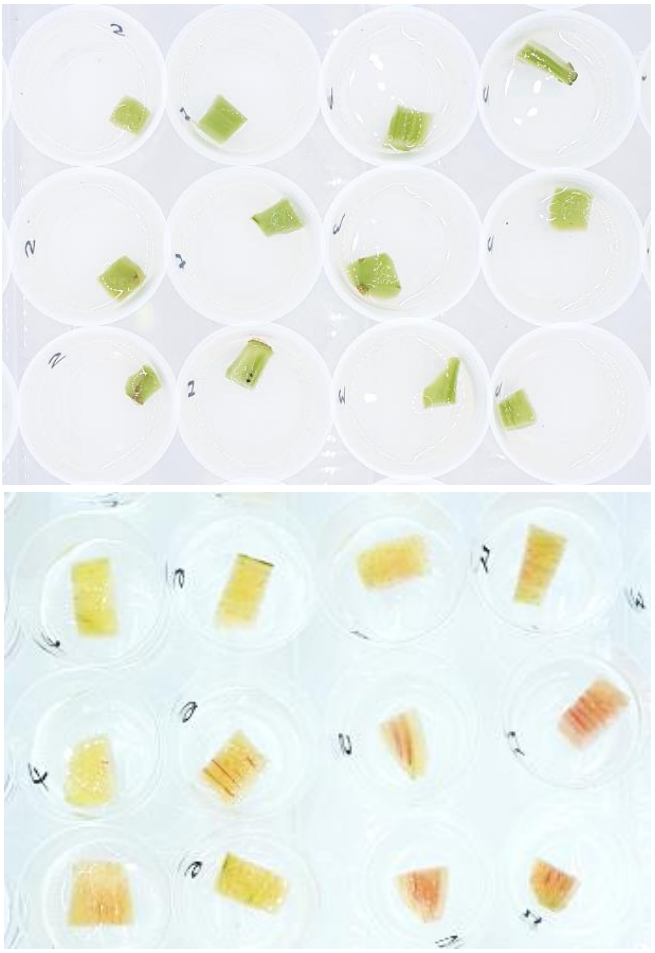

COVER STORY

These images are the outer pericarp of kiwifruit in different water potential solutions. These solutions are used to provide more information about kiwifruit cell turgor loss dynamics and how shrivel occurs. The data collected here was then used to determine the water capacity of the outer pericarp of kiwifruit.

Images generated by Raquel Lozano

Plant Science Central 2021

Welcome

Plant Science Central 2021

On behalf of the New Zealand Institute of Agricultural and Horticultural Science (NZIAHS), the New Zealand Branch of the International Association of Plant Biotechnology (NZIAPB) and the New Zealand Society of Plant Biologists (NZSPB), it is with great pleasure that we welcome you to this conference. In addition we are delighted to host sessions throughout the conference that are building towards the ISHS 'Postharvest 2024' Conference.

The concept of bringing organisations together to collaborate and provide a bigger and better conference, which makes use of the overlap in expertise and interests of our members, has served us well at biennial Plant Science meetings since 2013. In these Covid-constrained times, the opportunity of a web-supported but primarily face-to-face conference is highly attractive to plant scientists throughout the country and make this the premier plant science event in New Zealand.

We have a strong desire to promote collaborative and cross-disciplinary science, as well as excellence in research, and this meeting is designed to advance those aims. We expect that new connections will be formed and existing ones strengthened. We will be exposed to the latest cutting-edge research, both here and internationally through our invited speakers. We will welcome the current 'crop' of postgraduate students often making their first public presentation. And we will take time to celebrate the success of our colleagues in their particular fields.

We thank you for supporting Plant Science Central 2021, trust that you will gain much from the interaction, and wish you an interesting and enjoyable time.

Jon Hickford
President
NZIAHS

Richard Macknight
President
NZSPB

Maree Debenham
National Representative
NZ Branch IAPB

Andrew East
Allan Woolf
Co-convenors
Postharvest 2024

Mihi Whakatau waiata

Te Kunenga ki Pūrehuroa

Nei rā te reo karanga e tau atu nei	*Hear the call, the message*
Ki te hāpai ake i te rau tāngata	*To uplift the diverse human nature*
Whakaako, whakaeke ki te kōmata.	*Learn and aspire to reach the pinnacle.*
Te Kunenga ki Pūrehuroa.	*This is the message from Massey University.*
Te ara mātauranga	*The pathways to learning*
Ka whakarewa e	*Can be inspirational*
Te māramatanga ka kitea e	*And deeper understanding can enlighten*
Kimihia, rangahaua kia whita e.	*Therefore, seek out and grasp knowledge*
Te Kunenga ki Pūrehuroa!	*This is the message from our University!*

Te Aroha

Te aroha	
Te whakapono	
Me te rangimarie	
Tatou tatou e	*May love, hope and peace be with us all*

Table of Contents

Plant Science Central Conference
is brought to you by

Organising Committee

Massey University
Prof Julian Heyes (Chair of Organising Committee)
Prof Andrew East
Dr Svetla Sofkova-Bobcheva
Dr Mo Li
Sebastian Rivera Smith

AgResearch
Dr Kim Richardson

NZ Institute for Plant & Food Research
Dr David Brummell
Dr David Lewis
Dr Marian McKenzie
Dr Jeremy Burdon
Dr Maree Debenham (NZIAPB National Correspondent)
Yvonne McDiarmid

University of Otago
Assoc Prof Richard Macknight (President of NZSPB)

Conference Secretariat
Jenny Taylor

We gratefully acknowledge their employers:

We gratefully acknowledge our sponsors

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Postharvest 2024 sponsors

Programme at a glance

Tues 6 July

9.30 am	Registration/Morning tea
10.45 am	Mihi Whakatau/Maori welcome
11.15 am	**Session 1: Opening Addresses**
12.30 pm	Lunch in foyer
1.30 pm	**Session 2: Gene editing (concurrent)**
1.30 pm	**Session 3: Plant microbe or insect interactions (concurrent)**
1.15 pm	**Session 4: International Development Workshop (concurrent)**
3.00 pm	Afternoon tea in foyer
3.30 pm	**Session 5: Three-minute oral posters**
5.00 pm	Wine and cheese / Poster session

Wed 7 July

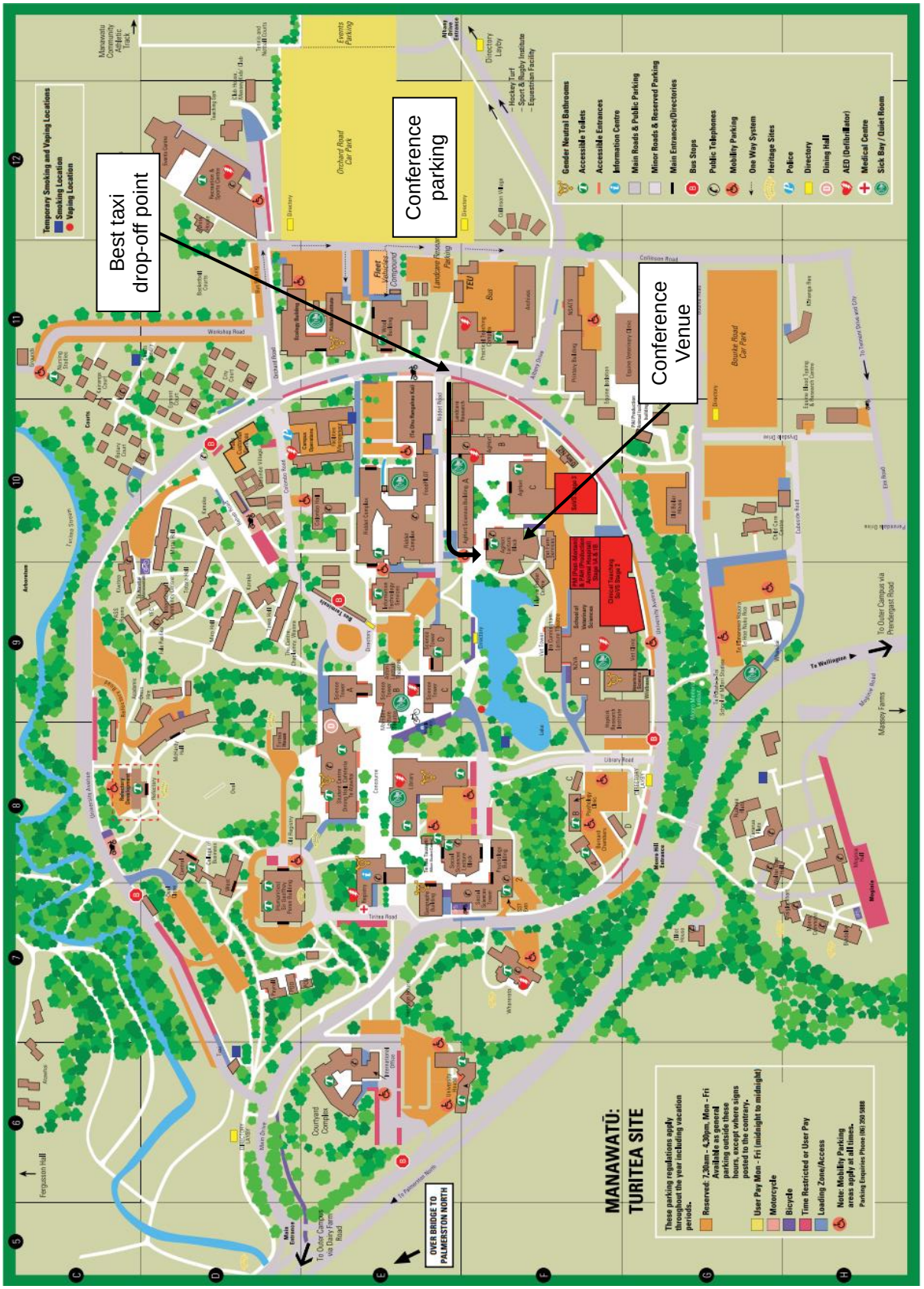
9.00 am	***Keynote 1: The evolution and diverse functions of stress-related red pigmentation in land plants***
9.45 am	**Session 6: Flavonoid metabolism (concurrent)**
9.45 am	**Session 7: Development horticulture (concurrent)**
9.45 am	**Session 8: Chilling (concurrent)**
10.30 am	Morning tea in foyer
11.00 am	**Session 9: Plant metabolism and development (concurrent)**
11.00 am	**Session 10: Germplasm conservation (concurrent)**
11.00 am	**Session 11: Modelling (concurrent)**
12.30 pm	Lunch in foyer
1.30 pm	***Keynote 2: Integrative approaches to understand and predict avocado ripening***
2.15 pm	**Session 12: Plant development (concurrent)**
2.15 pm	**Session 13: Climate change and environment (concurrent)**
2.15 pm	**Session 14: Postharvest treatment (concurrent)**
3.00 pm	Afternoon tea in foyer
3.30 pm	**Session 15: Tree & vine physiology I (concurrent)**
3.30 pm	**Session 16: Biosecurity (concurrent)**
3.30 pm	**Session 17: Supply chain (concurrent)**
5.00 pm	NZIAHS, NZSPB, NZIAPB AGMs
7.00 pm	Conference dinner

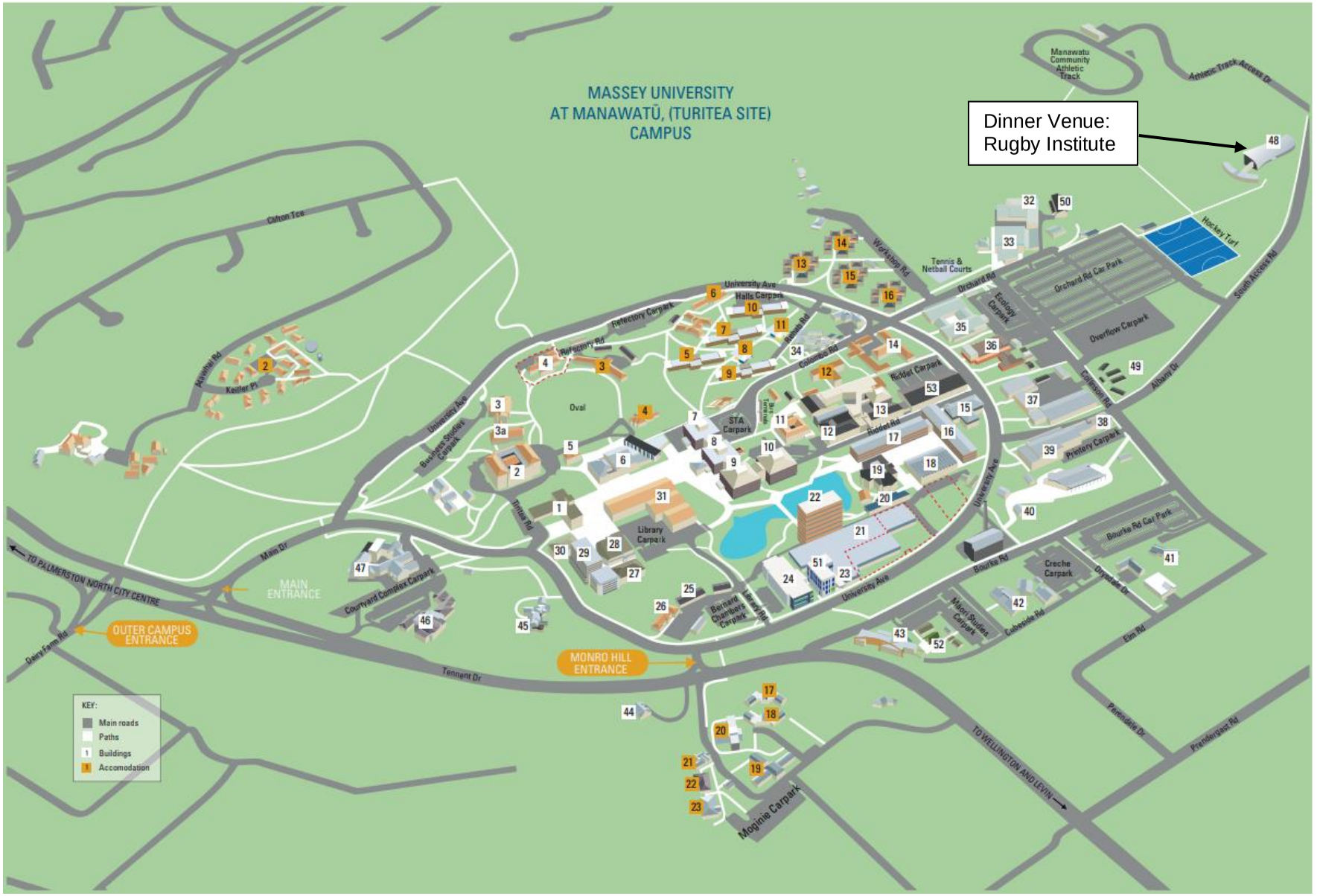
Thurs 8 July

9.00 am	***Keynote 3: NZSPB Roger Slack Award Speaker: Insights into the biosynthesis, control and function of red pigmentation in plants***
9.45 am	**Session 18: Non-destructive technologies (concurrent)**
9.45 am	**Session 19: NZSPB Michael McManus Awardees (concurrent)**

10.30 am	Morning tea in foyer
11.00 am	**Session 20: Ripening and shelf life (concurrent)**
11.00 am	**Session 21: Tree & vine physiology II (concurrent)**
11.00 am	**Session 22: Breeding technologies (concurrent)**
12.30 pm	Lunch in foyer
1.30 pm	***Keynote 4: Non-powered cool storage solutions***
2.15 pm	Conference close / awards

