8 mm plunger on the one cheek of the fruit and with an 11.2 mm plunger on the other cheek. Fruit quality was also determined at SOS and EOS.

Key Results

For the three cultivars tested there were slight variations in the regressions comparing the 8 mm and 11.2 mm plungers at the three evaluations, namely; at harvest, SOS and EOS. On average the conversion factors varied between 1.8064 (R^2 0.7236) for 'Fortune', 1.7691 (R^2 0.7910) for 'Laetitia' and 1.7016 (R^2 0.6322) for 'African Delight'. The average across cultivars was 1.76 which is comparable to the conversion factor of 1.8 that was previously established for nectarines. The flesh firmness distribution curves established for the 8 mm and 11.2 mm plungers for each of the cultivars showed similar trends and there was a normal distribution of flesh firmness readings in all cases. Clear patterns on the effect of the various harvest maturities on fruit quality after cold storage could not be established and it differed between cultivars. However, at the EOS fruit quality evaluation all the cultivars showed a tendency to develop more shrivel at the later harvests, despite the fact that flesh firmness differences between the harvest dates were small.

Conclusion and Discussion

Milestones 1 and 2 were achieved and it was established that both the 8 mm and 11.2 mm penetrometer plungers tested could measure flesh firmness accurately with R^2 values of up to 0.791.

The fact that shrivel generally increased in the later harvested fruit, and in some cases internal disorders as well, points to environmental factors that probably had a greater effect on these disorders than flesh firmness, in the range that was tested.

Application of postharvest bioactive edible coatings and natural antimicrobial peptides as a green solution to alleviate shrivel and extend storage life of plums

(O Fawole and N Jenneker)

Objectives and Rationale

Stone fruits, in particular, plums are the most important stone fruits in South Africa, but the commercial success of the fruits has been limited due to postharvest losses resulting from short storage life, excessive moisture loss and decay. This research focuses on the application of a composite coating formulated with various natural bioactives to maintain quality and extend the shelf life of plums through the application of bioactive edible coatings. In particular, the potential of cyclic antimicrobial peptides (cAMPs) (– patented products (WO/2013/150394 A1) by BIOPEP Peptide Group (BPG) at Stellenbosch University) as bioactives in coating candidates are to be explored.

Methods

The peptides (Tyrocidine, TRC; patented and gramicidin, GS) were tested separately at different concentrations, as well as incorporation with Gum-Arabica (GA), by dipping. Fifteen test concentrations were investigated in total. Our hypothesis was that TRC and GS will improve the efficacy of identified edible coatings (EC) that have proven success to alleviate shrivel in stone fruits.

Key Results

Control unwashed fruit had the highest decay incidence (30%) followed by washed uncoated fruit with 20% decay. In GA-based coated fruit (without peptides), 10% of decay was observed. When TRC was incorporated into the GA-based coating, little to no decay was detected. GA + TRC 5, GA + TRC 20 and GA + TRC 35 completely inhibited decay. Fruit coated with GA + TRC 10 and GA + TRC 50 had 10% decay incidence, similar to those coated with GA base coating alone. Unlike TRC, the other peptide, GS, was less effective. Only GA + GS 5 prevented decay (0%), however, addition of GS at concentrations other than 5 µg/L resulted in the same decay incidence as GA coated-fruit, with the exception of GA + GS 10 which had higher decay incidence (20%) similar to the wet control. However, the investigated peptides seemed to have promoted fruit shrivel, and overall, there is a positive and strong correlation (r = 0.89) between mass loss and shrivel incidence in plum fruit. In addition, some PEP treated fruit had extensive gel breakdown, which may have been induced by the treatments.

Conclusion and Discussion

In terms of decay control, TRC and GS are promising as bioactives in gum arabic edible coating, although the results remain inconclusive. All of these observations need to be confirmed in different, large scale trials – where handling, shipping and shelf conditions are simulated. All milestones scheduled to this stage have been met.

Develop a six week storage protocol for plums harvested from week 5 onwards (H Viljoen)

Objectives and Rationale

Moisture loss, often manifesting as shrivel, as well as decay, are problems that may occur with late season plum cultivars cold stored in bins for up to 6 weeks prior to packing and export. The objective of this trial is to develop a protocol for plums stored in bins with the focus on reducing moisture loss and controlling shrivel, without negative consequential fruit quality effects such as decay.

Methods

'Angeleno' plums were harvested into bins and then subjected to a SmartFresh℠ treatment. Bins were placed in cold rooms either with or without relative humidity (RH) control, with and without a fungicide drench containing Fludioxonil in each instance. The cold room without humidity control had an average RH of 85.6%, while the cold room with humidity control had an average RH of 95.8%. Sub samples were weighed and placed with other fruit in the bins for 6 weeks regular atmosphere cold storage at -0.5 ˚C. Plums were then re-weighed after bin storage to determine mass loss during bin storage. Fruit from these bins were again weighed and packed in cartons as for commercial export and cold stored for another 3 weeks to simulate shipping and distribution. Fruit were again weighed after cold storage and subsequent shelf life. Fruit quality was also assessed after cold storage shelf life.

Key Results

Humidity control during prolonged bin storage of 'Angeleno' plums reduced mass loss and shrivel significantly, compared to plums cold stored without humidity control. Moisture loss, measured as the mass loss percentage of fruit during cold storage, was significantly higher in fruit drenched with Fludioxonil and cold stored without humidity control in bins, compared to plums in bins that did not receive the drench or that were held in the humidity controlled cold room (irrespective if drenched or not). It is surmised that the risk of decay is too high if there is high decay potential, so the fungicide application is recommended.

Conclusion and Discussion

Humidity control during prolonged bin storage is crucial to reduce mass loss of 'Angeleno' plums via moisture loss, and to reduce shrivel levels after subsequent in-carton storage. No decay was recorded in this trial. However, due to the previous dry seasons, the decay potential might have been very low. It is likely that decay risk potential might change with changing seasons; hence, post-harvest fungicide application is probably essential.

Identify and test improved packaging as well as humidity control in cold stores to reduce moisture loss and shrivel in plums (H Viljoen)

Objectives and Rationale

Moisture loss and shrivel is an ongoing problem in plums packed and stored for export by sea. The objective was to identify liner packaging to reduce moisture loss and shrivel, and evaluate the effect of humidity control systems in cold stores on the same quality parameters.

Methods

Plums were packed in different polyethylene based perforated and non-perforated wrapper and perforated bag treatments and then force-air cooled and accumulated for 7 days in cold rooms with and without humidity control equipment fitted. The impact of these treatments on fruit quality after application of simulated export shipping regimes and subsequent shelf life was determined.

Key Results

The results relating to mass loss from plums and shrivel levels were quite variable over the three years of study, so the condensed version is presented below. This variability is to be expected, since shrivel development is highly complex and seems to be influenced by multiple factors.

Conclusion and Discussion / Recommendation

Overall conclusion relating to humidity control for 'Laetitia' and 'African Delight': For 'Laetitia' and 'African Delight', the results of this study showed that good humidity control during forced-air cooling (FAC) and accumulation was important for optimizing plum quality, as far as mass loss and shrivel control are concerned. It appeared that if humidity is well controlled at a high level (> 90%), the impact of liner type packaging on post-storage plum quality may be minimized.

Overall conclusion relating to liner type to be used to control shrivel for 'Laetitia': The variable results recorded for 'Laetitia' over the three years of study, in terms of optimal liner packaging to control shrivel specifically, makes it difficult to identify the single best option. Perhaps a middle of the road option is safest, namely to expand commercial testing of 36 x 4 mm perforated bags, used in combination with good humidity control during FAC and accumulation. Special attention must be paid to risk of skin cracking.

Overall conclusion relating to liner type to be used to control shrivel for 'African Delight': The 18 x 4mm and 36 x 4 mm perforated bags warrant expanded commercial testing, in combination with good humidity control during FAC and accumulation.

Identify and test improved packaging as well as humidity control in cold stores to reduce moisture loss and shrivel in nectarines

(H Viljoen)

Objectives and Rationale

To improve the current packaging of nectarines to reduce shrivel without negative effects on general quality and determine the effect of improved relative humidity control in cold stores on moisture loss and shrivel.

Methods

'August Red' nectarines were sourced from commercial pack houses in 2017, 2018 and 2019, repacked into different packaging liner types and then accumulated in two cold rooms, one with and one without humidity control. Fruit was weighed at repacking and again after cold storage and subsequent shelf life. Fruit quality was assessed after cold storage as well as after a shelf life period.

Key Results

The results of this study showed that good humidity control during forced-air cooling and accumulation was important for optimizing nectarine quality. It appeared that if relative humidity is well controlled at a high level (> 90%), the impact of liner type packaging on post-storage nectarine quality may be minimized. The biggest factor influencing moisture loss and shrivel was the type of inner packaging. It was evident that fruit packed without wrappers or perforated bags lost more moisture and developed more shrivel compared to those packed in liners or bags. No substantial negative effects of the liner treatments tested were evident in terms of internal quality. Overall, 36 x 4 mm and 72 x 4 mm perforated bags gave the best mass loss and shrivel control.

Conclusion and Discussion

The 36 x 4mm and 72 x 4 mm perforated bags warrant expanded commercial testing, in combination with good humidity control during forced-air cooling and accumulation. To simplify, it may be lower risk to test the more highly vented 72 x 4 mm perforated bag only. Impact on fruit ripening and decay, in particular, should be carefully monitored.

Develop optimum ripening protocols for nectarines and plums arriving too green (skin colour) or too firm in market (H Viljoen)

Objectives and Rationale

Develop protocols to ripen firm, poorly coloured nectarines and plums, to an acceptable eating quality and skin colour in the market place.

Methods

Nectarines were cold stored with and without pre-ripening, before onset of cold storage. Plums on the other hand were subjected to treatments with or without ethylene after cold storage. At the end of cold storage, nectarines and plums were subjected to different ripening temperatures for various durations, based on the rate of quality deterioration, and the fruit quality examined when different treatments reached the target flesh firmness. The ripening patterns were monitored and the effect of the various treatments on fruit quality assessed.

Key Results

Nectarines

'Regal Pearl': In both 2017 and 2018, nectarines pre-ripened before cold storage exhibited the best internal quality after simulated sea export. The post cold storage ripening temperature of 20 ˚C was generally the best option in terms of fruit quality for pre-ripened and non-pre ripened fruit. Pre-ripening shortened the ripening process of nectarines after cold storage by ± 3 days, compared to non pre-ripening. The 2019 'Regal Pearl' population did not require ripening after cold storage because they were at desired flesh firmness at start of shelf life.

'August Red': In 2017 extremely high decay levels occurred after storage, thus neither flesh firmness nor fruit quality could be assessed. In 2018, pre-ripening before cold storage did not have the same positive effect as with 'Regal Pearl'. Similarly, the ripening temperature of 20 ˚C resulted in the best quality, irrespective of pre ripening. It was evident in 2019 that 'August Red' nectarines pre-ripened before cold storage exhibited a big difference in firmness reduction. Ripening of pre-ripened 'August Red' nectarines at 15 ˚C and 20 ˚C generally resulted in better post storage quality, with careful monitoring required to avoid overripeness.