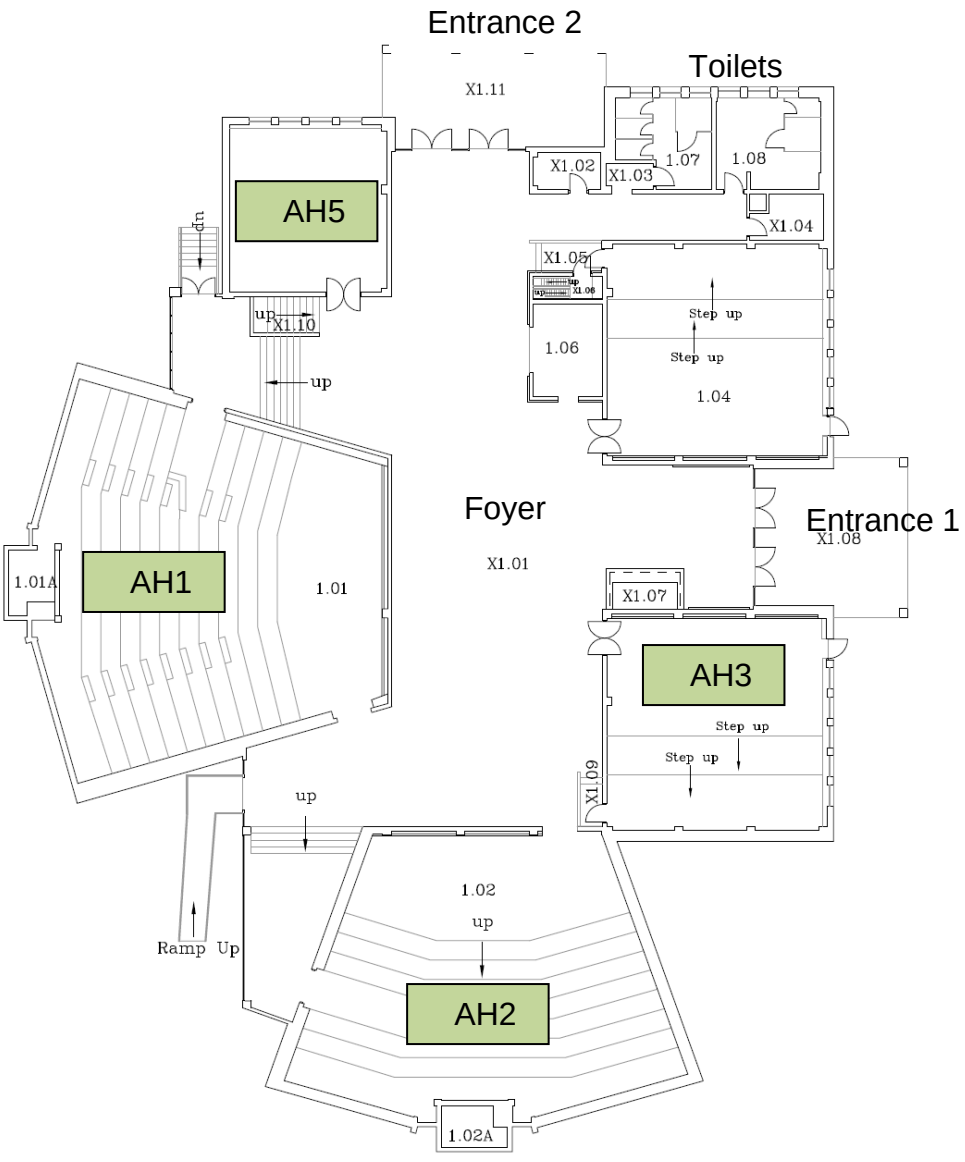
Campus Map


Best taxi drop-off point
Conference parking
Conference Venue
MANAWATŪ:
TURITEA SITE
OVER BRIDGE TO PALMERSTON NORTH


MASSEY UNIVERSITY
AT MANAWATŪ, (TURITEA SITE)
CAMPUS
Dinner Venue:
Rugby Institute
Manawatu Community Athletic Track
Athletic Track Access Dr
Hockey Turf
South Access Rd
Tennis & Netball Courts
Orchard Rd Car Park
Overflow Carpark
Ecology Carpark
Orchard Rd
Workshop Rd
Colombo Rd
Ridder Carpark
Ridder Rd
Albany Dr
Oval
University Ave
Halls Carpark
Refectory Carpark
Refectory Rd
Hostel Rd
Keiller Pl
Massey Rd
Business Studies Carpark
STA Carpark
Turitea Rd
Main Dr
Library Carpark
Primary Carpark
Bourke Rd Car Park
Bourke Rd
Creche Carpark
Cubbon Rd
Orpheus Dr
Elm Rd
Bernard Chambers Carpark
Courtyard Complex Carpark
Maori Studies Carpark
Mogima Carpark
Tennent Dr
Dairy Farm Rd
TO PALMERSTON NORTH CITY CENTRE
MAIN ENTRANCE
OUTER CAMPUS ENTRANCE
MONRO HILL ENTRANCE
TO WELLINGTON AND LEVIN
Palmerston Dr
Pranergasi Rd
KEY:
Main roads
Paths
Buildings
Accomodation

Venue Layout

AgHort Lecture Block



General Information for Delegates

Venue
The conference is being held in the AgHort Lecture Block on Massey University's Turitea Campus. A campus map is in this booklet and a larger version is available for your reference at the Registration Desk.

Registration Desk
The Registration Desk will operate throughout the conference during the following hours. NB: the desk is likely to be unmanned during sessions.

Tues 6th July	9:30 am - 5:00 pm
Wed 7th July	8:30 am - 4:30 pm
Thurs 8th July	8:30 am - 2:45 pm

Name Badges
For security reasons and easy identification we ask that you wear your name badge at all times during the conference and social events.

Lost Property
Please check with the Registration Desk if you lose or find any property during the conference.

Doctor
City Doctors Phone: 06 355 3300 (open 7 days 8am to 8pm)
22 Victoria Avenue, Palmerston North

Palmerston North Hospital
Palmerston North Hospital Phone: 06 356 9169 (open 24 hours)
50 Ruahine Street, Palmerston North

Chemist
City Health Pharmacy Phone: 06 355 5287 (open 7 days 8am to 8pm)
22 Victoria Avenue, Palmerston North

Mobile Phones
Please ensure that your mobile phone is set to silent mode throughout presentations. You are most welcome to join the silent conversation on Twitter using the conference official hashtag #NZPSC2021

Smoking
Smoking is not permitted in all workplaces, grounds and buildings, staff/student accommodations, farms and vehicles, except where there is a designated smoking area. The temporary smoking concessions include adjacent to the Courts Laundry, (off

Workshop Road), intersection of University Ave and Main Drive, Moginie Hill (off the Ruahine Path), Library Road (opposite Library carpark) and Facilities Services Compound (Southern entrance).

In Case of Emergency

In the unlikely event of a fire, a continuous alarm bell will sound, all delegates are asked to leave the venue without delay and congregate on the main concourse outside Entrance 1 of the AgHort Lecture Block.

Catering

Morning tea, lunch and afternoon tea are included in your registration fee and will be served in the foyer area of the AgHort Lecture Block, during programmed breaks.

Special Dietary Requirements

If you have advised the conference secretariat of any special dietary requirements during the on-line registration process, your meals will be available on a 'Special Dietary Requirements/Buffet' table in the foyer area.

Conference Dinner

The Conference Dinner will be held at Rugby Institute beginning at 7:00 pm on Wed 7th July. Pre-purchase of tickets was essential.

Loading presentations

A prerecorded All presentations must be loaded at least three hours before your scheduled presentation time to ensure smooth running of sessions. IT support staff will be on hand during each break to pre-load presentations. Please note that any embedded sound files or video clips need to be contained in the folder of your presentation file, so that PowerPoint can locate these during your presentation. As a precaution against Covid alert level changes, we have asked presenters to submit their powerpoints the week before the conference with a voice-over recording.

Posters

Posters will be displayed throughout the conference in the AgHort Lecture Block Foyer. Presenters are asked to put their posters up on arrival on Tuesday and not take them down until lunch on Thursday. Oral poster presenters will have the opportunity to advertise their posters in a 3-minute quick-fire session on Tuesday afternoon.

Shops

There is a MUSA convenience shop and a Bennett's bookshop in the concourse.

Wireless Internet Access

Free wireless access is available at this meeting for delegates with their own wireless devices via "inspirefreewifi" or "MUGuests".

Parking
Free conference parking is available in the Orchard Road carpark (E12 on campus map). Please drive in and take a ticket; but you MUST bring this to Registration Desk by lunchtime and they will secure an exit card for you, each day. If you miss the lunchtime deadline, you can exchange your entry ticket for a subsidised exit ticket at Facility Management before 4 pm, or pay the normal price at the pay booths in the carpark. Normal price is $2.70 - $4.20 depending on length of stay.

Taxis
Taxis are available in Palmerston North and contact numbers of taxi companies are listed below. Use of taxis is at your own expense.
Taxis Palmerston North:
Phone 06 355 5333 or book online https://www.pntaxis.co.nz/bookings/
Taxis Gold & Black:
Phone 0800 35 12345 or book online https://www.taxicaller.com/en/booking

Bus
There is limited bus transport availability in the University vacations which will take you up Fitzherbert Avenue to the town centre. Timetables are available at Reception.

Liability
The members of the conference organising committee accept no liability for personal accident nor loss or damage suffered by any participant, accompanying person, invited observer or any other person by whatever means. Neither do we accept liability for any equipment or software brought to the conference by delegates, speakers, or any other party.

First Aid
A First Aid Kit and Defibrillator are available in the AgHort Science Tower B & C link (in corridor beside Reception), or by contacting Facilities Management Security Help Desk during business hours on (06) 356 9099 Ext 85030, or 24 hours on 0800 627 750.

COVID-19 Contingency Plan

The Plant Science Central Conference will be held at Massey University, Palmerston North from 6-8 July 2021. It is a face-to-face meeting only and will not be live-streamed. However, in the event of interference from COVID-19 we will deliver **a fully or partially online meeting**. This requires all presenters to be prepared to submit pre-recorded talks about 10 days before the conference. These recordings will be password protected and made available only to registrants and will be taken down soon after the meeting.

Below is our plan on how the Plant Science Central Conference will be managed under the various COVID-19 Alert Levels.

COVID-19 Alert Level Change in New Zealand

Should the COVID-19 Alert Levels change anywhere within New Zealand before the start of the Plant Science Central Conference the following scenarios will come into effect:

1. If Palmerston North remains at Alert Level 1 the Plant Science Central Conference will continue as a face-to-face meeting.
2. If a region in New Zealand outside Palmerston North is at Alert Level 2 or above, delegates **from that region** will be able to join the Conference via the live stream option (links will be sent). Delegates from the rest of New Zealand, still at Alert Level 1, are expected to physically attend the Conference. The Chair for each session will ensure online and local questions are equally valued. The meeting will be recorded and remain available for a limited period after the conference is over.
3. If Palmerston North is at Alert Level 2 or above, the option to physically attend the Conference will not be available due to New Zealand Government protocols. We will ensure all pre-recorded presentations are made available to all delegates and remain available for a limited period after the conference is over. We may struggle to offer a full live stream experience if our staff are unable to come into the University, so there will be **more communication** in this case.

We understand that there are a number of different Alert Levels and protocols that affect New Zealand and as these can change at short notice we recommend you keep the following link bookmarked for ease of reference:

Unite against COVID-19

Delegates choosing to travel from outside of New Zealand to attend this Conference, do so at their own risk and expense.

Plant Science Central Conference

Program

6-8 July 2021, Ag/Hort Lecture Block, Massey University, Palmerston North, New Zealand

Tuesday 6th July 2021 NB Parallel Sessions in AH1, AH2 and AH3		
09:30 – 10:45	Registration/morning tea in foyer	
10:45 – 11:15	Mihi whakatau and welcome	
Session 1	**AH1 Opening session – Climate Change & Environment**	**Chair: Julian Heyes**
11:15 – 12.00	**Opening Address**	Nicola Shadbolt, Climate Commissioner
12.00 – 12.30	**Opening Address**	Dame Juliet Gerrard, Chief Science Advisor to PM
12:30 - 13:30	**Lunch**	
Session 2	**AH1 Gene Editing**	**Chair: Lynette Brownfield**
13:30 – 14:00	**Extended Talk** Plant Gene Editing: are we there yet?	Andy Allan
14:00 – 14.15	Knockout of AcBFT2 by CRISPR/Cas9 – targeted mutagenesis to reduce plant dormancy in kiwifruit *(Actinidia chinensis)*	Dinum Herath
14:15 – 14:30	CRISPR gene editing of the GFP reporter gene in *Epichloë festucae* Fl1	Taryn Miller
14:30 – 14:45	Controlling ripening in kiwifruit	Robert Schaffer
14:45 – 15:00	What are they do*ING*? Gene editing of *INHIBITOR OF GROWTH* in the model legume *Medicago truncatula*	Matthew Mayo-Smith
15:00 – 15:30	**Afternoon Tea**	
Session 3	**AH2 Plant Microbe or Insect Interactions**	**Chair: David Lewis**
13:30 – 13:45	Reduction of the attachment, survival and growth of *L. monocytogenes* on lettuce leaves by UV-C stress	Emmanuel Kyere
13:45 – 14:00	Understanding the chemical effects of Zebra chip disease in two potato *(Solanum tuberosum)* cultivars	Jess Fitzgerald
14:00 – 14:15	*Delphinium* alkaloids as promising botanical pesticides with potential commercial value	Wenliang Xu
14:15 – 14:30	The effects of ultraviolet (UV) light on important crop plant-pathogen interactions in the Taranaki region of New Zealand	Cade Fulton
14:30 – 14:45	Host influence on *Epichloë* seed transmission in *Lolium perenne*	Wei Zhang
14:45 – 15:00	Investigating methods of long-term storage in *Ciborinia camelliae*	Kay Pilkington
15:00 – 15:30	**Afternoon Tea**	
Session 4	**AH5 International Development Workshop**	**Chair: Fran Doerflinger**
13:15 – 13.45	Emerging trends in international development from the perspective of a donor in horticulture research	Irene Kernot
13:45 – 14:00	Enhancing the capacity of mango packhouses in the Mekong River Delta	Tram Anh San

14:00 – 14:15	High-value horticulture builds resilience for small farmers in developing countries	Julian Heyes
14:15 – 14:30	Assessing the effectiveness of a hot water treatment to eliminate *Phytophthora colocasiae* from freshly harvested taro corms in Samoa	Seeseei Molimau-Samasoni
14:30 – 14:45	Industry Association as an agent of system-wide change in temperate fruit industry development in Son La province, Vietnam	Oleg Nicetic
14:45 – 15:00	Horticulture postharvest development initiatives in Asia	Antonio Acedo Jr.
15:00 – 15:15	The complexity of smallholders' livelihoods and the implications for rural development: a case study of cattle management in Eastern Indonesia	Janet Reid
15:15 – 15: 30	**Afternoon Tea**	
Session 5	**AH1 Oral Posters**	
15:30 – 17:00	3 min Poster Presentations	
17:00 – 18:00	**Poster session with drinks and nibbles**	
18:00 -	**Free time (NZSPB: dinner in town)**	

Wednesday 7th July 2021 NB Parallel Sessions in AH1, AH2 and AH3

	AH1 Keynote 1	**Chair: Nick Albert**
09:00 – 09:45	**Plenary Speaker (IAPB)** The evolution and diverse functions of stress-related red pigmentation in land plants	Kevin Davies
Session 6	**AH1 Flavonoid Metabolism**	**Chair: Charles Dwamena**
09:45 – 10:00	Spatiotemporal modulation of flavonoid metabolism in *Vaccinium* berries	Catrin Guenther
10:00 – 10:15	MYBPA1.1 is a dual regulator of both anthocyanin and proanthocyanidin pathways in *Vaccinium*	Declan Lafferty
10:15 – 10:30	Bicolours, bullseyes and landing lights – molecular regulation of complex floral patterning in *Antirrhinum*	Nick Albert
10:30 – 11:00	**Morning tea**	
Session 7	**AH2 Development Horticulture**	**Chair: Svetla Sofkova-Bobcheva**
09:45 – 10:00	Improving shallot bulb yield in extremely acidic soil by applying N, P fertilisers and lime in West Java, Indonesia	Gina Aliya Sopha
10:00 – 10:15	Using cassava extracts to leach gold	Chris Anderson
10:15 – 10:30	Comprehensive evaluation of antioxidative potential, *in vitro* antioxidant activities and oxidative stability (Pre-recorded)	Anurak Malik
10:30 – 11:00	**Morning tea**	
Session 8	**AH3 Chilling**	**Chair: Jung Cho**
09:45 – 10:00	First steps towards understanding the genetic basis of cold-induced ripening in apple fruit	Jason Johnston
10:00 – 10:15	Transcriptome responses to mild and severe chilling stress in cold-stored ripe cherry tomato fruit	Zoe Erridge