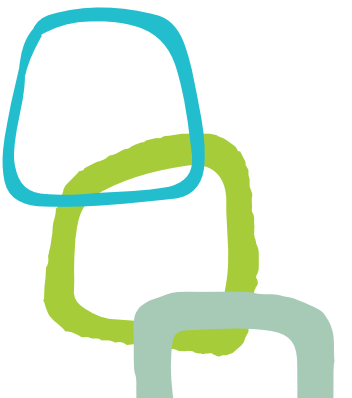
Plums

'Songold': In 2017 the ethylene treatment after cold storage just before onset of post storage ripening resulted in faster ripening of 'Songold' plums as measured using flesh firmness. There was a tendency for ethylene application after cold storage to cause higher levels of internal browning and gel breakdown. Ethylene treatment and higher post storage holding temperature, in 2018, resulted in accelerated fruit ripening, measured by flesh firmness. Gel breakdown occurred in all treatments. In the 2019 season, the ethylene application of 'Songold' plums had no softening effect. Generally, higher post storage ripening temperature resulted in faster ripening of 'Songold' plums with no problematic internal disorders exhibited by this 'Songold' population. A shelf life of 4-5 days was possible with this population.

'African Delight': In the 2017 season, ethylene applications had no effect on flesh firmness of 'African Delight' plums. However, post cold storage ripening at 25 ˚C had a significant effect on reducing flesh firmness. In 2018, ethylene treatment had an effect on the 15 ˚C and 20 ˚C treatments, accelerating the reduction in flesh firmness, compared to the same temperature treatments without ethylene applications. The use of 25˚C as ripening temperature seemed to be the best temperature option for skin colour development, with no shrivel and moderate levels of overripeness. However, committed monitoring is necessary. The application of an ethylene treatment in 2019, after cold storage, had no softening effect on the 'African Delight' plums. Ripening required 6 days, with high levels of shrivel developing, while the target flesh firmness of 2.7 to 3.6 kg was not reached. The best practice will be to harvest at the right maturity to avoid the need for post cold storage ripening.

Conclusion and Discussion

The research is based on results generated for specific fruit populations, with each population being unique. Arrival quality at overseas destinations will determine if ripening procedures are possible and which actions need to be followed. Generally, pre-ripening of nectarines resulted in good quality fruit after simulated sea export, with limited ripening needed. Post cold storage ethylene treatment of plums before ripening is not advised and can reduce quality. Generally, the warmer the ripening temperature, the faster fruit ripen. In this case it will be critical to monitor closely not to over ripen and then to cool fruit temperature down as soon as the target flesh firmness is reached to slow the ripening process and enable acceptable shelf life.



Postharvest moisture loss studies in Japanese plums (Prunus salicina Lindl)

(E Lötze and I Kritzinger)

Objectives and Rationale

A comparison of cuticle ultrastructure, chemical composition, peel permeability and lenticels between Japanese plum cultivars is required to understand why some cultivars are more prone to post-harvest moisture loss and shrivel. Different shrivel prone and non-prone cultivars were selected for various measurements.

Key Results

Peel permeability differed between farms, seasons, cultivars, orchards and developmental stage. The water vapour permeance of the peel was higher in susceptible cultivars, but not in all cases. Lenticel numbers differed between seasons and cultivars and clearly contribute to moisture loss, but differing between cultivars. Number of open lenticels could not explain all the variation in peel permeability.

Cuticular composition differed significantly between cultivars and seasons. 2,4-bis (dimethyl benzyl) phenol was present in high concentration in both cultivars. The combination of a rigid cuticle, due to high phenol content, fewer tri-hydroxy acids, and high primary alcohol content, and its smaller intercellular spaces, reduces 'Songold' cuticle deformation due to excessive postharvest moisture loss. Since the hypodermal cells of 'Songold' are closer together, their dehydration and collapse might not lead to significant shrinkage compared to the other cultivars. The cuticle is rigid, which means that it is less likely to collapse when the supporting cells underneath it shrink and collapse due to moisture loss.

Low-Density Poly-Ethylene packaging with 92 or 72 micro-perforations reduced moisture loss, while still preventing excessive in-package humidity, decay and chilling injury.

Conclusion and Discussion

This study showed the complex interplay of different cuticle characteristics in response to or as a result of, moisture loss. Elucidating some of the mechanisms involved in the functioning and response of this complex biopolymer might enable manipulation of the cuticle to improve fruit quality and extend shelf life or to select and breed cultivars that are not prone to cuticular defects.

PHYSIOLOGICAL DEFECTS

Compilation of a database of high quality images of pome fruit disorders from South African growing and storage conditions to contribute to the further development of software-based determination (APP) for the detection and reduction of bearing damage in fruit (Frudistor) in an international context **(I Crouch)**

Objectives and Rationale

Compilation of an extensive database of high-quality images representing the disorders and diseases occurring on deciduous fruit.

Methods

High definition professional quality photographs have been taken with a 24 MP camera using a 60 mm macro lens with sophisticated flash photography and specialized augmented lighting. Fruit were photographed at different planes and detail of the disorder recorded.

Key Results

A form was distributed to the industry requesting samples of disorders to be sent to ExperiCo accompanied with a full case history. Very few samples arrived in this manner. The initiation of a WhatsApp group (Store-It) addressed many of the immediate disorders and problems presented to the group. Unfortunately, very few of these samples were sent to ExperiCo. Regardless of the above, many examples of disorders have been sourced and photographed, mainly from the ExperiCo labs and from participating players in the industry.