10:15 – 10:30	*AcCBF3* promotes freezing tolerance in *Actinidia* (kiwifruit) fruit	Tina Wang
10:30 – 11:00	**Morning tea**	
Session 9	**AH1 Plant Metabolism and Development**	**Chair: Catrin Guenther**
11:00 – 11:15	Probing the carotenoid pathway for regulators of yellow-fleshed apple	Charles Dwamena
11:15 – 11:30	Gene regulatory network for russetting-related triterpene biosynthesis in apple	Christelle Andre
11:30 – 11:45	Timing is everything: Circadian control of *Medicago truncatula*	Soledad Perez-Santangelo
11:45 – 12:00	Investigating the role of peptide hormones in coordinating growth, nitrogen demand signalling and symbiotic nitrogen fixation	Nijat Imin
12:00 – 12:15	Comparison of polyphosphate accumulation between six species of microalgae	Alex Cliff
12:15 – 12:30	Conditional biased transmission of herbicide-resistant alleles in *Brassica napus*: a gene drive mimic	Tony Conner
12:30 – 13:30	**Lunch**	
Session 10	**AH2 Germplasm Conservation**	**Chair: Sarah Moss**
11:00 – 11:15	Developing cryopreservation methods for *Syzygium maire* zygotic embryos	Karin van der Walt
11:15 – 11:30	Investigation of taxonomy and diversity of *ex situ* collections of *Rhododendron* (subsection *Maddenia*) for conservation	Ling Hu
11:30 – 11:45	Optimisation of germination requirements and long-term storage conditions for *Actinidia* species seeds	Liya Mathew
11:45 – 12:00	Establishing an *in vitro* grape berry growth culture system to study Pinot Noir berry development	Mei Meiyalaghan
12:00 – 12:15	In vitro therapies for effective eradication of virus species from *in vitro*-grown potato shoot tips	Jean Bettoni
12:15 – 12:30	Indigenous responses to taonga impacted by Myrtle rust	Alby Marsh
12:30 – 13:30	**Lunch**	
Session 11	**AH3 Modelling**	**Chair: Nicolette Niemann**
11:00 – 11:30	**Extended talk** Applications of models in a commercial supply chain	Sunny George Gwanpua
11:30 – 11:45	Optimal box design for containerised shipping of produce	Gabe Redding
11:45 – 12:00	A 10-year journey for predicting storage life in apples	Jason Johnston
12:00 – 12:15	A multi-omics apple profiling to identify at harvest, biomarkers predicting perfect storage life	Laurie Favre
12:15 – 12:30	Predicting dried quality of Fijian *Theobroma* cacao beans using a mechanistic model (Pre-recorded)	Rupa Raju
12:30 – 13:30	**Lunch**	
	AH1 Keynote 2	**Chair: Andrew East**

13:30 – 14:15	**Plenary Speaker** **Integrative approaches to understand and predict avocado ripening**	Romina Pedreschi
Session 12	**AH1 Plant Development**	**Chair: Soledad Perez-Santangelo**
14:15 – 14:30	Prototype planar cordon apple orchards double yield and increase fruit quality	Ben van Hooijdonk
14:30 – 14:45	Do localised supra-optimal concentrations of jasmonates control tissue responses?	Nathanael Napier
14:45 – 15:00	A transcriptome study of shoot branching potential	Luke Luo
15:00 – 15:30	**Afternoon tea**	
Session 13	**AH2 Climate Change and Environment**	**Chair: Rainer Hofmann**
14:15 – 14:30	Engineering perennial ryegrass for greater energy density, growth and lower on-farm emission	Luke Cooney
14:30 – 14:45	Modelling the effect of climate change on land use suitability for growing cherry	Carlo van den Dijssel
14:45 – 15:00	Conditions triggering N_2O production from *Chlamydomonas reinhardtii* axenic cultures and putative pathways involved	Laura Teuma
15:00 – 15:30	**Afternoon tea**	
Session 14	**AH3 Postharvest Treatment**	**Chair: Abdul Jabbar**
14:15 – 14:30	Effects of phosphine on fruit quality and target pest mortality of 'Hass' avocado fruit	Paul Pidakala
14:30 – 14:45	Semi-commercial application of hot water treatment for control of bull's eye rot in apples	Jung Cho
14:45 – 15:00	Postharvest curing and storage of New Zealand-grown potato cultivars ('Moonlight' and 'Nadine') for export to Fiji	Hans Mahilum
15:00 – 15:30	**Afternoon tea**	
Session 15	**AH1 Tree & Vine Physiology**	**Chair: Michael Kramer**
15:30 – 15:45	Use of physiological principles to guide precision orchard management and facilitate increased yields of premium quality fruit	Ken Breen
15:45 – 16:00	New Zealand Juniper studies	Svetla Sofkova
16:00 – 16:15	Floral bud type influences fruit quality in 'PremP009' pear	Hassan Saei
16:15 – 16:30	Comparing light interception and productivity in two modern apple-growing systems	Michelle Schurmann
16:30 – 16:45	Can summer pruning strategies produce more compact rabbiteye blueberry plants grown in tunnels?	Jill Stanley
16:45 – 17:00	Can reflective mulch improve light conditions to reduce fruit quality variability in very narrow-row planar cordon cherries?	Claire Scofield
17:00 - 18:00	**AH1 AGM for NZSPB**	
17:00 – 18:00	**AH2 AGM for NZIAHS**	
17:00 – 18:00	**AH3 AGM for IAPB (NZ)**	

19:00 – 22:00	**Conference Dinner, Rugby Institute, Massey University**	
Session 16	**AH2 Biosecurity**	**Chair: Ed Morgan**
15:30 – 15:45	Future challenges at the border. The next generation of biosecurity researchers	David Teulon
15:45 – 16:00	Facing unfamiliar new biological threats: a risk assessment framework for Aotearoa	Tracey Godfery
16:00 – 16:15	A case study of the New Zealand response to the introduction of Myrtle Rust	Madeline Marshall
16:15 – 16:30	Detecting volatile organic compounds using an insect odorant receptor device	Ned Treacher
16:30 – 16:45	No evidence of genetic bottlenecks following the accidental introduction of three agricultural weeds into New Zealand	Sandra Savinen
16:45 – 17:00	Can sterile parasitoids be employed for eradication by mitigating potential risk of non-target impacts?	Kiran Horrocks
Session 17	**AH3 Supply Chain**	**Chair: Sunny George Gwanpua**
15:30 – 15:45	Aggregating 'Hass' avocado fruit before packing	David Billing
15:45 – 16:00	Severity of scuffing discolouration of SunGold™ Kiwifruit as influenced by maturity	Talon Sneddon
16:00 – 16:15	Consequences of sustainable packaging systems on kiwifruit weight loss and quality maintenance	Raquel Lozano
16:15 – 16:30	Influence of storage technologies on mechanical properties of blueberry	Sebastian Rivera-Smith
16:30 – 16:45	Considerations for developing a physical scale model of a refrigerated container to study airflow and temperature control	Abdulquadri Alaka
16:45 – 17:00	A survey of conditions in the kiwifruit supply chain in India and Singapore	Praveen Veeregowda

Thursday 8th July 2021 NB Parallel Sessions in AH1, AH2 and AH3		
	AH1 Keynote 3	**Chair: Richard Macknight**
09:00 – 09:45	**Plenary Speaker – NZSPB Roger Slack Award** Insights into the biosynthesis, control and function of red pigmentation in plants	Kathy Schwinn
Session 18	**AH 1 Non-Destructive Technologies**	**Chair: Mo Li**
09:45 – 10:00	Near infrared spectroscopy and aquaphotomics for non-destructive fruit quality measurement	Harpreet Kaur
10:00 – 10:15	Spectrally distinguishing kiwifruit chilling injury from other tissue damage types in high-speed grading applications	Mark Wang
10:15 – 10:30	Kiwifruit storage breakdown disorder detection using laser backscattering image system	Zoe Yang
10.30 – 11.00 am	**Morning tea**	
Session 19	**AH 2 NZSPB Michael McManus Awardees**	**Chair: Paul Dikjwel**
09:45 – 10:00	The Role of *DAM* and *SVP*-Like Genes in Regulating Dormancy Cycle in Temperate Fruit Trees	Rongmei Wu

10:00 – 10:15	Molecular regulators of masting in *Celmisia lyallii*	Samarth
10.30 – 11.00 am	**Morning tea**	
Session 20	**AH 1 Ripening and Shelf Life**	**Chair: Sebastian Rivera**
11:00 – 11:30	**Extended Talk** Functional characterization of tomato (*Solanum lycopersicum*) SlPDX1-3 reveals a role for vitamin B6 in regulation of fruit ethylene biosynthesis	Nigel Gapper
11:30 – 11:45	Post-storage softening of 'Zes008' kiwifruit	Kristie O'Donnell
11:45 - 12:00	Quantifying ethylene production magnitude and timing in SunGold™ kiwifruit as influenced by ethylene exposure	Carlos Lopez-Lozano
12:00 – 12:15	Early stages towards understanding the genetic basis for maintaining fruit quality at high ambient market temperatures	Anna Tattersall
12:15 – 12:30	Quality and cell wall characteristics in specialty tomatoes during extended shelf-life	Erin O'Donoghue
12:30 – 13:30	**Lunch**	
Session 21	**AH 2 Tree & Vine Physiology**	**Chair: Claire Scofield**
11:00 – 11:15	How pre-harvest foliar potassium nitrate improved at-harvest fruit quality of 'Zesy002' kiwifruit?	Marya Hashmatt
11:15 – 11:30	Exploring the regional effect of pollinisers on fruit set and quality of 'PremP009' (PIQA™BOO™) pear	Jess Byrne
11:30 – 11:45	'Scifresh' apple fruit size and colour remain high as trees age in a planar cordon orchard design	Tessa Leitch
11:45 – 12:00	Chilling requirements of an extensive apple germplasm set based on two bud-break phenotyping approaches	Moon Chen
12:00 – 12:15	Reflecting on light in kiwifruit orchards	Michael Kramer
12:15 – 12:30	Crop load influences fruit quality more than canopy structure in 'Zesy002' kiwifruit	Kris Kramer-Walter
12:30 – 13:30	**Lunch**	
Session 22	**AH3 Breeding Technologies**	**Chair: Rowan Herridge**
11:00 – 11:15	Overexpression of a *VcMYBA* anthocyanin transcription factor in *Vaccinium corymbosum* produces dark red shoots *in vitro*	Murray Boase
11:15 – 11:30	Evolution of cytonuclear coordination in *Tragopogon* (Asteraceae) allopolyploids	Sidra Hussain
11:30 – 11:45	Stable genetic transformation of *Papaver somniferum* increases capsular morphinan alkaloid concentrations	Murray Boase
11:45 – 12:00	Understanding pollen abortion in female kiwifruit	Liam Le Lievre
12:00 – 12:15	Nitrous oxide and ploidy changes in a model crop	Juana Cordoba
12:15 – 12:30	Automated identification of blueberry flowering buds using RGB-depth cameras	Janelle Mo Li
12:30 – 13:30	**Lunch**	
	AH 1 Keynote 4	**Chair: Allan Woolf**
13:30 – 14:15	**Plenary Speaker** Non-powered cool storage solutions	Randy Beaudry
14:15 – 14:30	**Conference Close & Awards**	**Julian Heyes**

Posters

Number	Presenting Author	Title
P1	Tyler McCourt	The Role of DUF247 in Ryegrass Self-Incompatibility
P2	Danxia Shi	Antioxidant Nutrients Evaluation of Hass Avocado By-products Extracts
P3	Alex Nguyen	Functional characterisation of candidate genes modulating anthocyanin biosynthesis in *Vaccinium*
P4	Marian McKenzie	Identification of metabolites associated with good and bad potato flavour
P5	Caitlin Harris	Assessing the impact of self-fertility in ryegrass
P6	Trevorne Douglas	The response of three banana hybrids to drought and simltaneous drought and pathogen stress
P7	Murray Boase	Stable transformation of *Solanum muricatum* with a *MYBA* anthocyanin transcription factor from *Vaccinium corymbosum* produces fruit with purple skin and flesh
P8	Umani Walallawita	Changes in lycopene content in powdered Red ('Merlice') and Orange ('Moonglow') tomatoes during freeze-drying and long-term storage
P9	Tony McGhie	Exploring the transcriptome basis of cold tolerance signals of grafted apple stem vasculature using RNA-seq workflow
P10	Nicolette Niemann	Characteristics of a 'PremA96' apple skin disorder
P11	Ruth Palmer	Measurement of density, for the determination of dry matter and brix
P12	Shiny Varghese	Genetic technologies for developing F1 hybrid ryegrass
P13	Henry Luo	Expression of the *GUSA* reporter transgene from *Escherichia coli* in various organs of stably transformed *Solanum muricatum*
P14	Thilini Warusawithana	Gene duplication fate in a genetic pathway context: An examination of the plant epidermal cell fate pathway in the allopolyploid genus *Pachycladon (Brassicaceae)*
P15	Kyle Macadam	Hass avocado yield estimation viability using machine vision
P16	Chelsea Kerr	Why do some fruit store for longer than others? Do oxidative processes play a role?
P17	Yujie Han	Hayward kiwifruit responses to modified atmosphere packaging
P18	Michele Reid	The "how to" guide for molecular breeding of High Metabolisable Energy GM ryegrass
P19	Sarah Robinson	Understanding Peptide Hormone Signalling: a functional analysis of plant peptide-receptor interactions
P20	Rainer Hofmann	Intraspecific differences in the transpiration rates of white clover in drying soil
P21	Danna Camiring	Characterization of Candidate Genes Associated with Onion *(Allium cepa L.)* Bulb Formation
P22	Su Liu	In vitro multiplication of *Juniperus communis L.* from shoot tip explants– preliminary findings
P23	Julie Latimer	Importing Grapevine Germplasm into New Zealand - Level 2 Post Entry Quarantine
P24	Dona Shanika Komahan	Evaluation of the performance and potential of Industrial Hemp *(Cannabis sativa L.)* cultivars across two environments in the North Island of New Zealand
P25	Dipenhumar Hadiya	Studying the potential for improved irrigation of apples using Nanobubble technology
P26	Mary Christey	Phenotypic variation in kiwiberry *(Actinidia arguta)* induced by γ-irradiation

Keynote Speakers

We have pleasure in welcoming
these keynote speakers to this conference

Prof Nicola Shadbolt, ONZM, Opening Address

Professor of Farm & AgriBusiness Management, Massey University. Climate Change Commissioner. Delivering farm and agribusiness management research and education - risk, strategy, business analysis, cooperatives; Chair of Plant & Food CRI; Director of the International Food & Agribusiness Management Association and former elected director of Fonterra Cooperative and representative for NZ in the International Farm Comparison Network (IFCN) in Dairying. Managing Editor of International Food and Agribusiness Management Review. Fellow of the New Zealand Institute of Primary Industry Management, the Australian Institute of Company Directors and the International Food & Agribusiness Management Association. An in-depth understanding of global farming and agribusiness. Awarded Officer of NZ Order of Merit for services to agribusiness in 2018.

Dame Juliet Gerrard, Chief Science Advisor to PM, Opening Address

Professor Juliet Gerrard completed a DPhil in Biological Chemistry at Oxford University before coming to New Zealand in 1993, as a research scientist at Crop & Food Research. In 1998, she was appointed as a Lecturer in Biochemistry at the University of Canterbury and moved to the University of Auckland in 2014. Juliet's research covers a broad base and is interdisciplinary, cutting across biochemistry, chemistry, health, agricultural and food science and biomaterial design. Juliet was Chair of the Marsden Council and a Director for Plant & Food Research, prior to her appointment in 2018 as the Prime Minister's Chief Science Advisor. She became a Dame in 2021. For more detail visit: *https://www.pmcsa.ac.nz/our-community/professor-juliet-gerrard/*

Dr Kevin Davies, IAPB Keynote Speaker

Kevin Davies is a principal scientist at Plant and Food Research Palmerston North. He studied at The University of Birmingham and University of Nottingham before moving to Aotearoa-New Zealand in 1989. He has researched plant pigments for more than 30 years, working on both fundamental aspects and application of genetic technologies for new cultivar development. Over the last decade he has led pioneering research on the origin and current diversity of the flavonoid stress-tolerance systems, and how these may have contributed to the colonisation of the land by plants. He has published more than 100 journal papers, and is a previous recipient of the Roger Slack Award and the Groupe Polyphénols Scientific Prize. He is also the Senior Editor of the New Zealand Journal of Crop and Horticultural Science. In 2020, he was awarded a James Cook Research Fellowship by the Royal Society Te Apārangi to investigate the evolution of flavonoid biosynthesis and red pigmentation in hornworts.

Dr Romina Pedreschi, Keynote Speaker

Romina Pedreschi obtained her PhD in Bioscience Engineering from KU Leuven in Belgium and performed a postdoctoral stay at the EU Institute for Reference Materials and Methods. Then, she joined as senior researcher in postharvest physiology and technology the Food and Biobased Research Institute of Wageningen University.

Currently, she works as associate professor at the Faculty of Agronomic and Food Sciences of Pontificia Universidad Católica de Valparaíso in Chile and serves as Director of the PhD Program in Agri-Food Sciences. She leads the research group in Postharvest Physiology and Food Biochemistry. Her research lines include fruit biology and postharvest technology and use of functional genomics - omics tools to study and understand quality traits of interest. To date she has published more than 70 WoS publications and has led several national basic and applied research projects in collaboration with international entities. She has coached several graduate students and postdoctoral researchers.

Dr Kathy Schwinn, Keynote Speaker
2021 NZSPB Roger Slack Award in Plant Biology

Dr Schwinn completed her BSc at the University of Minnesota, USA. In 1988, she joined what is now Plant & Food Research (PFR). She obtained an Overseas Study Fellowship to study for her PhD at the John Innes Centre/University of East Anglia, UK, which she completed in 2000. Dr Schwinn is currently a Science Leader at PFR. She has had leadership roles on MBIE and Marsden projects and has supervised nine PhD students.

Dr Schwinn's research focuses on the biosynthesis and function of the red plant pigments. Her groundbreaking research has identified the genetic regulation systems that enable the production of specific pollinator signals in flowers and contributed new findings on the biosynthesis of betalains and how they can ameliorate salinity stress. This has given us a greater understanding of how plants have evolved to interact with their abiotic and biotic environment.

Dr Randy Beaudry, Keynote Speaker

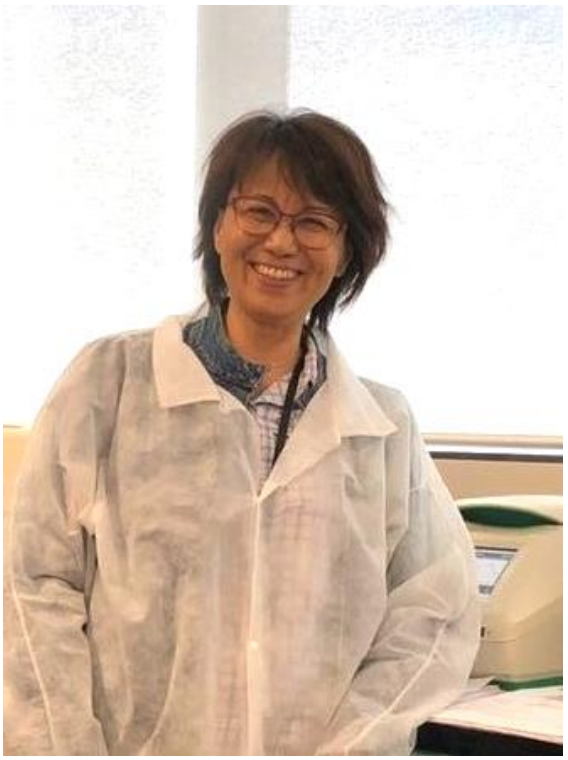
Randy Beaudry is a postharvest physiologist working at Michigan State University in the Department of Horticulture since 1989. Dr. Beaudry's activities focus on both practical and fundamental aspects of preserving the postharvest quality of fruits and vegetables. For developing world, Dr. Beaudry is engaged in work to develop low-cost, grid-independent cold storage options. In 2016, he and Dr. Sangeeta Chopra from the Indian Agricultural Research Institute (IARI), Delhi, were awarded a two-year USAID grant through the MSU Global Center for Food System Innovation to evaluate novel materials and designs in evaporative cooling for perishables storage and hybridizing evaporative cooling with solar-based refrigeration. Currently, Dr. Beaudry consults for a USAID-PEER project (2019 - 2021) with IARI in constructing hybrid cold storage structures (Farm SunFridge) for smallholder farmers with Dr. Chopra in an effort we call the Cool Sun Project. Aspects of this work can be seen online at a website for the Cool Sun Project: *https://coolsunproject.com/farm-sunfridge/*.

McManus Student Awardees

Dr Samarth

Samarth grew up in New Delhi, India and completed a Master's in Plant Biotechnology at the University of Hyderabad. He moved to New Zealand to pursue a PhD studying the molecular control of mast flowering in New Zealand endemic flora. This was under the guidance of the 'fantastic five' - the name he gave his supervisory team of Professors Paula Jameson, Dave Kelly, Matthew Turnbull, Richard Macknight and Anthony Poole. Samarth then worked as a Postdoctoral Fellow in the laboratory of Prof. Macknight & Dr Lynette Brownfield, investigating flowering genes in perennial ryegrass. He is currently working as a postdoctoral scientist under Prof. Kevin Davies, studying the stress tolerance mechanisms and regulation of flavonoid production in hornworts, the ancestral basal plants.

Dr Rongmei Wu



Rongmei grew up in China, studying for her BSc at Shanxi University and then worked at the Shanxi Agriculture Academy. In 1991 she received a Chinese Education grant to undertake her MSc at the University of Canterbury. Rongmei then began working at Plant & Food Research (PFR), Mt Albert. While working at PFR, she completed a PhD on winter dormancy in kiwifruit and apple under the supervision of Dr Erika Varkonyi-Gasic (PFR) and Prof. Richard Macknight (University of Otago). Rongmei has recently been appointed as a Research Aim leader of a parthenocarpy project at PFR.

Abstracts


Intl Assn Plant Biotechnology (NZ)
PLANT SCIENCE
NZ Society Plant Biologists
CENTRAL
NZ Institute Agricultural & Horticultural Science

Plant Gene Editing: are we there yet?

Andrew Allan[1 2]

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Key Words: Flowering, ripening, CRISPR, Breeding

Despite an acceptance that New Zealand would allow, on a "case-by-case" basis, the development of genetically modified (GM) plants or animals, there has been no commercial release of such organisms in this country. This may have been an advantage – NZ's clean-green-image (CGI) has delivered NZ many market opportunities. However, GM plants are now 15% of world agricultural value – a market sector in which NZ has no part to play. Gene edited plants are also regulated as GM, in this country. In many other countries gene edited plants are not regulated. Furthermore gene edits cannot be detected, unless editing sites are published or disclosed.

Such plants – with gene edits – are not generated "lightly", i.e. a considerable effort must be made to overcome biological and technical issues to make an edit. Despite this new cultivars are available (overseas) which show step changes in yield, improved growth in stressful environments, and increases in consumer-centric phenotypes such as colour, health compounds and flavour.

New Zealand now faces a decision point; how to adapt our regulatory system to cope with "evolved" plants which are better than grower's current cultivars. What are the benefits and risks of change, versus the risks/benefits of the status quo? What does the future look like for NZs plant-based industries?

Knockout of *AcBFT2* by CRISPR/Cas9 – targeted mutagenesis to reduce plant dormancy in kiwifruit (*Actinidia chinensis*)

Dinum Herath[1, 2], Charlotte Voogd[1], Andrew Allan[1, 2], Joanna Putterill[2], Erika Varkonyi-Gasic[1]

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Key Words: *Actinidia chinensis*, CRISPR/Cas9, *AcBFT2*, dormancy,

Members of the phosphatidylethanolamine-binding protein (PEBP) gene family have key roles in regulating flowering and architecture in various plant species. Here we study a kiwifruit PEBP gene called *AcBFT2*. It shows homology to *Arabidopsis BFT,* implicated in regulation of axillary inflorescence development. Previous research suggested that *AcBFT2* might control dormancy, flowering and plant architecture. However, the exact function of this gene in kiwifruit is unknown. In the present study, we used *Agrobacterium*-mediated transformation and CRISPR/Cas9 to target four sites in *AcBFT2*. Multiple stable knock-out lines were generated, demonstrating high editing efficiency, with bi-allelic mutations detected in 26.13% of transgenic plants. Furthermore, transgenic lines overexpressing *AcBFT2* were produced. The *bft2* edited, control and *35S:AcBFT2* lines performed differently in the glasshouse during the winter. The *bft2* lines displayed an ever-growing phenotype, while control and *35S:AcBFT2* plants went through dormancy. *35S:AcBFT2* plants showed early senescence and late budbreak compared with controls. To understand the molecular basis of these phenotypes, an RNA-seq transcriptomic analysis of dormant buds was conducted. Comparison of *bft2*, control and *35S:AcBFT2* buds at different times during winter identified differentially expressed genes (DEGs) implicated in regulation of oxidative stress, response to plant hormones, carbohydrate metabolism, and shoot system development. However, no effect of *AcBFT2* on flowering time regulation was found under present conditions, and none of the DEGs was associated with flowering. Therefore, editing of *AcBFT2* has the potential to reduce plant dormancy with no adverse effect on flowering, giving rise to cultivars better suited for the changing climate.

CRISPR gene editing of the GFP reporter gene in *Epichloë festucae* Fl1

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Key Words: *Epichloë*, CRISPR, GFP, Gene disruption, Microscopy

Epichloë forms a symbiotic association in the aerial apoplastic tissue of Poaceae grasses where the endophyte confers abiotic and biotic advantages to the host. Traditionally *Epichloë* has been genetically modified using protoplast mediated transformation in conjunction with homologous and/or random integration. However, this is not footprint less, inefficient, and cannot be applied to all strains. The successful application of CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) in fungal species prompted investigation into possible application of CRISPR in *Epichloë*. We have recently shown that CRISPR-Cas9 mediated gene editing can be applied to a range of *Epichloë* strains and utilising an autonomously replicating fungal vector to express the Cas9 protein, guide RNA and selectable marker simultaneously, and have demonstrated that this is footprint less. To determine how parameters such as guide RNA design and vector concentration impact the gene editing efficiency we tested a range of guide designs and guide concentrations to mutate a randomly integrated GFP gene in *E. festucae* strain Fl1. Successful gene editing was assessed by microscopy through loss of GFP fluorescence and gene edits were confirmed through sequencing. Both the guide RNA design and vector concentration had an impact on the efficiency of gene editing and this information will be useful to optimise CRISPR-Cas9 gene editing to study the molecular basis of the *Epichloë* symbiosis.

Controlling ripening in kiwifruit

Robert Schaffer[1], Marcela Martinez-Sanchez[2,] Tianchi Wang[2], Lara Brian[2], Ben Warren[2], Charlotte Voogd[2], Erika Varkonyi-Gasic[2], Niels Nieuwenhuizen[2], Tina Wang[2], Jeremy Burdon[2], Peter McAtee[2], Nigel Gapper[2], Ross Atkinson[2], Andrew Allan[2]

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Key Words: Kiwifruit, Fruit Ripening, CRISPR

Fruit have been classified by the way they respond to ethylene. Strongly ethylene responsive fruit (climacteric fruit) need ethylene to ripen, whilst non-climacteric fruit such as grapes and strawberry appear be less dependent on ethylene. Kiwifruit is unusual as, even though it is classed as climacteric, many ripening associated changes (such as starch breakdown, colour change and softening) occur without detectable ethylene. Large scale transcriptomics studies in multiple species have identified networks of transcription factors that may control these ripening changes. One such network in tomato includes the well characterised *RIPENING INHIBITOR* (*RIN*) and *NON RIPENING* (*NOR*) like genes. In kiwifruit multiple *NOR* genes were identified and two have been shown to complement the tomato *nor* mutation. The *CENTRORADIALIS* (*CEN)* CRISPR-edited kiwifruit that continuously flowers significantly reduces the time to flower and fruit allows rapid fruit-associated gene testing. A selection of ripening associated genes including *RIN*- and *NOR*-like genes are being edited in these fruit and progress on characterising these lines will be presented.

“What are they do*ING*? Gene editing of *IN*HIBITOR OF *G*ROWTH in the model legume *Medicago truncatula*”

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Key Words: Gene editing, CRISPR Cas9, epigenetics, *Medicago truncatula*, legumes.

*IN*HIBITOR OF *G*ROWTH (*ING*) are a group of conserved chromatin remodelling genes found across all eukaryotes. The proteins contain two domains. A highly conserved C-terminal Plant Homeodomain (PHD) recognizes and preferentially binds H3K4me3, a histone modification associated with active transcription. The ING proteins then recruit histone editing complexes through a N-terminal ING domain to direct chromatin remodelling and transcriptional silencing. Although well studied in humans and yeast, *ING* genes have been sparsely investigated in plants and not at all in legumes. We have gene-edited both *ING1* and *ING2* in *Medicago* to determine their function *in vivo*. This genetic work has been complemented with other techniques such as *in vitro* protein binding assays and qRT-PCR. Analysis of 13 mutant plants shows *ING2* acts non-redundantly with *ING1*, and loss of *ING2* has significant and varied effects on plant development including flowering time, compound leaf patterning, trichome development and plant architecture. Surprisingly, loss of some highly conserved amino acids in the PHD finger does not seem to disrupt ING2 function in some alleles. In contrast, the role of *ING1* is less clear, although it may still have a significant effect on plant development. Legumes are a vital but under-optimized agricultural family. By elucidating the role of the *ING* genes in the development of *Medicago*, this PhD project can provide the basis for improved forage and pulse production in legumes.

Reduction of the attachment, survival and growth of *L. monocytogenes* on lettuce leaves by UV-C stress

Emmanuel O. Kyere[1], David G. Popovich[1], Jon Palmer[1], Jason J. Wargent[2], Graham C. Fletcher[3] & Steve Flint[1].

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[2] Institute of Agriculture & Environment, Massey University, Private Bag 11222 Palmerston North, New Zealand.
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Key Words: Fresh produce, UV radiation, phytochemicals, food safety, plant stress response

Mild stress of leafy greens by UV-C radiation has been reported to stimulate plant defences capable of reducing pathogens on produce surfaces. In this study, the attachment, survival and growth of *Listeria monocytogenes* was investigated on lettuces stressed with mild UV-C radiation (1.3 and 2.6 kJm^{-2}). Attachment of *L. monocytogenes* to UV-C stressed (1.3 kJm^{-2}) lettuce leaves after 1 h was significantly ($p < 0.05$) reduced by 1.4-1.5 log cfu/cm². UV-C stress also reduced the survival of *L. monocytogenes* on lettuce by 1.8-1.9 log cfu/g 96 h after inoculation, however a higher dosage of UV-C stress (2.6 kJm^{-2}) did not inhibit the survival of *L. monocytogenes*. The total phenolic compounds in lettuce significantly increased following UV-C stress (1.3 kJm^{-2}) indicating the accumulation of polyphenols might have contributed to the inhibition of *L. monocytogenes* attachment and growth. Appropriate dosage of mild UV-C stress of lettuce can reduce the attachment, survival and growth of *L. monocytogenes* in lettuce and can therefore be explored further for application in fresh produce safety.

Understanding the chemical effects of Zebra chip disease in two potato (*Solanum tuberosum*) cultivars

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Key Words: Zebra Chip, Potato, Zebra Chip symptoms, Cultivar variation, *Candidatus Liberibacter solanaceum*

Zebra chip disease causes significant waste and economic loss to the New Zealand potato industry. The disease, caused by the infection of bacterium *Candidatus Liberibacter solanaceum*, (CLso) is characterized by dark brown stripes or blotches on potatoes which develop during frying. Browning develops due to the Maillard reaction where the two precursors: reducing sugars and specific free amino acids, react under high heat. Infection by CLso increases the level of reducing sugars and affects several other chemical and biochemical processes. This study uses cultivars that present different symptoms in CLso infected raw tubers, and will investigate how infection affects the chemistry and biochemistry in regard to cultivar and severity. This data will help to enhance the current understanding of Zebra chip disease and present useful ideas for further research.

Delphinium alkaloids as promising botanical pesticides with potential commercial value

Wenliang Xu[1], Lin Chen[2], Iftikhar Ali[3], David Harding[1], Jennifer Tate[1] and David Popovich[1]

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Key Words: *Delphinium,* botanical pesticide, diterpenoid alkaloid, New Zealand, aconitine

Botanical pesticides are derived from secondary metabolites in plants. These secondary metabolites are formed in long-term survival competition, which is the result of their defence evolution. Therefore, these substances are often possess specific biological activities such as antimicrobial and insecticidal effects. *Delphinium* is a genus of perennial flowering plants, rich in diterpenoid alkaloids with strong biological activities. In particular, its extensive insecticidal and antifeedant activity have been reported recently. Our previous study screened the antifeedant effect on 57 diterpenoid alkaloids by using leaf disc test against 3rd instar larvae of *Spodoptera exigua*. Most of the tested alkaloids showed certain antifeedant activity, the most potent alkaloids are aconitine, pubescensine, 3-deoxyaconitine and chasmanthinine ($EC_{50} \leq 0.07$ mg/cm^2). *Delphinium* was introduced in New Zealand at the end of the last century. So far, large-scale cultivation has taken place, and New Zealand has thus become an exporter of *Delphinium* seeds. Consequently, the above-ground parts of *Delphinium* have become by-products after seed harvest and are largely abandoned each year. Our research happens to be the way to utilize these by-products for new botanical pesticide development. Compared with common chemical pesticides, these botanical pesticides are easily degraded under natural conditions, soil and water pollution can be largely avoided; also, alkaloids can be manufactured into alkaloid hydrochlorides, easy to clean and increase edible safety of agricultural products; moreover, the composition of plant extracts are complex, have multiple effect targets and less possibility of causing drug resistance. Altogether, New Zealand *Delphinium* as a source of promising botanical pesticide has potential commercial value.