Conclusion and Discussion

The photographs will be presented at the end of the project but it is envisioned that this will be ongoing and expand into different fruit kinds and also possibly expand to include relevant pests and diseases. The output is yet to be finalized but may be presented as a book, in an App or in some form of electronic media. It is not yet known whether the initial link up with the EU to assist in the development of an App will still proceed.

Quantifying the role of vapour pressure deficit in the development of lenticel breakdown in 'Braeburn' apples

(E Lötze and D Viljoen)

Objectives and Rationale

Lenticel breakdown (LB) was highlighted by the Store-it group in June as one of the most important defects in the 2018 season, but is not yet well understood. Two approaches were suggested to increase the understanding of this disorder: i) establish how pre- and ii) post-harvest factors (influencing the vapour pressure deficit (VPD)) of the fruit influence LB incidence. This will involve a microscopy study to follow and quantify the lenticel development of individual fruit from approximately 40 days after full bloom until harvest and again post-harvest, after different management practices were applied. In addition, the post-harvest treatments will be evaluated to indicate the potential reduction of LB after treatment.

Methods

The pre-harvest evaluation for LB will only commence in Nov 2019. Post-harvest treatments are complex and are described in detail in the full report. In summary it comprised manipulation of the VPD after harvest including applying wet blankets onto bins, using various fan speeds, times and temperatures during cooling and the influence of packaging on LB incidence. This was complemented with an anatomical investigation of the lesions using a light microscope.

Key Results

During the first season of this study, only the post-harvest treatments were applied and evaluated. In none of the trials LB was sufficient to notice an effect, even though data still has to be analysed. Initial microscopy studies were carried out to quantify the average number of lenticels per $1cm^2$ of different fruit, as well as noting the number of open lenticels.

Conclusion and Discussion

All milestones scheduled to this stage have been met; however, insufficient LB occurred for further conclusions about treatments.

Superficial scald on 'Granny Smith' - understanding the mechanisms and limitations of the storage protocols used by industry and assess risk indicators in storage for scald development

(E Crouch, A Botes, P Mathabe, D Viljoen, T Pandian, M Gerber and A Hlungwani)

Objectives and Rationale

Granny Smith (more susceptible to superficial scald) is the third most exported apple cultivar from South Africa. Historically, fruit was treated with diphenylamine. Maximum residue levels were reduced in 2014 to unusable levels due to environmental concerns, by the EU and UK markets. 1-Methylcyclopropene (1-MCP; ethylene inhibitor) application for constraining superficial scald, yet, in some seasons it was not completely effective. This study aims to develop storage protocols to inhibit superficial scald development in order to find biochemical risk indicators prior to the incidence of scald.

Methods

Apples were subjected to twelve storage treatments and evaluated after 4, 8, 16, 24, and 34w+6w RA+10d @20 ˚C. Apple peels were tested for quantifying a-farnesene, conjugated trienols (CTols), 6-methyl-5-hepten-2-one (MHO), and ethanol. Reactive oxygen species (ROS) level are determined. Any off-flavours production was identified by descriptive sensory analysis.

Key Results

During the 2018 season, DCA-CF, 1-MCP+DCA-CF, CA, 1-MCP+CA, 1-MCP+CA+(1-MCP), and 1-MCP+CA+(1-MCP+DCA-CF) treatments had an inhibitory effect on the scald development, during 34w+6w RA+10d @20˚C. This can be associated to the decreased accumulation of a-farnesene, CTols and MHO and ethanol level increase in some treatments. ROS level as a marker of oxidative damage in the fruit.

Conclusion and Discussion

The DCA-CF, 1-MCP+DCA-CF, CA, 1-MCP+CA, 1-MCP+CA+(1-MCP), and 1-MCP+CA+(1-MCP+DCA-CF) had an inhibitory effect on the development of scald, during 34w+6w RA+10d @20˚C. The biochemical processes leading to the superficial scald are complex and involve ethylene promoted ripening, responses to chilling stress and the balance between oxidative and antioxidative processes.

Detection of internal heat damage and identification of techniques to prevent the expression of the disorder in plums (A de Kock)

Objectives and Rationale

There were two objectives in the project, (i) determine if internal heat damage in 'Laetitia' plums can be expressed within 2 days by rapid cooling as a prediction method, and (ii) determine if the expression of internal heat damage can be reduced or eliminated in 'Laetitia' plums by SmartFresh℠ and/or slower cooling rates.

Methods

Objective 1

'Laetitia' plums that were exposed to heat waves to the extent that external heat damage was visible were selected. Fruit were cooled rapidly (within 6 hours) or slower (within 24 hours) to -0.5 ˚C. Fruit were cut immediately after cooling and again after 2 days at 20 ˚C and inspected for internal heat damage.

Objective 2

Fruit from the same source used for objective 1 were cooled within 6, 24, 48 or 72 hours. Half of the fruit of each treatment, except for the 6 hour cooling treatment, was treated with SmartFresh℠. Fruit cooled within 6 hours was added as a treatment after it became clear that Objective 1 did not yield positive results. After cooling, the fruit was cold stored at a PD 7 dual temperature regime and examined for flesh firmness and internal and external disorders.

Key Results

Objective 1

No heat damage was detected within 2 days following rapid cooling.

Objective 2

Fruit cooled within 6 hours were significantly firmer than fruit subjected to the other cooling rates.

However, these fruit (6 h cooling) developed significantly more internal heat damage compared to fruit cooled more slowly. Differences across other cooling rates in terms of heat damage were insignificant.

SmartFresh℠ did not reduce the expression of heat damage after cold storage.