The effects of ultraviolet (UV) light on important crop plant-pathogen interactions in the Taranaki region of New Zealand

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Key Words: Plant immunity, fungal pathogen, crop disease management

The effects of ultraviolet (UV) light can be both harmful and beneficial to plants. UV light has been shown to have positive effects on plant immunity and crop yields and as well as altering plant morphology and physiology. Direct effects of UV light on phytopathogenic fungi have also been demonstrated. Currently, there is a need to better understand the effects of UV light on plant-pathogen interactions in field conditions as well as how to best maintain the balance between the benefits of UV light on plant health while keeping its harmful effects minimal. Therefore, this research will examine the mechanisms behind the promotion of disease resistance and tolerance in plants by UV light treatments under field conditions typical for the Taranaki region. UV light levels will be manipulated in the field with physical screens and filters. Additional research into the responses observed in the field will inform further work to define the genetic mechanisms behind these interactions in both the plant and the pathogen of interest. The knowledge gained here may be used to inform growers in the region of the potential benefits of UV light as a method of disease control.

Host influence on *Epichloë* seed transmission in *Lolium perenne*

Wei Zhang[1], Natasha T. Forester[1], Paul H. Maclean[1], Milan Gagic[1], Stuart Card[1], Cory Matthew[2], Sai Arojju[1], Marty J. Faville[1], Christina D. Moon[1], Christine R. Voisey[1]

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Key Words: AR37, genotyping-by-sequencing, plant disease resistance, transcriptome, vertical transmission

Asexual *Epichloë* species are fungal endophytes that colonise the aerial tissues of temperate grasses and can confer protection against certain biotic and abiotic stresses. The hyphae are transmissible through seed and the success of transmission is influenced by environmental and genetic factors, although the underpinning mechanisms are poorly understood. Here we examined host responses to *Epichloë festucae* var. *lolii* strain AR37 infection in the developing inflorescence primordia and ovary tissues of high- and low-transmitting *Lolium perenne* genotypes from a breeding population. In addition, we used a genome-wide association study (GWAS) within the same breeding population to identify single nucleotide polymorphisms (SNPs), and associated open reading frames, that are highly correlated with endophyte transmission into seed. Transcriptomic analysis indicated that *L. perenne* receptor-like kinases and resistance genes, typically associated with pathogen detection, comprised the largest group of differentially expressed genes (DEGs) in both tissues. DEGs involved in cell wall modifications and other defence responses were also enriched. GWAS analyses indicated transmission-associated SNPs clustered with an NB-ARC domain-containing resistance gene, as well as markers linked to endophyte biomass and alkaloid expression. Gene ontology analysis of SNP-associated genes identified “response to fungal pathogen” as the most significantly enriched category. Concomitantly, endophyte biomass was significantly lower in the reproductive tissues of low- versus high-transmitting genotypes. We conclude that host genetic influences on the efficacy of AR37 endophyte transmission into seed is influenced primarily by plant defence responses which reduce endophyte colonisation of host reproductive tissues.

Investigating methods of long-term storage in *Ciborinia camelliae*

Kay, Pilkington;[1], Paul, Dijkwel[1], Ron, van Toor[2], Cade, Fulton[1]

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Key Words: Ascospore, spore storage, *Ciborinia*, *Camellia*

Ciborinia camelliae is a host-specific pathogen in the Sclerotiniaceae that causes disease of the flowers in *Camellia* species. This species is a significant pathogen for both ornamental and oil seed *Camellia* industries. The disease of *C. camelliae* occurs from ascospores, spread through the air, which land on petal tissue. These ascospores germinate to produce fungal hyphae and causes rapid browning of the petal tissue and early detachment from the plant. One of the disadvantages of working with *C. camelliae* has been the inability to store ascospores for use in experiments. This resulted in being limited to the natural growth season for *C. camelliae* (from about June to September) for all experiments. Our work aimed to test different methods of ascospore collection and storage which would allow flexibility in carrying out experiments. These included storage temperatures of 4°C, -20°C and -80°C in water or glycerol solutions. We also collected dry ascospores on filter paper and stored these at -80°C. Ascospores stored at -20°C and -80°C remain viable and able to infect petal tissue after two months. Dry collected ascospores, stored at -80°C, were viable after eight months and were able infect petal tissue. The ability to store ascospores from *C. camelliae* reduces the reliance the natural lifecycle of *C. camelliae*. As well it allows us to test viability of ascospores and obtain consistent concentrations in spores among experiments. This enables us to continue work aimed at preventing disease from plant fungal pathogens.

Emerging trends in International Development from the perspective of a donor in Horticulture Research

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In the International Year of Fruit and Vegetables the focus is increasingly on the contribution of fruit and vegetables to health and nutrition outcomes. A major aim of the year is to raise awareness of the nutritional and health benefits of consuming more fruit and vegetables as part of a balanced and healthy diet. As a result, research funders increasingly ask about how a proposed project will benefit the food system. How will the proposed research contribute to making food more accessible, more available, more affordable and very importantly more desirable for the consumer?
The investment strategy for the development of nutrition sensitive food systems is less clear. Agro-ecological approaches that balance yield and system health, intensification approaches that maximise return from resource investment and valuing indigenous knowledge including wild harvest and indigenous crops are all solutions with trade-offs and advantages. Increased research on understanding the role of shorter more resilient supply chains including urban and peri-urban horticulture is a response to system vulnerability experienced during the pandemic. And all of this without forgetting the impact climate change, addressing food loss, ensuring equity for women, youth, minorities and the disabled.
This presentation will explore the diversity of approaches to horticulture research for development and consider how they can support a development toolkit enabling technical, social and policy interventions.

Enhancing the capacity of mango packhouses in the Mekong River Delta

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Key Words: Mango, packhouse, capacity

The mango value chain in Viet Nam is currently lacking the postharvest technology to maintain quality mangoes for export markets. Fruit that fail to meet export requirements are absorbed by the domestic market or discarded. Postharvest loss could be as high as 26.9%. Vietnamese fruit trading companies usually prefer to export fruit by sea freight due to lower cost versus airfreight. However, poor infrastructure and lack of postharvest knowledge have caused a significant reduction in the supply and distribution of mango fruit. This project aims to enhance the capacity of the model packhouse in terms of harvesting, pre-processing, packing, and preservation of mango in the Mekong River Delta (MRD). The facilities including a desapping tank, washer combined with fungicide hot water spray, conveyor line, packing room, cool room, and solar energy system were set up. Moreover, dessapping and postharvest trials were implemented to improve fruit quality and disease incidence. As a result, capacity increased from 20-30 tons to 40-50 tons per day and postharvest loss reduced from 26 to 5%. Turnover has likewise increased from 63 to 124.5 billion VND per year.

High-value horticulture builds resilience for small farmers in developing countries

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Key Words: Development, markets, postharvest, quality, supply chain

Farmers in developing countries have little resilience against natural or political disasters. During a five-year MFAT-supported programme in East Indonesia we worked with farmers in North Lombok to link their horticultural production to higher-value markets than their traditional village wet markets. Key to the project were some simple basics: know what market you intend to sell into; know what your customers in that market are looking for in terms of products, quality and price; and then work out how to get your products to that market at that quality. We supported the growers to create a network of 'grading sheds' to allow product aggregation and segregation into batches at the right quality. A key problem in accessing the high-value tourist trade was that hotels wanted to pay up to three months in arrears; so microfinance also became vital. During our programme North Lombok was struck by a magnitude 7 earthquake that killed over 500 people in the district and destroyed homes and irrigation channels. It also impacted the tourist trade heavily (as did Covid-19, later). The success of our programme led the District Government to prioritise the restoration of infrastructure to our 'horticultural' villages. The programme evolved rapidly to support product distribution from North Lombok into adjacent urban areas. One farmer commented as he approached one of our field officers, stepping over the ruins of his home, 'I just sold some chillies. Horticulture brings hope (hortikultura membawa harapan!).'

Assessing the effectiveness of a hot water treatment to eliminate *Phytophthora colocasiae* from freshly harvested taro corms in Samoa

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Key Words: Taro, *Colocasiae*, *Phytophthora*, hot water treatment

Taro is one of the most important food staples export commodities in Samoa and across the Pacific. The significant populations of Samoans and other Pacific islanders in New Zealand and Australia provide lucrative markets for taro exports from the Pacific. Taro was the most important crop export from Samoa before the taro leaf blight (TLB) caused by Phytophthora colocasiae (Pc) destroyed taro production in Samoa in the early 1990's. TLB was identified as a serious biosecurity threat to Australia which led to fresh Samoan taro being banned from the Australian market. Following evidence from intensive research programme in Samoa on the disease in 2019-20 the biosecurity risk was downgraded, with a requirement for modified field controls and the development of a post-harvest hot water treatment (HWT). Currently, a HWT of 48.5°C for 25 mins is being trialled for the disinfestation of mites and nematodes from fresh taro corms entering New Zealand. Our preliminary study assessed the effectiveness of this same treatment against *P. colocasiae* Preliminary experiments showed that HWT at 48.5°C for 25 mins was 100% effective against taro corms inoculated with sporangial and mycelial forms of Pc. These experiments provided encouraging evidence that the HWT regime being developed for mites and nematodes may also be an effective treatment against Pc. Further research is planned to confirm the results and support a case for Australian quarantine authorities to allow access of fresh Samoan taro to Australia.

Industry Association as an agent of system-wide change in temperate fruit industry development in Son La province, Vietnam

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Key Words: Industry association, system-wide change, temperate fruit

Market research prioritised the introduction of new varieties to mitigate the negative price impacts of increased production of the limited number of plum, peach and pear varieties available. However, the introduction of new varieties into Vietnam faces the barrier of an underdeveloped nurseries suffering from lack of autonomy from government institutions, overreliance on projects, a lack of entrepreneurship and international contacts, and an inability to protect breeders' rights and collect royalties. To address this issue the ACIAR temperate fruit (TF) project focused on technical and organisational improvements of nurseries by involving the leading nursery producers from Australia. The technical intervention had limited impact because of the complexity of the TF industry and a lack of coordination between the private sector and local government, resulting in uncoordinated government-led industry planning and development, disconnected from market opportunities. The project facilitated broad consultation between major industry stakeholders, including large growers, traders, processors and high-level government officials, leading to the formation of the Son La Temperate Fruit Industry Association and a strategic plan that addresses production, marketing and capacity building. The Association became a platform for dialogues between local government and TF industry actors, enabling the private sector stakeholders to inform and influence the government TF industry planning and development. As a pilot, the Association has signed a contract with an Australian variety management company to develop a legal and management framework for the introduction of licenced peach varieties to Son La. This case demonstrates that specific improvements might require broad industry-wide system change.

Horticulture Postharvest Development Initiatives in Asia

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Horticulture, particularly vegetables and fruits, provides the prosperity and food security needs of many developing countries. Main production and marketing constraint is the high perishability and postharvest losses of fresh produce which could exacerbate food insecurity under normal and crisis situations. Lack of technological options and increased quality and food safety expectations of consumer markets contribute to losses. Through various initiatives with the World Vegetable Center, Mekong Institute and other development agencies, a value chain approach (value chain analysis, technology generation and building capacities) to reducing postharvest losses was introduced and mainstreamed targeting smallholders in several Southeast and South Asian countries. The technological and organizational interventions reaped some benefits (e.g. increased awareness; improved socioeconomic standing of technology adopters) and failures (e.g. low technology adoption rate in some countries). Other technical deficiencies and management challenges were associated with working in environments of diverse cultures with different levels of education, economic and human development. However, the initiatives influenced several postharvest development works resulting in various collaborative actions. These undertakings could contribute to achieving the United Nations Sustainable Development Goal 12 target 12.3 of halving postharvest losses by 2030.

The complexity of smallholders' livelihoods and the implications for rural development: a case study of cattle management in Eastern Indonesia

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Key Words: Smallholder livelihoods, market-led development, cattle as savings, Eastern Indonesia

Market-led rural development initiatives in lesser developed countries (LDCs) often target one type of productive enterprise of smallholder farmers: including for example livestock or crops. The livelihoods of smallholder farmers comprise multiple interrelated activities (both on-farm and off-farm) associated with a mix of enterprises that are valued by smallholders for more than production, consumption, or the income they may generate. Therefore, the management of any one enterprise by smallholders reflects not only aspects related to that enterprise but also its broader relationship to other enterprises and the diversity of values embodied in these enterprises. The failure of market-led rural development initiatives to account for these complexities, goes some way to explaining why expected outcomes are not achieved. The management of cattle by smallholder farmers in Eastern Indonesia provides a rich illustration of how the complex of livelihoods and sociocultural norms shapes one enterprise. The value of cattle as a form of saving rather than for consumption or income dominates farmers engagement in the market and market dynamics and smallholder farmer's likely response to initiatives directed at increasing the commercialisation of cattle.

The evolution and diverse functions of stress-related red pigmentation in land plants

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Key Words: Bryophyte, flavonoid, stress, pigment, hornwort

The production of red pigments in response to stress is a prominent character of land plants. In the great majority of cases these red pigments are flavonoids. The flavonoid pathway for pigmentation and colourless compounds critical to UV-B tolerance is hypothesised to have arisen in the early land plant ancestor, with subsequent functional diversification to facilitate interaction with the biotic environment. The flavonoid pathway is one of the best characterised metabolic pathways of flowering plants, yet relatively little is known about the pathway in other major plant groups. Recently, progress has been made in characterizing the flavonoid pathway of the model liverwort *Marchantia polymorpha*. The production and function of colourless flavonoids in response to UV-B exposure was found to be conserved between marchantia and *Arabidopsis*. However, the stress-related red pigments appear to have striking biosynthetic and functional diversity across land plants. We discovered that the red pigments of liverworts are a previously unreported flavonoid type, termed ‘auronidins’, that are cell-wall located and provide protection against both abiotic and biotic stresses. In certain families in the Caryophyllales, the nitrogen-containing betalains replace anthocyanins, and our research has shown that betalain production can enhance salinity tolerance. Moreover, although flavonoids and red colour are both commonly considered as universal features of land plants, inherited from the early common ancestor, it appears that one major plant group lacks both – the hornworts. We are conducting comparative analyses across land plants to address the hypothesis that red pigmentation has evolved multiple times to deliver diverse physiological functions.

Spatiotemporal Modulation of Flavonoid Metabolism in *Vaccinium* berries

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Key Words: anthocyanins**,** bilberry, blueberry, flavonoids, mass-spectrometry imaging, phytochemistry, RNAseq

Cultivated blueberries and wild bilberries (*Vaccinium* spp.) are distinguished by their purple-blue colour, which is derived from a characteristic composition of flavonoid pigments, known as anthocyanins. Not only anthocyanins but also structurally related polyphenolic phytochemicals have been associated with astounding health benefits, contributing to the superfood status of these berries. While in bilberry, anthocyanins are present in both flesh and skin, blueberry flesh is usually devoid of these pigments. Although flavonoid biosynthesis has been well studied, less is known about the genetic processes regulating their tissue-specific production. Here we link targeted metabolomics, transcriptomics and MS-imaging to compare the spatiotemporal biosynthesis of flavonoids during fruit development and ripening. Comparing commercial New Zealand Northern Highbush and Rabbiteye blueberry cultivars with Norwegian bilberry, we found that compound composition was distinct between species and concentrations of phenolic phytochemicals were generally higher in skin compared with flesh. An orthologous set of structural genes was identified to drive anthocyanin production across species and their transcript abundance was significantly higher in bilberry compared with blueberry flesh. We propose a set of three candidate genes as being bottlenecks for anthocyanin accumulation in blueberry flesh. Co-expression of the identified structural genes with a set of transcriptional regulators, including the activators MYBA, MYBPA1 and bHLH2 together with the repressor MYBC2, was characteristic for pigmentation, indicating an interdependent role of these transcription factors in regulating anthocyanin production. These integrated findings provide a systematic view on flavonoid biosynthesis in *Vaccinium* and how this might be modulated between species.