Conclusion and Discussion

The results confirmed that rapid cooling can cause the expression of internal heat damage. Future research should include: (i) The cooling of Laetitia plums with suspected heat damage to a temperature of 2 ˚C instead of -0.5 ˚C, (ii) Determination of how long it takes for heat damage to be expressed after the heat wave event, and (iii) Investigation of other methods to determine if internal heat damage occurred for use as an early warning.

'Fuji' browning types explored via x-ray CT in collaboration with existing trial

(E Crouch and K Chigwaya)

Objectives and Rationale

The storage potential of 'Fuji' is limited by the incidence of internal browning during long term storage.

The objectives of this study were to

- Determine which storage regime is most effective in reducing browning incidence
- To use high resolution X-ray computed tomography in establishing microstructural differences between different browning types

Methods

Three different storage regimes were used namely, regular atmosphere (RA), controlled atmosphere (CA) and delayed controlled atmosphere (delayed CA). Fruit were subjected to a storage period of 6 months at -0.5 °C + 4 weeks RA + 7 days shelf-life at 20 °C. After shelf-life evaluations, 20 fruit were selected from each of the main browning types and these fruit were scanned using x-ray computed tomography.

Key Results

- Fruit evaluations done at the end of shelf life showed that core-flush browning was higher in RA stored compared to delayed CA and CA stored fruit.
- CA stored fruit had the lowest core-flush type of browning.
- Radial browning was high in CA stored fruit and lowest in RA stored fruit.
- Results from X-ray CT scanning showed that fruit tissue affected by radial browning had a significantly higher porosity compared to unaffected fruit.
- Fruit tissue with CO_2 damage had a high porosity with a disrupted tissue structure.

Conclusion and Discussion

CA storage reduced the incidence of core-flush in 'Fuji' apples; however, it resulted in a higher incidence of radial browning at the end of shelf-life compared to RA storage. The delayed CA treatment didn't reduce the incidence of radial browning, and had the same amount of core-flush browning compared to CA stored fruit. Core flush might be a senescence related disorder. Radial browning is related to the collapse of vascular tissue cells, hence a higher porosity. Micro X-ray CT will be used to further explore fruit before and after high CO_2 treatments, comparing tissue structure before and after damage occurs.

Identification of factors involved in the expression of internal browning in 'Fuji' apples and the development of a strategy to reduce risk of incidence

(D Viljoen)

Objectives and Rationale

In 2015, unacceptable levels of internal browning (IB) (up to 80%) reported for shipments of 'Fuji' apples to the Far East lead to many claims. The objective of this trial was to investigate factors that resulted in IB expression in 'Fuji' apples; to develop a predictive test for the risk of IB expression and to develop an industry protocol that will reduce the risk of IB expression.

Methods

Eight 'Fuji' orchards, with a history of IB were selected in the Koue Bokkeveld and EGVV areas. Fruit were harvested at optimum and 10 to 14 days after optimum, taken to CA storage facilities immediately after harvest and again 3 weeks after harvest and evaluated after ± 6 months CA cold storage and 4 weeks RA. As a means of predicting IB, fruit were subjected to 50% CO_2 for 3 days after harvest at ambient temperature and evaluated daily for IB to compare to IB expression after 6 months cold storage.

Key Results

2016: two orchards exhibited high levels of IB after shelf life. One of the orchards exhibited high IB incidence on fruit from both harvests. Later harvested fruit had higher incidence of this disorder. Two out of the three instances where IB was detected, RA had the highest incidence. Core flush was detected in fruit from the first harvest of one population. RA stored fruit had the highest incidence of this disorder.

2017: low to no IB was detected after cold storage and shelf life. High incidence of core flush was detected in later harvested fruit. RA stored fruit had the highest incidence of this disorder.

2018: IB incidence was higher in later harvested fruit. RA stored fruit generally developed the highest incidence of IB. Core flush incidence was higher in earlier harvested fruit compared to later harvested fruit. RA stored fruit had higher core flush incidence compared to fruit from the other regimes.

Conclusion and Discussion / Recommendation

Some conclusions can be made from the data over the 2016 to 2018 seasons:

- IB and core flush are seasonal.
- IB and core flush risk is orchard related. Some orchards are more prone to develop IB than others.
- IB was generally more prone to develop in later harvested fruit.
- RA stored fruit generally exhibited the highest incidence of internal browning and core flush.
- Three to four weeks delay before CA initiation (3wkCA) resulted in fruit with slightly higher IB compared to fruit moved to CA within the first 7 days after harvest (CA). There is however, not a clear distinction between the two storage regimes regarding IB incidence.

The CO_2 predictive test did produce fruit with IB, but correlated poorly with IB incidence after storage.

To assess internal browning development potential from high watercore incidence FEMA 'Forelle' (D Viljoen)

Objectives and Rationale

The 2016 season exhibited high incidence of watercore in 'Forelle' fruit destined for the FEMA programme. Watercore is exacerbated by delayed harvest especially in seasons where sugar levels in the fruit are high. PPECB inspectors are rating this disorder as internal breakdown which has a 2% tolerance compared to 10% for watercore. This trial needs to determine the risks of watercore incidence on fruit quality and will assess whether the disorder diminishes over time, or develops into internal browning.

Methods

Five orchards in the Ceres and EGVV environs were harvested and assessed for watercore incidence. In the 2018 season, trees were flooded three days before harvest. All fruit were subjected to a SmartFresh^{SM} application after harvest and stored for 5, 8 and 12 weeks at -0.5 ˚C under regular atmosphere (RA). Fruit were evaluated after cold storage and after a simulated shelf life of 7 days at 20 ˚C. Some fruit were subjected to 50% CO_2 after harvest for three days and assessed for internal browning (IB) to determine if this will correlate with internal browning after storage.

Key Results

In the 2017, 2018 and 2019 seasons, out of the 15 orchards that were monitored for this trial, eight exhibited watercore at harvest ranging from 1.7% incidence to 6.7% incidence. Fruit from only one orchard exhibited watercore after 5 weeks cold storage. Two orchards exhibited internal browning (0.5 – 5.3%), and two orchards other internal disorder (0.9 – 1.3%) after cold storage or after shelf life. No internal disorders were detected after 12 weeks cold storage.

Conclusion and Discussion / Recommendation

According to this data, watercore disappears during storage. Orchards with watercore at time of harvest may develop internal browning or senescent or internal breakdown during storage. It is a concern that some orchards had low levels of these disorders after storage. No internal browning developed during the CO_2 test in any season rendering this method not suitable as a predictive measure for internal browning risk in fruit with watercore.

STORAGE TECHNIQUES

The effect of OTFLOW system on temperature distribution in containers specifically for cold steri protocols (H Viljoen)

Objectives and Rationale

Distribution of cold air evenly throughout a shipping container has been a major problem, with warm spots forming close to the door and cold spots close to the cooling unit. The temperature of plums, undergoing cold-sterilization for phytosanitary purposes in a shipping container, may not exceed 1.11 ˚C at any point in the stipulated cold sterilization period. In an event of this happening the treatment will be nullified.

The OTFLOW system is easy to use and evidently channels more air to the warmer part of the container and less air to the coldest part, thus potentially having a better and more even temperature distribution. It was proven in a shipping container filled with precooled table grape packed in punnets to have a 30% reduction in temperature difference between warmest and coldest measurement locations.

Methods

The trial consisted of three 40 feet shipping containers, in each of these, 3 pallets were utilized to measure fruit pulp and air temperature, as well as relative humidity (RH), at 2 positions in each pallet. Logtag loggers were placed in one standard container and two containers with the OTFLOW system. This was done on 'Angeleno' plums from Robertson and Franschhoek exported on PD1, a single temperature regime at -0.5 ˚C. The project required overseas co-operators to remove the loggers and courier these back to South Africa. To this extent, regular communication via email was conducted. In addition, the trial was discussed in detail with a representative of fruit exporter.

Key Results

For the one OTFLOW container sent to the UK, only 8 out of the 12 loggers were retrieved. The other two containers (one standard and one OTFLOW) were sent to Spain, where they evidently retrieved and misplaced the loggers. The approximate loss is 28 loggers. Results from the UK loggers are not yet available.

Conclusion and Discussion

Due to loss of loggers, the milestones scheduled have not yet been met. The recommendation is to repeat with the intended overseas visit to assess quality in 2020.

Determine optimum storage conditions for 'Abate Fetel' pears

(A Botes)

Objectives and Rationale

'Abate Fetel' plantings in the South African pear production areas have increased significantly over recent years from 540 ha in 2009 to 810 ha in 2015 and subsequently also the export volumes to approximately 1.4 million cartons in 2018. The aim of this project is to identify the optimum storage conditions for 'Abate Fetel' pears in order to maintain the best fruit quality. The objective is to evaluate the effect of different storage regimes on the quality of 'Abate Fetel' pears from two production areas to extend the storage life to 6 months.

Methods

'Abate Fetel' were obtained from two production areas, Grabouw and Ceres. Fruit were harvested at two maturities (optimum and post-optimum) and eight treatments (1.5% O_2 + 0.5% CO_2, 1-MCP + 1.5% O_2 + 0.5% CO_2, 6% O_2 + 0.5% CO_2, 1-MCP + 6% O_2 + 0.5% CO_2, DCA-CF + 1-MCP, DCA-CF, RA and 1-MCP + RA). Fruit quality evaluations were done after the simulated shipping and handling period and after shelf life.

Key Results

Optimum and post-optimum harvested 'Abate Fetel' from Grabouw and optimum fruit from Ceres were successfully stored under CA for 6 months at -0.5 ˚C without physiological disorders when Smartfresh™ was used. Optimum fruit from both production areas stored under DCA with a pre-shipment Smartfresh™ treatment also resulted in fruit with no scald after 6 months. These fruit were also at a ready-to-eat stage. Fruit treated with Smartfresh™ and stored under CA at 6% O_2 at 1 ˚C decreased more in firmness than fruit stored at -0.5 ˚C, but not to values of below 2 kg. Fruit treated with Smartfresh™ had a greener skin colour with a higher firmness than non-treated fruit.

Conclusion and Discussion

Smartfresh™ in combination with CA was effective to prevent the development of superficial scald and soft scald for 6 months on 'Abate Fetel' when fruit were stored at -0.5 ˚C. The fruit were however not at a ready-to-eat stage. Fruit stored under DCA with a Smartfresh™ application just before packing gave the best results for the optimum harvested fruit – a pear with no physiological disorders and ready-to-eat after 6 months storage. If optimum fruit needs to be stored for 4 months, SF+RA at -0.5 ˚C is the most cost-effective option.

To investigate different step down cooling regimes, utilised in conjunction with SmartFresh℠, to reduce the risk of internal browning of 'Cripps' Pink' apples and provide year round supply of good quality fruit

(H Tayler, D Viljoen, E Crouch and T Kholoane)

Objectives and Rationale

Internal browning (IB) of 'Cripps' Pink' apples is a worldwide tendency. It has been a very important internal defect for the South African industry. The types of browning in this cultivar have been verified, and current storage regimes adapted according to the knowledge of the risk factors involved for shorter-term controlled atmosphere (CA) storage (up to 5 months). However, long-term CA storage (7-9 months) is still at risk of developing diffuse browning in particular. The objective of this study therefore was to investigate different step down cooling regimes, utilised in conjunction with 1-MCP (SmartFresh℠), to reduce the risk of internal browning of 'Cripps' Pink' apples and provide longer supply of good quality fruit.