MYBPA1.1 is a dual regulator of both anthocyanin and proanthocyanidin pathways in *Vaccinium*

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Key Words: Anthocyanin, blueberry, bilberry, *Vaccinium*, flesh, skin

Members of the *Vaccinium* genus bear fruit rich in anthocyanins, a flavonoid compound responsible for plant pigmentation that positively impacts human health. Several MYB transcription factors have been implicated in regulating the anthocyanin content of these berries. We used two species of *Vaccinium*, the white fleshed highbush blueberry (*V. corymbosum*) and the red-fleshed bilberry (*V. myrtillus*), to examine the differential regulation of anthocyanins in different tissues. Two MYB genes, *MYBPA1.1* and *MYBA1*, correlate strongly with anthocyanins in coloured skin and flesh while they are absent or weakly expressed in the white flesh of blueberry. *MYBPA2* expression was correlated with proanthocyanidin (condensed tannins) accumulation in in young berries. *MYBPA1.1* had a biphasic expression profile correlating with both proanthocyanidin biosynthesis early during fruit development, and anthocyanins during berry ripening. We used functional assays in tobacco to show that *MYBPA1.1* cannot activate anthocyanins or proanthocyanidins alone, but plays an essential role in their regulation. Both the anthocyanin specific *MYBA1* and the proanthocyanidin specific *MYBPA2* genes upregulate the expression of *MYBPA1.1*. This hierarchy then acts on elevating the expression of specific genes encoding flavonoid biosynthetic enzymes. We postulated that they work in concert with each other to elevate polyphenolics of both the anthocyanin and proanthocyanidin branch-points. Our results suggest an absence of MYBA1 results in a loss of *MYBPA1.1* expression, which then drastically alters the flesh phenotype of blueberry. This has implications for the breeding and understanding of coloured fleshed berries.

Bicolours, bullseyes and landing lights – molecular regulation of complex floral patterning in *Antirrhinum*

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Key Words: Anthocyanin, flavonoid, transcription factor, snapdragon

Flower colouration is an important visual cue for attracting pollinators, often forming complex and intricate patterns. These patterns can involve multiple classes of pigments, generating high-contrast visual signals that can act as ‘nectar guides’ to direct pollinators into the flower towards pollen and nectar rewards, and in doing so ensure pollination. Within the *Antirrhinum* genus, a range of flower colour morphs exist, which include diffuse or localised patterning of yellow aurone and magenta anthocyanin pigments. Additionally, UV-absorbing flavones are also abundant, which are conspicuous to insect pollinators. Anthocyanins can be present across the entire flower (full colour), as a vein-associated pattern (venation), restricted into ‘bullseye’ patterns, bi-colours (petal lobe only); or absent. These patterns are determined by the interaction of regulatory loci: *Rosea*, *Venosa*, *Delila*, *Incolorata1* and *Eluta*. Anthocyanin biosynthesis is regulated by a transcription factor complex involving R2R3-MYB, bHLH and WD-Repeat proteins, which activates the biosynthetic gene expression in cells where all three proteins are expressed. Additional types of MYB proteins can act as repressors of this complex. We describe how the regulatory loci interact to form complex pigmentation patterns in *Antirrhinum*, the mechanistic basis for these, and discuss how they may have shaped the evolutionary history of the genus.

Improving shallot bulb yield in extremely acidic soil by applying N, P fertilisers and lime in West Java, Indonesia

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Key Words: *Allium cepa*, acid soil, bulb yield, soil amendments

Shallot (*Allium cepa* Aggregatum group) has shallow and hairless roots, and its root growth and function are further restricted in extreme low soil pH conditions due to high concentrations of exchangeable Al^{3+}, affecting the bio-availability of essential nutrients such as phosphorus (P) and calcium (Ca). Agronomical practices, like liming, have been known to increase soil pH, and P fertiliser application increases soil available-P; both improve shallot bulb yields, but high N fertiliser rates reduce soil pH. This study was carried out by observing the combined effect of lime, N and P fertiliser application on chemical soil properties, nutrient uptake, plant biomass and shallot bulb yield in West Java, Indonesia. Application 8 t ha^{-1} lime + 120 kg P ha + 200 kg N ha^{-1} significantly improved soil pH, Ca^{2+} and Bray1-P and reduced Al^{3+} and Al:Ca ratio than control (0L+0P+0N). Application 1-8 t ha^{-1} lime + 120 kg P ha^{-1} + 200 kg N ha^{-1} significantly increased the concentration of root-N and root-P, leading to a higher bulb yield (range from 5.2 to 6.4 t ha^{-1}) than control (3.78 t ha^{-1}). While applying 200 kg N ha^{-1} alone increased Al:Ca ratio and root-Al concentration and decreased the bulb yield by 18% than control. It was concluded that incorporated lime and NP fertiliser is essential to growing shallot in extremely acidic soil, and a high ratio of Al:Ca in the soil improve Al uptake by the plant, leading to decreasing in bulb yield.

Using cassava extracts to leach gold

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Key Words: Gold, cyanide, cassava, leaching

Cyanide has been used by the gold mining industry for more than 130 years to leach the precious metal from crushed rock. Cyanide used in gold mining is synthetic, and large quantities are produced each year, however the use of cyanide in well-regulated mining is generally safe. Public concerns around cyanide relate to long term management of cyanide-contaminated waste and where mining is unregulated, such as is common for artisanal and small-scale gold mining (ASGM) in developing countries around the world. Cyanide is also synthesised by a large number of bacteria, fungi, algae and plants and the chemical is remarkably common in biological systems. Bitter forms of cassava, for example, contain high amounts of cyanide in both tubers and leaves, and this cyanide can be released when cell walls are ruptured. Research at the University of British Columbia in Canada recently showed that addition of cassava tubers to gold ore and water in a rod grinder can leach more than 50% of the gold in the rock as cyanide is liberated through the crushing of the tubers. This idea has been further explored in Indonesia by the authors of this paper, where cassava leaf and tuber tissues have been blended in water producing a stable solution of dissolved cyanide that can potentially be used in gold mining. The current work is looking at how this ‘cassava juice’ can replace synthetic cyanide in small-scale gold leaching operations that are common for ASGM.

Comprehensive evaluation of antioxidative potential, in vitro antioxidant activities and oxidative stability of different parts of Moringa oleifera L.

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Key Words: Sub-Himalayas, phytochemicals, enzyme activity, animal consumption, human consumption.

Moringa oleifera is a plant native to the sub-Himalayas and an important plant in India for human and animal consumption. All plant parts contain antioxidant flavonoids and phenolic compounds and may be used as sources of dietary supplements. A systematic comparison of phytochemicals in different tissues of Moringa and their correlation with different biological activities are still being studied. Current research aims to compare antioxidative enzyme activities (SOD, CAT, POX, APX and GR) and in vitro antioxidant activities of the crude extracts of leaves, roots, entire seedling, and seeds. Activity from seedlings grown at different temperatures (25°C, 30°C, 35°C) was assessed to determine any differences in the rate of germination and biochemical changes. Activities of antioxidants were measured using different assays viz. DPPH (2,2-diphenyl-1-picrylhydrazyl), FRAP (Ferric-Reducing Antioxidant Power), and ABTS (2,2′-azinobis-(3-ethylbenzthiazoline-6-sulfonic acid) to determine their in vitro antioxidant potential. Leaf extracts exhibited the highest DPPH and FRAP radical scavenging activities with IC50 values of 1.22 ± 0.18 mg/mL and 0.87 ± 0.04 mM Fe2+/g, respectively, at 30°C. The phenolic content of leaves (188.26 ± 2.54 mg rutin equivalent (RE)/g) was higher. The specific activities of SOD, CAT, POX, APX and GR were higher in leaves, followed by seedlings and seeds at 30°C. The leaf and seed extracts also exerted a higher accumulation of proline, glycine betaine and antioxidants, viz. ascorbic acid and carotenoids, as measured by inhibition of ROS production. The findings demonstrate that M. oleifera plants have a high concentration of phytochemicals and antioxidants, making them an excellent choice for further research to determine their use as health-promoting dietary supplements.

First steps towards understanding the genetic basis of cold-induced ripening in apple fruit

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Key Words: Ethylene; firmness; maturity; physiological disorders; transpiration

Initiation of ripening involves a complex interaction between genetic makeup, and several developmental and environmental cues. Cold temperatures in the orchard can be an important stimulus for initiation of ripening, especially for autumn-maturing fruit crops programmed to ripen before extreme winter conditions arrive. This can create some challenges for horticultural management, as too much cold too early can result in premature ripening on the tree, making the fruit too soft to harvest. In the opposite sense, if not enough cold is received it can result in fruit that do not ripen properly, or may lack synchronicity between different ripening indicators. The mechanism for cold-induced ripening is complex, with evidence to date indicating roles for both ethylene-dependent and -independent pathways. To advance knowledge on the genetic basis of cold-induced ripening, we have used an apple mapping population made from parents with contrasting cold responses ('Royal Gala': low cold dependency, and 'Granny Smith': high cold dependency). We will present phenotyping data for fruit harvested from 100–150 genotypes across multiple years ripened at warm and cold temperatures. The next step will be to map these traits to provide new insights into the genetic regulation of the cold response, paving the way for selecting future genetics that are less dependent on cold.

Transcriptome responses to mild and severe chilling stress in cold-stored ripe cherry tomato fruit

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Key Words: *Solanum lycopersicum*, Tomato, Chilling Injury, Fruit Softening, RNA-Seq, Transcriptome

Low-temperature storage is an effective technology for maintaining fruit quality during transit. However, tomato fruit stored below 12ºC lose quality and can develop chilling injury when subsequently transferred to a shelf temperature of 20ºC. We compared the effects of exposure to mild (10ºC) and severe chilling (4ºC) on the fruit quality and transcriptome of 'Angel', a cherry-type tomato, harvested at the red ripe stage. Storage at 4ºC (but not at 10ºC) for 27 d plus an additional 6 d at 20ºC caused accelerated softening and the development of mealiness, both of which are commonly related to cell wall metabolism. Transcriptome analysis using RNA-Seq identified a range of transcripts encoding enzymes involved in cell wall disassembly whose expression was strongly down-regulated at both 10 and 4ºC. In fruit exposed to severe chilling, the reduced transcript abundance of genes related to cell wall modification were predominantly irreversible and only partially restored upon rewarming of the fruit. Within 1 d of exposure to 4ºC, large increases occurred in the expression of enzymes that protect cell contents from oxidative damage. Numerous heat shock proteins and chaperonins also showed large increases in expression, with peak transcript accumulation after different times of chilling exposure. These changes in transcript abundance were not induced at 10ºC, and were reversible upon transfer of the fruit from 4 to 20ºC. The data shows that genes involved in cell wall modification and cellular protection have differential sensitivity to chilling temperatures, and exhibit different capacities for recovery upon rewarming of the fruit.

AcCBF3 promotes freezing tolerance in *Actinidia* (Kiwifruit) fruit

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Key Words: Actinidia Kiwifruit, freezing tolerance, chilling injury, CBF.

'Hayward' kiwifruit has dominated the global kiwifruit industry for over 60 years. This is largely due to its outstanding postharvest performance, including slower softening and better chilling tolerance. Previous research has mostly focused on softening, with little research on chilling injury (CI). While all commercial cultivars appear to be susceptible to CI, 'Hayward' is particularly robust in chilling tolerance, showing little or no CI when harvested at the correct maturity and given appropriate temperature management. Early harvest and fast cooling exacerbate CI expression. Transcriptomic analysis of the cold response of fruit at different ripening stages identified a number of cold-related and ripening associated genes. We identified two potential genes associated with a cold response, the C-repeat-binding factors (*CBF)* class of gene that were differentially activated with cold. In addition, we demonstrated that the expression of *CBF* in response to cold was correlated with fruit maturity. Overexpression of *AcCBF3* in a rapid flowering *Actinidia chinensis* resulted in dwarf plants and enhanced freezing tolerance of leaves. Using CRISPR-Cas gene editing of the RP kiwifruit, we have edited the two *CBF* genes to assess the function of them and will use these transgenic plants to ultimately understand the relationship of temperature and chilling response in the way the fruit responds to cold stress.

Probing the carotenoid pathway for regulators of yellow-fleshed apple

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Key Words: Apple, carotenoid, yellow flesh, transcription factors

The carotenoid biosynthetic pathway is well characterised, however the regulation of this metabolic process *in planta* is not well understood. In this study, we overexpressed the apple phytoene synthase (PSY) gene and used this as a basis to examine regulation of the carotenoid pathway in fruit. PSY expression led to increased carotenoid pathway flux, resulting in significant increases in total carotenoid concentration in fruit skin and flesh tissues during development. The increased carotenoid concentration in the transgenic fruit was associated with increased plastid concentration and upregulated carotenoid gene expression. Transcriptome analysis of PSY fruit identified groups of differentially expressed genes that strongly correlated with carotenoid accumulation. Fruit bagging was then used to assess the effect of light on carotenoid accumulation and how that could be modulated by PSY expression. While bagging reduced carotenoid concentration, PSY expression significantly increased carotenoid content in these fruit compared with the control. Comparative analysis of differentially expressed genes between the bagged and 'during development' fruit highlighted a cohort of transcription factors that could play significant roles during carotenoid accumulation in apple. The transcriptional and metabolite changes induced by PSY expression have revealed potential carotenoid regulatory genes in apple.

Gene regulatory network for russetting-related triterpene biosynthesis in apple

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Key Words: apple, cuticle, wax, triterpene, russetting, regulation

The cuticle plays a vital role in the protection of fruit, preserving the integrity and quality during development and postharvest storage. Severe cuticle failure in apple skin during fruit development results in a disorder known as russetting, a major concern for the apple production sector. Genetic factors, as well as fruit exposure to extreme environmental conditions, induce the development of microcracks in the cuticle and the subsequent formation of russet, a waterproofing periderm layer made of suberin. Cuticular wax composition, including its associated specialized metabolite profile, is also altered in russeted skin. Important changes occur in triterpene metabolism, impacting both the mechanical strength of the cuticle and its health-promoting properties. We investigated the molecular events associated with cuticle failure and the triterpene shift. Using a transcriptomics approach on two genetically close clones of ‘Golden Delicious’ apple with either no or fully russeted skin, we identified a unique molecular profile for the russet clone, including a decreased expression of most cuticle-specific genes in the early stages of fruit development. We showed that the expression of numerous MYB transcription factors were strongly correlated with the amount of suberin-associated triterpenes (lupanes) and that MdMYB66 could drive their production by binding to the promotor of Oxydosqualene Cyclase 5 (*MdOSC5*), a key enzyme in lupane-type triterpene synthesis. Further, we showed that the biosynthesis of suberin, and potentially of the associated triterpenes, is regulated through a hierarchical mechanism involving a NAC transcription factor. A new model representing its relationships with suberin-related MYB activators will be presented.

Timing is everything: Circadian control of *Medicago truncatula*

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Key Words *Medicago truncatula*, Circadian Clock, Legumes, Local adaptation, Natural variation.

The circadian clock is an endogenous time-keeping mechanism that allows the anticipation of upcoming daily changes and adjusts the timing of biological processes to occur at the most appropriate time of day. This includes metabolism, growth and stress responses. The circadian clock also provides a mechanism to measure changes in day-length to allow the seasonal control of developmental traits, including flowering, shoot branching and development of fruits and seeds. Most of our knowledge about the plant circadian clock has come from extensive studies in the model plant *Arabidopsis thaliana*. However, less is known about how the circadian clock works in crop species.

Legumes are essential as a source of protein for both humans and livestock, and for fixing nitrogen. Our project aims to discover naturally occurring genetic variation in the circadian clock of barrel-clover (*Medicago truncatula*) and understand how these variations enhance fitness to grow in local environments. We have collected circadian phenotypic data and measured the clock parameters - period, phase and amplitude - for 75 populations, representing Medicago's natural geographic range. We performed a Genome-Wide Association Study (GWAS) analysis and identify potential natural allelic variations associated with changes in clock parameters. We also found a population with a distinctive clock. These findings and a more in-depth study of the Medicago circadian clock will reveal how the circadian system impacts growth and development. And will provide novel ways to improve crop production through targeted modification of the circadian system.