Methods

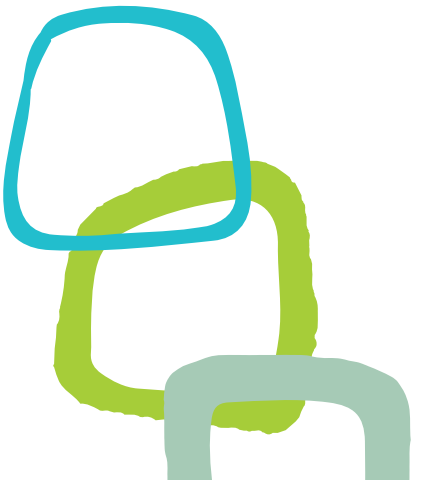
'Cripps' Pink' apples were sourced in Elgin and Ceres areas from internal browning risk orchards (5 populations/ orchards per area) in 2018 and subjected to step down cooling regimes and compared to a South African commercially used regime after 9 months in CA (1% CO_2 and 1.5% O_2) + 4 weeks regular atmosphere (RA) and a 7 day shelf life period (2019).

Key Results

- With the high superficial scald and internal browning incidence found across 10 farms after RA and especially after a shelf life period, storing 'Cripps' Pink' apples for up to 9 months CA is certainly not recommended at this stage, especially in a high risk season like 2018-2019. These conditions were followed for trial purposes to improve the chances of getting treatment differences, which identified possible risk protocols not to be followed commercially.
- A risk of radial browning development was identified if fruit were subjected to SmartFresh℠, not stepwise cooled and stored at 1 ˚C for 9 months in CA plus shipped for 4 weeks in RA and ripened for 7 days at 20 ˚C.
- Diffuse browning was influenced by low storage temperature and seems related to post-optimum maturity at harvest.
- Step down cooling starting from 3 ˚C proved to be more favourable than starting from 4˚C, delivering the best (least defects) and most consistent results, but further investigation around the specific step cooling protocol and total storage duration to be followed commercially is required with the input from industry representatives.

Conclusion and Discussion / Recommendation

Contrary to inconclusive results found in the low risk 2017-2018 browning season, the 2018-2019 season was a high risk season for internal browning development and clear treatment differences were exhibited. A risk for internal browning development (radial and diffuse browning) and fruit quality was identified in not first step down cooling (starting at 3 ˚C) 'Cripps' Pink' apples and storing at 1 ˚C. The radial browning risk was further exacerbated by 1-MCP during long term storage. Diffuse browning seems to be related to over maturity and low storage temperature which substantiate previous studies' results that could affect handling protocols. The 2019-2020 season's fruit are currently in CA storage.



Optimisation of RLOS protocol for superficial scald prevention on 'Packham's Triumph' pears

(A Botes)

Objectives and Rationale

Repeated low oxygen stress (RLOS) can prevent superficial scald incidence on 'Packham's Triumph' during long term storage. In certain seasons the alcohol build-up during the stress periods in the pear is higher than the prescribed maximum levels of 100-150 ppm which can lead to off-tastes. The aim of this project is to optimize the RLOS protocol to control superficial scald on South African 'Packham's Triumph' pears.

Methods

Three treatments (RLOS+ULO, RLOS+CA and RA) were applied to optimum harvested 'Packham's Triumph'. A minimum of one stress and a maximum of 9 stress periods were applied over the storage period of 10 months. Fruit quality evaluations were done after each shelf life period.

Key Results

RLOS+ULO and RLOS+CA was effective in preventing superficial scald on optimum 'Packham's Triumph' up to 10 months with 7 day shelf life, irrespective of the number of stress periods that was applied in 2017. In the second season, RLOS+CA was only effective up to 8 months. For 10 months storage, at least 7 stresses needed to be applied for effective storage. Both RLOS treatments resulted in fruit with good firmness and green skin colour retention. In 2017 the alcohol concentration in the fruit stored under RLOS+ULO was higher than the recommended maximum levels after the stress periods, but still there were no off-tastes detected after shelf life. The alcohol concentrations were much lower in the second season. No off-tastes were also found in 2018.

Conclusion and Discussion

The RLOS+ULO treatment is effective to control superficial scald for 10 months with only one stress period at the beginning of storage. When RLOS+CA is used with only one stress period it is recommended to not store longer than 8 months. The alcohol concentration build-up differed between seasons. Application of monthly stress periods resulted in high alcohol concentrations in the RLOS+ULO treatment in 2017. However, the fruit did not have any off-tastes after shelf life, whether it was stored with or without a bag.

PACKAGING / LOGISTICS

Implementation of Next-generation Packaging Systems in High Cube Refrigerated Containers for Efficient Cooling and improved Volume Usage

(T Berry and A Tiamiyu)

Objectives and Rationale

The introduction of a new packaging system could provide a unique opportunity to utilise the refrigeration system of containers more effectively. This would enhance fruit quality preservation, reduce fuel consumption of the refrigeration unit and enable improved application of various temperature treatments (e.g. intermittent warming and ambient loading). Before an optimal packaging system can be developed, it is necessary to first identify relevant design guidelines. For instance, the impact of gaps between pallet stacks must be known in order to determine an optimal loading strategy. Furthermore, the optimal air flow (ventilation) for the respective packaging system should be determined. Together, this new knowledge will enable future packaging systems to be matched with the optimal working point of refrigerated units.

Methods

A CFD model is being developed and validated to investigate conceptual packaging design scenarios. Using literature and survey information from past and current collaborating projects, the CFD model will be applied to evaluate a refrigerated container when loaded with standard pome and stone fruit packaging systems as a base line for remaining objectives (WP1). Refrigerated container performance will be assessed using a range of pallet stacks with varying airflow resistances to identify an optimal air permeability (ventilation) specification (WP2). Next, the model will be used to evaluate the effect of various gaps between pallet stacks and the potential use of slip sheets on container performance (WP3). Finally, the combination of results obtained from the present study and inputs from collaborating projects will be used to develop novel packaging solutions, which will then be assessed for cold chain performance (WP4).

Key Results

A mechanical engineering student (from Nigeria), with experience in fluid dynamics was identified in January 2018. The student (Adewale Nuryan Tiamiyu) joined the project in July 2018 and has completed the development phase of the model. Currently, the model is complete and is being refined so that it can be used in in the simulations that will address the main research questions of this project.

Discussion and Conclusion

The project is progressing well, but experienced some unavoidable delays to the student schedule occurred. Specifically, the student could only start 6 months into the project and was then required to complete additional course work (as an outside student at Engineering) in 2019. An extension to the project's deadline has thus been requested. Nevertheless, a working model has now been completed and is in the process of being refined. The next step will be to address the respective research questions as stated in the project's objectives.

Logistical considerations and limitations of refrigerated containers used in the pome and stone fruit export markets

(L Goedhals-Gerber, T Adams and C Neethling)

Objectives and Rationale

The internal dimensions of the 40' high cube containers differ between different shipping companies. In addition, most containers used by the fruit industry are leased for one-way shipping from third party operators. It is, therefore, generally not known what model or type of high cube container will arrive for loading. In addition, each refrigerated container also has a red line, which specifies the maximum allowable pallet stack height. These red lines also vary depending on the container model. Furthermore, the mechanical specification of the refrigeration units in each container has also developed and adapted over time and can differ substantially between manufacturers.

Methods

This research performed a detailed survey of high cube refrigerated containers, to identify the usage distributions applicable to the SA fruit export markets.

While a general overview of refrigerated container specification has already been compiled. This study investigated container usage at a much greater level of detail. Specifically, the main high cube refrigeration containers factors that were investigated are the (1) types, (2) models, (3) internal dimensions and (4) red line heights in use.

In addition, this study also investigated the actual refrigeration unit performance capabilities. A secondary objective was to determine if all refrigeration units are made equal and if there is any trend in performance or if any leaps in technology can be expected.

Key Results

- The internal dimensions of the 40-foot high cube refrigerated containers do vary, but not by substantial amounts.
- There is a trend towards standardization, not only on the outside, but also on the inside dimensions and specifications of the reefers.
- There is a trend towards standardisation of the various refrigerating systems used.
- Improved technology allows for the reefer age to be extended up to 15 years.
- Standardisation is hampered by the various ages of current reefers circulating in the shipping industry and the way they were manufactured. Once the older reefers are out of circulation, uniformity can be achieved.

Conclusion and Discussion / Recommendation

The internal dimensions of different 40-foot high cube refrigerated containers do vary, but not by substantial amounts as they only differ by a few millimetres. The research determined that in terms of the type of refrigerated unit model used, Carrier is the preferred model due to its reputation of being reliable. The containers can be used for up to 20 years, if they are well-maintained, continue to meet the safety requirements and operate in good working conditions. The average age of a 40-foot high cube refrigerated container was identified as approximately 10 to 15 years, if they meet all the requirements and specifications. There are no significant changes expected in the design of the container in the near future.

It is recommended that companies start sharing relevant information of the various containers in the market. Companies in SA often focus on improvements that will be beneficial to themselves in the short term rather than improvements that could benefit the industry as a whole in the long term. Companies should consider working more closely in the future to achieve uniformity in terms of the internal dimensions of refrigerated containers.

RETURN ON INVESTMENT

Developing a research information system for two South African agricultural industries: Learning about the impact of funded research

(N Boshoff and H Esterhuyse)

Objectives and Rationale

Contemporary funders have a need to understand the potential impact of the research that they support already before project completion. The current study is therefore aimed at impact monitoring and will combine, in a research information and management system (called RIS-Agric), select insights from three approaches for assessing the broader impacts of research (SIAMPI, IOM and ASIRPA). The deliverable is a set of impact-oriented monitoring tools for funders.

Methods

The impact understandings of funders were investigated by surveying individuals on the funders' decision-making committees (43 Winetech and 23 Hortgro responses were received). An international discussion workshop was conducted in December 2018. Conceptual frameworks were developed to organise the classifications and categorisations from which relevant indicators will be constructed.

Key Results

To some extent the two funders placed different emphasis on what they perceived to be ideal impacts. The different perceptions of impact were translated into twelve research outcomes (reflecting both immediate and long-term impacts). The identified research outcomes each has its own research impact pathway (e.g. a pathway to produce knowledge that is relevant for industry, or a pathway to develop new or improved products for industry). The twelve different pathways overlap and one pathway could be a necessary condition for the other. Essentially, the pathway to produce knowledge that is relevant for industry should underpin all other pathways.

Discussion and Conclusion

RIS-Agric through its monitoring, will 'construct' the research impact pathways associated with each research outcome. In that way, RIS-Agric will provide insight into the process of impacting by collecting information about the interactions of the project team and linked stakeholders (i.e. those directly associated with the project), along a particular pathway. The interactions are interpreted as 'alignment efforts' for a project towards attaining a particular research outcome.