Investigating the role of peptide hormones in coordinating growth, nitrogen demand signalling and symbiotic nitrogen fixation

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Key Words: Nitrogen uptake, peptide signalling, root architecture, symbiosis, nodule formation

Nitrogen (N) is a key determinant of crop productivity. We have discovered a molecular process involving a peptide hormone (CEP, C-TERMINALLY ENCODED PEPTIDE - a hunger for N signal that is induced by N limitation in the root. The peptide travels to the shoot node through the xylem to activate its receptor, which in turn generates rootward systemic signals to regulate N uptake and root proliferation (including root nodule formation and symbiotic N-fixation in legumes). Contrarily, CLE (CLAVATA 3/ESR-related) peptides inhibit cell proliferation and nodulation in a receptor dependent manner. Here, I present overview of plant peptide signalling and how they involved in the modulation of root, nodule, shoot and seed development in response to nitrate limitations. Overall, our work suggests signalling peptides are important positive and negative regulators of plant development and symbiotic N-fixation, linking N-demand signalling to developmental programs, and we propose a unified comprehensive model for the regulation of source to sink relationship and symbiotic N-fixation.

Comparison of polyphosphate accumulation between six species of microalgae

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Key Words: Polyphosphate, microalgae, luxury uptake

The ability to sequester phosphorus during periods of high availability, for later use during nutrient scarcity, is believed to be an important trait driving seasonal species dominance among freshwater algae. This phenomenon, known as ‘luxury uptake’, is observable as the accumulation of granules of inorganic polyphosphate (polyP) within algal vacuoles known as acidocalcisomes. While this phenomenon has been described in many species of algae, there has to date been no rigorous comparison of the kinetics of luxury uptake across species. Six well-studied species were examined using a standard assay developed to trigger rapid polyP accumulation. Visual observations of stained granules were corroborated by estimation of sequestered phosphorus and showed that the rate of accumulation varied greatly between the species examined, in well-controlled conditions. This variation may reflect differences between the species in terms of responses to changes in extracellular phosphorus concentration or different strategies for storing phosphorus. The numbers and size of granules also varied between species and suggests a link between vacuole abundance and capacity for polyP storage. This knowledge will help to better understand how polyP accumulation may vary between species, and the implications this variation has for species dominance in differing ecological niches.

Conditional biased transmission of herbicide-resistant alleles in *Brassica napus*: a gene drive mimic

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Key Words: Distorted segregation, biased segregation, herbicide resistance, gametic selection, embryonic selection, gene drive, *Brassica napus*

An inducible biased inheritance is described for plant populations with herbicide resistance; a conditional form of allele transmission that operates following herbicide application with the outcome mimicking a gene drive. *Brassica napus* plants heterozygous for an allele conferring sulfonylurea resistance at a single locus exhibit normal Mendelian inheritance. However, following application of the herbicide, highly distorted segregation of herbicide resistance occurs among progeny. Screening progeny from controlled crosses demonstrated that the herbicide imposes *in planta* gametic selection against pollen and ovules with the recessive allele for herbicide susceptibility, as well as embryonic selection against embryos homozygous for the susceptible allele. This outcome of biased inheritance of specific alleles from parents to offspring through sexual reproduction mimics a gene drive. We postulate that such gene drives are common in plant populations and may operate in a conditional manner in response to abiotic and biotic stresses resulting in non-Mendelian inheritance.

Developing cryopreservation methods for *Syzygium maire* zygotic embryos

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Key Words: Conservation, desiccation, myrtle rust, recalcitrant, swamp maire vitrification

The pandemic pathogen, myrtle rust (*Austropuccinia psidii*), was discovered in New Zealand in 2017 and has established through most of the climatically suitable areas. Although it is not clear what the long-term impact of myrtle rust will be on New Zealand Myrtaceae species, reproduction in fleshy fruited species such as *Lophomyrtus bullata* and *Syzygium maire* has declined, with some populations no longer producing flowers. Seed banking is a reliable conservation option for species affected by myrtle rust and although some species are amenable to conventional banking conditions (desiccation tolerant), *Syzygium maire* is a desiccation-sensitive species and cryopreservation is probably the only viable option. We investigated the impact of physical (rapid desiccation) and chemical (cryoprotectant solution) methods to lower *S. maire* zygotic embryos' moisture content, and their subsequent plantlet formation. Once the critical moisture content for rapidly desiccated embryos was determined, embryo survival following desiccation was optimized through the addition of antioxidants. To limit the toxic effects associated with Plant Vitrification Solution 2 (PVS2) application, duration of application (3–120 min), temperature (20°C vs 0°C) and method (conventional vitrification vs vacuum infiltration vitrification) were compared for optimisation of embryo survival. Refinement of the physical and chemical methods increased embryo survival prior to freezing while biochemical analysis, Differential Scanning Calorimetry (DSC) and Transmission Electron Microscopy (TEM) were used to analyse the possible causes of cell and embryo death following cryopreservation.

investigation of taxonomy and diversity of *ex situ* collections of *Rhododendron* (subsection *Maddenia*) for conservation

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Key Words: *ex situ* conservation, *Rhododendron* subsection *Maddenia*, wild-source accession, taxonomic complexity, phylogeny, diversity

Rhododendron L. (Ericaceae) is a 'big genus' of more than 1,000 species, providing valuable resources in horticulture, culture, medicine, wood products, etc. Previous assessments have suggested more conservation attention for almost half of the species, because many species are listed in threatened categories or are data deficient. *Rhododendron* plants in cultivation form an essential part of *ex situ* collections for *Rhododendron* biodiversity conservation, with living accessions (especially of wild species) conserved outside their natural habitats. Subsection (ss.) *Maddenia* is a group of ~59 taxa in this genus with 49 in cultivation; however, the number, origin and diversity of their wild-source accessions have not been summarized to understand the *ex situ* conservation status of these taxa. These knowledge gaps and the taxonomic debates about some taxa result in challenges when deciding conservation priorities. New Zealand provides an advantageous climate for growing *Rhododendron*, with a broad coverage of ss. *Maddenia* taxa cultivated in botanical and private gardens. The present project proposes to utilize the latest high-throughput molecular markers to reconstruct the phylogeny of this subsection, using multiple *ex situ* accessions of ss. *Maddenia* taxa in New Zealand. Together with a global database survey of the diversity of the wild-source accessions conserved *ex situ*, these results are expected to help resolve the taxonomic complexities in ss. *Maddenia* and aid conservation decisions concerning distinct taxa. A plan for conservation management will be developed, focusing first on the *ex situ* collections of ss. *Maddenia* and subsequently used as a model for *Rhododendron* conservation in general.

Optimisation of germination requirements and long-term storage conditions for *Actinidia* species seeds

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Key Words: Conservation, cryopreservation, germination, kiwifruit seeds, seed storage

Kiwifruit is New Zealand's most important commercial fruit crop, with a global revenue generated by fruit sales of $NZ3.14 billion in 2019/20. Plant & Food Research (PFR) has a large kiwifruit breeding programme that draws from more than 20 species. Many thousands of kiwifruit seed are germinated annually to provide seedlings for breeding. Regular, reliable and uniform germination of seeds of all kiwifruit species offer significant advantages within PFR breeding programmes. With respect to conservation, field germplasm is under constant threat from both biotic and abiotic factors and therefore require optimisation of *ex situ* conservation. Seed storage at cooler temperatures, including cryopreservation provide an alternative and complementary conservation strategy for this valuable germplasm. Seed germination of 10 kiwifruit species was tested using five treatments: gibberellic acid (GA3) alone, chipping alone, chipping followed by GA3, GA3 followed by chipping, and a control. Germination was via an alternating temperature regime (24°C followed by 12°C for 8h with 16h photoperiod). Gibberellic acid either alone or followed by chipping gave better germination, but this was kiwifruit 'species' dependent. The germination optimisation study was followed by a seed storage study where seeds of 7 species were stored at 5°C, -20°C and -196°C, before being assessed for germination after 0, 6, 12, 18 and 24 months to understand the best regime for long-term seed storage. The results are currently being reviewed ahead of implementation within our kiwifruit germplasm management systems, meeting the critical need to ensure the conservation of New Zealand's kiwifruit genetic resources.

Establishing an *in vitro* grape berry growth culture system to study Pinot noir berry development

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Key Words: Pinot noir, *in vitro*, berry development, wine, ripening.

Pinot noir is the second most grown grape varietal by area and production in New Zealand after Sauvignon blanc. However, Pinot noir is subject to significant variation year on year in production and wine quality. As part of the Bragato Research Institute Pinot noir programme, we are interested in understanding fundamental biological and chemical controls of Pinot noir berry development. Grape berry development is a highly complex process. It is partly mediated by factors such as nutritional status and hormonal balance and is directly influenced by environmental conditions. To study any one of these factors *in situ* in grapevines is challenging because of vine and bunch physiology, and exacerbated by variations in annual climatic conditions. A system to test the impacts of these factors in a controlled environment, would be a useful tool to understand factors affecting berry development and subsequent berry quality. A berry *in vitro* culture system would enable us to isolate all the direct influences on berry development. Although other wine grape cultivars have been reported to be amenable to *in vitro* culture, there is no literature knowledge of Pinot noir berry performance in a culture system. We have successfully established such a system for Pinot noir. We have analysed factors important for berry ripening such as sugar contents, hormone concentrations (e.g. abscisic acid) and environmental conditions (e.g. temperature). We will present an overview of this culture system and preliminary results from our trials.

In vitro therapies for effective eradication of virus species from in vitro-grown potato shoot tips

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Key Words: *Solanum tuberosum*, thermotherapy, cryotherapy, chemotherapy, virus diseases

Potato is mainly propagated via tubers, therefore, viral diseases are a major constraint for cultivation. At least 50 viruses are known to infect cultivated potatoes, but only a few cause major crop losses globally. *Potato virus M* (PVM), *Potato virus A* (PVA), and *Potato virus S* (PVS) are among the most widespread and significant viral pathogens responsible for substantial losses to the potato industry. This project attempts to develop an effective protocol for eradication of PVM, PVA, and PVS from virus-infected in vitro cultures of three potato cultivars by using cryotherapy, thermotherapy, and chemotherapy or combinations of these treatments. The in vitro cultures were analysed for the presence of viruses using reverse-transcription polymerase chain reaction to ensure that all plant sources were virus infected before exposure to the therapies. In vitro shoot segments were chemotherapy-treated using 100 mg L^{-1} ribavirin for 4 weeks; thermotherapy-treated using an alternating temperature of 40°C (day) and 28°C (night) for 2 weeks; cryotherapy-treated using droplet-vitrification, or by a combination of these techniques. Shoot tip regrowth will be recorded 6 weeks after plating on regrowth medium. The sanitary status of control and recovered plants from therapies will be assessed after at least 2 months in post-regeneration culture and virus-free plants will be grown in the greenhouse for 3 months before retesting for the presence of viruses. This recently initiated project is expected to deliver an effective strategy for supplying virus-free planting materials, which is essential for sustainable breeding programme activities including preservation of potato germplasm.

Indigenous responses to taonga impacted on by Myrtle rust

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Key Words: Myrtle rust, Indigenous, Māori, Whakapapa, Taonga

Myrtle rust (*Austropuccinia psidii)* a recent arrival to New Zealand is one disease impacting on indigenous species around the Pacific. Originally from Central and South America it has been moving steadily around the world infecting Hawaii in April 2005, Australia and New Caledonia in 2016 and New Zealand in May 2017. Indigenous worldviews and concerns around the impacts of myrtle have often been overlooked as many researchers have tended to focus in on native ecosystems and the environmental impact of such incursions. The cultural impact and the ability for indigenous communities to interact in their traditional forage and hunting areas is often overlooked The importance of including indigenous knowledge in incursion response research including Te Ao Māori concepts such whakapapa (a concept which linking Māori people to all other living things), mauri (life force or essence), and ropu led solutions (local people and knowledge) have so far been underrepresented in literature.

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Application of models in a commercial supply chain

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Key Words: Fruits, Prediction, quality, biological variability, data

The world is currently experiencing a data revolution driven by new technologies that are able to capture data previously not possible, but also because of significant advancement in computing that is enabling storage and processing of large amount of data. In the context of horticulture and postharvest, we can now capture real time data on the conditions under which crops are grown, various information about plants during growth and development, and finally the conditions to which products are exposed to along the supply chain. Many companies continue to invest on new data capturing technologies. However, the real value in the data we currently collect is being able to use modelling and advanced analytics to understand and interpret the data. This will aid decisions within the supply chain, as we will be able to make predictions and optimise quality outturn. This talk discusses important consideration in developing robust models. Using real industry examples, we will look at the process of selecting the right modelling approach, assessing model performance and the use of modelling in managing quality in the supply chain. We will also discuss how to incorporate randomness in modelling, as biological variability is an unavoidable reality with horticultural produces.

Optimal box design for containerised shipping of produce

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Key Words: Packaging, design, fruit, transportation

The design of boxes to maximise the amount of produce that can be transported in shipping containers is a non trivial problem due to the unlimited combinations of dimensions that can be employed. This is further complicated by the biological variability of produce, and any user imposed constraints such as maximum box and container mass. Together these issues make experimental determination of suitable boxes a largely trial and error approach likely to result in a suboptimal solution. In this work we demonstrate how the optimal box design problem can be solved by filling virtual boxes with virtual produce and employing local search techniques to find optimal designs without the need for experimentation. A case study is presented to demonstrate this process and the resulting improvements in volumetric efficiency of containerised produce transport.

A 10-year journey for predicting storage life in apples

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Key Words: Controlled atmospheres; ethylene; 1-methylcyclopropene; physiological disorders

Prediction of storage life is a challenging topic for many crops, and has been a focus area for many researchers for decades. Knowing which fruit has the longest storage life would enable supply groups to deliver premium quality over a longer selling window, and reduce waste associated with spoilage. Prediction of storage life is challenging for two reasons: 1) variation in performance is substantial and varies between years, countries, regions within countries, orchards, harvests, and between fruit within the same harvest; and 2) many of the defects found in storage are caused by unknown orchard factors. This presentation highlights a 10-year journey in this research area that summarises learnings from multiple projects. We will highlight our science approach to the problem, discuss how we implemented learnings and dealt with challenges associated with implementation, and offer insights gained from commercial partners involved from the outset. We found four pieces of knowledge were essential for predicting storage life: 1) identifying biological markers of storage performance; 2) building models from those markers; 3) linking the models to a postharvest management decision; and 4) developing systems that can be implemented with scale. This presentation will focus on internal browning in apple, although we expect insights from this presentation will be applicable to other crops.

A multi-omics apple profiling to identify at harvest, biomarkers predicting perfect storage life

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Key Words: Apple, Multi-omics, Metabolomics, LC-MS, GC-MS, Proteomics, mixomics

Apple (*Malus domestica*) is one of the largest fruit export crops from New Zealand. Delivering high-quality product is the major issue for New Zealand fresh fruit exporters, and fruit storage performance must be optimal to reduce losses and ensure perfect quality. Apples can be stored for long periods at cool temperature, but there is variability in outturn quality between orchards and seasons. Correct maturity at harvest is one of the most important factors affecting good storage, but parameters used to measure maturity are alone not reliable indicators of storage performance. Comparisons between harvest date and between orchards have shown that other factors must be involved. To identify new biomarkers of maturity at harvest and predictors of high eating quality post-storage, a multi-omics study was conducted on ‘Royal Gala’. To obtain an overview of fruit metabolism according to harvest time and between seasons, fruit were harvested from four different trees at four different times, each two weeks apart, for two consecutive seasons. LC-MS- and GC-MS-based metabolomic, proteomic and transcriptomic analyses combined with multi-statistical analyses were then carried out. Clear differences in metabolic fingerprints, protein patterns and transcripts were observed between harvest times and between fruit that stored well and those that did not. To identify the most relevant biomarkers, the information from all the datasets was maximised and then correlated using mixomics. Key variables that explain the phenotype of interest were isolated and a storage condition decisional tree was built using at-harvest fruit measurements.

Predicting dried quality of Fijian *Theobroma cacao* beans using a mechanistic model

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Key Words: Drying model, Fiji, quality, solar dryer, *Theobroma cacao*

Fiji exports dried Forastero and Trinitario varieties of *Theobroma cacao* beans and there is global demand for higher-quality fermented and dried Fijian cocoa beans for premium quality chocolate production. Postharvest processing preserves quality attributes (i.e. moisture content and phytochemicals) in dried cocoa beans. Standard processing protocols for cocoa beans exported from Fiji are 7 days of box fermentation followed by 14 days of sun drying. Intermittent sun drying causes quality losses, particularly mould growth. Cocoa beans dried in artificial dryers (>60 °C) have case hardening and shrinkage. Sustainable technology, such as solar dryers with dehumidified conditions (e.g. from a desiccant wheel) at mild temperature can prevent these quality issues. The study tested a mechanistic model to predict drying kinetics for 100 kg of fermented Forastero cocoa beans over a 30-hour dehydration period (i.e. two drying days and an intervening night). Drying consisted of preconditioning (6 h), followed by overnight tempering and drying for 10 hours under dehumidification at 45 and 55 °C. The required final moisture content for safe storage was 7% (wet weight basis). Experimental data was used to parameterize the model. The model was sensitive to variations in drying conditions, bean moisture content and diameter. Drying at 55 °C under 15% relative humidity projected a final bean moisture content of 7% (w.b). Phytochemical retention occurred at 45 °C. Drying was predicted with 95% accuracy. The model is useful for predicting quality of dried Fijian cocoa beans for export under differing drying conditions that could be achieved with a range of drying technologies.

Integrative approaches to understand and predict avocado ripening

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The physiological age of avocado cv. Hass is key to understand and predict ripening behavior in terms of softening rate and heterogeneity. Flowering period is very extended, and fruit does not ripen on the tree, thus even within a tree, fruit of very different age co-exist. At harvest all fruit is hard firm and green, differences in ripening behavior are only observed during postharvest. Commercial harvest is based on a minimum dry matter content that does do not account for differences in biological age within a single harvest. Thus, we hypothesize that the “physiological age” of Hass avocado batches can be captured at harvest using omics approaches and used to predict postharvest ripening behavior (softening rate and heterogeneity) using a mechanistic modelling approach.
Polar metabolite analysis by GC-MS, transcriptomics by RNA seq and targeted hormone analysis by LC-MS/MS have resulted in useful biochemical and molecular tools to assess these differences in biological age of Hass avocado fruit to early segregate fruit based on fast and slow softening, thus, potentially targeting different distant markets. In addition, besides, counting with potential biomarkers of biological age of Hass avocado, pathway re-construction has been performed. Transcriptomics have resulted in more robust potential biomarkers of biological age. Less advanced biological age fruit presented a higher expression of genes associated with DNA replication, transport of auxins and the synthesis of gibberellins and flavonols. On the other hand, fruit with a more advanced biological age presented higher expression of ABA, ethylene and phenylpropanoid synthesis.

Prototype planar cordon apple orchards double yield and increase fruit quality

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Key Words: Light Interception, tree architecture, productivity, harvest index, fruit size, fruit colour, fruit dry matter concentration

New Zealand apple orchards are planted with wide inter-rows (3-4 m) to facilitate machinery access. Consequently, mature apple orchards achieve a maximum fractional light interception of only 60%, limiting yields annually to ~100 t/ha. Therefore, we tested new prototype apple orchards comprising narrow inter-rows and 2-dimensional tree arrays, purposely designed to increase orchard light interception and yield. In 2014, bi-axis 'Royal Gala' and 'Scifresh' trees on 'Malling 9' rootstock were planted at 3 m between trees within the tree rows, with inter-row spacings of 1.5 m (2222 trees/ha) or 2 m (1667 trees/ha). Each inter-row spacing incorporated 2-dimensional planar cordon trees trained with upright fruiting branches oriented either vertically or in a narrow vee. Using 'Scifresh' as an example, 6-year-old experimental orchards planted at the 1.5-m and 2-m inter-row spacings achieved a fractional light interception of 88% and 75%, respectively, with corresponding gross yields of 177 t/ha and 155 t/ha. Comparatively, the upper quartile of high-performing commercial New Zealand 'Scifresh' orchards produce an average yield of ~80 t/ha at the same age. Thus, the commercial adoption of new orchard designs has potential to double New Zealand apple orchard productivity. In addition, fruit quality and uniformity (colour, size, dry matter concentration) from new experimental planar cordon orchard systems were often quantitatively superior than from similar-aged conventional tall spindle orchards. We discuss the pomological performance of planar cordon 'Royal Gala' and 'Scifresh' orchard prototypes across seven years of study, describe further research required, and new opportunities for technology development and automation.

Do localised supra-optimal concentrations of jasmonates control tissue responses?

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Key Words: Jasmonates, senescence, ROS

High concentrations of hormones are not thought physiologically relevant for control of cell responses. Is this true? Jasmonic acid, a plant hormone with roles in plant defence and senescence, appears to function differently in tissue depending on what concentration the tissue is exposed to. We found at low (5–100 µM) concentrations methyl jasmonate accelerated dark-induced degreening of chlorophyllous tissue, as often described previously, but at higher concentrations (5 mM) it unexpectedly led to the same tissue retaining an olive green hue. Here we report on physiological and transcriptome experiments aimed at understanding the mechanism behind this phenotypic difference and hypothesise on what signal pathways jasmonic acid might regulate at high concentrations in plant tissue.

A transcriptome study of shoot branching potential

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Key Words: Branching, axillary meristem, strigolactone, plant architecture, transcriptome

Shoot branching of flowering plants exhibits phenotypic plasticity and variability, and this plasticity is determined by the number and activity of axillary meristems. Bud outgrowth from axillary meristems is triggered by the perception of developmental and environmental cues and is controlled by a complex and interconnected regulatory network. A gap in our knowledge is related to the axillary meristems' differential outgrowth potential on the main shoot. In many species, not all the buds on the main shoot develop into branches despite growing under favourable conditions. For example, in petunia, the first and second basal nodes rarely produce branches, while more apical buds will grow out. Our aim is to understand this difference in growth potential, using transcriptome analysis of petunia axillary buds. In addition, our previous studies showed that modulating nutrient level and red:far red ratio led to a range of shoot branching outcomes in petunia. We used reduction of phosphate supply to suppress the growth of competent buds and examined the transcriptional changes in these buds at early time points (3 and 24 h) after treatment. We found there was a large number (~15,000) of differentially expressed genes between buds that are competent to grow out and those that are not competent to grow; however, low P treatment had a minimal effect on expression at the time points analysed. Information will be presented on selected candidate genes, and future work on these genes should contribute to our understanding of the genetic control of shoot branching.

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Engineering perennial ryegrass for greater energy density, growth and lower on-farm emissions

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Key Words: Perennial ryegrass. genetic engineering, plant oil, photosynthesis, methane reduction, field trials

Co-expression of diacylglycerol acyl-transferase and cysteine oleosin (collectively termed HME) enhances lipid accumulation in leaves of *Lolium perenne* and is predicted to both increase productivity and reduce methane emissions when digested by grazing ruminants. Here, I summarise three streams of research which assessed the potential benefit HME may deliver to NZ pastoral systems; field trials of HME ryegrass under simulated grazing, examination of HME ryegrass digestion in-vitro, and finally, the changes to plant physiology and photosynthesis that result following HME expression. Consecutive field trials between 2019-2020 have confirmed the nutritional changes reported for HME in the lab (elevated leaf lipids), translated consistently to the field and delivered an increase in dry matter gross energy of +0.2–0.5 kJ/gDW. In-vitro rumen fermentation of both fresh and ensiled HME ryegrass produced 10-15% lower methane than did fermentation of non-transformed material. Finally, leaf-level physiological changes have been identified (e.g. increased mesophyll conductance and nitrogen allocated to rate-limiting photosynthetic processes) for HME ryegrass which can enhance photosynthetic rate under specific growing conditions. I will discuss those conditions, their implication for HME production, and introduce our upcoming feeding trials utilising HME ryegrass and live animals. Collectively, HME represents a compelling opportunity to improve ruminant diet, increase farm-productivity without additional stock and reduce the environmental impacts of pastoral farming.

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Modelling the effect of climate change on land use suitability for growing cherry

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Key Words: suitability, climate change, modelling, growing cherries, Prunus

Under climate change, the suitability of land for horticultural production will change, and this will vary with both location and crop type. Understanding both the risks and opportunities will provide valuable information for adaptation strategies, not only from a management perspective, but also from a breeding perspective, to allow the development of cultivars that are more suited for future climates. We estimated the impacts of climate change on the spatial footprint of New Zealand horticulture, for a range of horticultural industries including cherry.
In this project we developed a new sliding-scale approach to model how well locations across New Zealand meet a range of growing requirements. This nuanced and holistic appraisal allowed us to estimate incremental changes in suitability over time. Using GIS data (including future climate forecasts), we have developed maps that show current relative rankings of locations for cherry production, and how these will change by mid-century and late-century under different climate change scenarios. In particular we have identified currently optimal locations that will become less suitable, and areas that will improve in suitability for cherry. We have also identified key factors that are behind changes in suitability under climate change for different locations. This provides an insight into how spatial footprints for cherry could change in the future, as well as help identify breeding targets to optimise future cherry production.

Conditions triggering N_2O production from *Chlamydomonas reinhardtii* axenic cultures and putative pathways involved

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Key Words: Microalgae, nitrous oxide, greenhouse gas release

The ability of microalgae to produce nitrous oxide (N_2O) has now been unambiguously demonstrated in the laboratory, and several synthesis pathways have been discussed in the literature. Recently, flavodiiron proteins (FLV), which are associated to the photoprotection of the photosystem I (PSI) during light fluctuation, and the nitric oxide reductase (NOR) CYP55, which catalyses the reduction of nitric oxide to N_2O and is similar to the fungal gene *CYP55* involved in denitrification, were proposed as N_2O sources in the microalgae *Chlamydomonas reinhardtii*. However, the physiological relevance of N_2O synthesis and the environmental conditions that promote its synthesis are barely known. During this work, batch assays using wild type axenic cultures of *C. reinhardtii* supplied with nitrite (NO_2^-) under aerobic conditions have been carried out under constant illumination and temperature to investigate the implication of different environmental factors that could affect N_2O synthesis by *C. reinhardtii*. Further inhibition assays were carried out using DCMU to block the electron flow from the photosystem II. The results showed that the wildtype was producing up to 31.5 ± 10.7 µmole $N_2O \cdot gDCW^{-1}$ over 24 hours, and that this production was slowed when the electron flow from the photosystem II was blocked. These preliminary results suggest that the electron transport chain is involved in N_2O production in Chlamydomonas. However, there is a high variability in the observed N_2O productions, and it is necessary to understand the cause of this variability to propose accurate methodologies for computing N_2O emissions from aquatic ecosystems.

Effects of phosphine on fruit quality and target pest mortality of 'Hass' avocado fruit

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Key Words: ECO_2FUME, disinfestation, export, postharvest, mould mite, green house thrips, fumigation

Phosphine is a methyl bromide alternative with potential to control surface pests of New Zealand avocados as a pre-export disinfestation treatment. Phosphine gas is available commercially as ECO_2FUME® (2% phosphine, 98% CO_2 (w/w); Cytec Industries Inc.). 'Hass' avocado fruit stored for 1 week were treated with three concentrations of phosphine (500, 750, 1500 ppm) at 5–6°C for 24, 48 or 72 h, along with vials containing the representative 'mould mite' and 'greenhouse thrips'. Fruit were then stored at 5°C for 3 weeks, and external and internal fruit quality assessed thereafter. Phosphine treatments had no impact on external fruit quality, as previously observed using ethyl formate. There were slight differences in time to ripen and ripe skin colour. Pest mortality studies indicated that for thrips all phosphine concentrations for 48 h achieved 100% mortality in all mobile stages, but only 50% mould mite mortality at the highest concentration of 1500 ppm for 72 h. This treatment had no effect on fruit colour development after 3 days of shelf-life but did provide a significant reduction in stem-end and body rots (~50–60%), decreased vascular browning and flesh discolouration. Longer treatment times improved the proportion of sound fruit compared with control. This initial study demonstrates that longer-duration treatments and higher phosphine concentrations have potential to improve ripe fruit quality, mostly through a reduction in the incidence and severity of body and stem-end rots. These treatments could fully control thrips but provided only partial control of mould mites.

Semi-commercial application of hot water treatment for control of bull's eye rot in apples

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Key Words: Disinfection, hurdle technology, postharvest, *Neofabraea alba*

Postharvest rots are a significant problem for horticultural industries, causing fruit loss during storage and posing a quarantine risk for export. Food safety (i.e. human pathogens) are also of increasing commercial significance. Hurdle technologies aim to reduce and/or eliminate human and fruit pathogens by combining control methods (or 'hurdles'). This semi-commercial-scale study examined the use of postharvest application of hot water treatment (HWT) and sanitiser for disinfection, particularly in reducing bull's eye rot caused by *Neofabraea alba.* Commercially sourced fruit were subjected to HWT with ≈80 ppm peracetic acid across a range of potential variables, including fruit temperature, cultivar, storage (controlled and normal atmosphere) and growing conditions (organic and conventional). No significant difference in fruit quality was observed between control and hot water treated apples when assessed by commercial quality-control staff. A significant reduction in incidence of both bull's eye rot and other postharvest rots was observed, but only when a relatively high incidence of rots were present in control/untreated lines. The results suggest combined hot water treatment and peracetic acid could be effective in reducing postharvest rots in apples.

Postharvest Curing and Storage of New Zealand-grown Potato Cultivars ('Moonlight' and 'Nadine') for Export to Fiji

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Key Words: Potato tuber quality, relative humidity, suberization, temperature, wound healing

Tuber quality problems such as skin tears ('skinning'), rots, browning, shrivelling and weight loss in New Zealand-grown export potatoes have caused significant postharvest losses and insurance quality claims from potato traders based in Fiji, the principal importer of potatoes from New Zealand. We hypothesized that these quality issues could be attributed to poor management of curing and subsequent storage conditions. This study investigated the effects of various curing and storage conditions (i.e. duration, temperature and relative humidity (RH)) on tuber quality of two potato cultivars, 'Moonlight' and 'Nadine', that are exported to Fiji. Results have shown that high curing RH (90-95%) obtained significantly lower dry browning, shrivelling and weight loss in both cultivars, and significantly lower dry rot in 'Nadine' than low curing RH (50-70%). Shorter curing duration (7 days) yielded significantly lower shrivelling in 'Moonlight', and significantly lower dry rot in 'Nadine' than longer curing duration (14 days) and control (0 day). Percent weight loss was significantly lower in shorter and longer curing durations for both cultivars than control. Curing temperatures (15°C and 25°C) and storage RH did not have a significant effect on the tuber qualities assessed. Therefore, curing factors such as RH and duration play a critical role in minimising quality problems occurring during transport of these potato cultivars to Fiji.

Use of physiological principles to guide precision orchard management and facilitate increased yields of premium quality fruit

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Key Words: Light interception, tree architecture, pruning, artificial spur extinction, fruit quality, yield

Deciduous fruit producers sell products into competitive markets where consumers make choices on visual appeal and pricing. Although orchard income is yield dependant, it may be altered considerably by fruit quality. The ability of trees to capture photosynthetically active radiation is the basic function regulating productivity. On an orchard basis, yield is closely correlated with orchard light interception. However, if light penetration into the canopy falls below a critical minimum, productivity and fruit quality are reduced. This reduces yield and increases fruit quality variability, compromising consumer experiences. Light interception and penetration are functions of orchard and canopy design. Within-canopy light relations in deciduous perennial trees and vines have been a discussion topic for at least 400 years, and orchard design and pruning for over 2.5 millennia. However, in today's commercial sector, orchard design and tree pruning remain highly subjective and there are few metrics to assist growers and designers of automated pruning technology to seek and achieve planned, measurable outcomes. Consequently, pruning by hand is regarded as an art, and non-quantitative automated pruning risks contributing to the problem not the solution. Our research illustrates that applying physiologically-based quantifiable metrics to both current and new tree canopy designs can increase apple and stonefruit yields by ~80–100% and enable >90% of fruit produced at such elevated yields to achieve the highest internal and external quality grades. Removing subjectivity in orchard systems and tree canopy management will greatly improve consistency of hand pruning and greatly facilitate the development of "intelligent" automated pruning.

New Zealand Juniper studies

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Key Words: *Juniperus communis,* genetic diversity, berry volatiles

Juniperus communis (Cupressaceae) is the most widespread of the junipers, found mainly in the cooler regions of the northern hemisphere and is able to grow in a wide range of habitats. An initial study of genetic diversity in juniper explored the opportunity for New Zealand to become a berry supplier, with value-add points of difference, including traceability and, as we can now confirm, potentially unique volatile oil attributes. 'Terroir effects' in New Zealand for *J. communis* could enhance the value of the berries, and products made from New Zealand berries, in international markets. The project has made progress in locating and identifying juniper plants across New Zealand. We have received/collected 90 samples, with 39 confirmed *J. communis* samples as at end of February 2020. Genetic testing of 24 *J. communis* samples has established that no two individuals had identical genotypes across all molecular markers. Significant differences also appear to exist in the oil composition of the berry samples sourced in New Zealand; the NZ-grown juniper berries seem to fit within the outlying 10% of *J.communis* studied globally. As juniper is the primary botanical component of gin, the results thus far suggest that we may have an opportunity to develop, and market, some of the world's most unique gins made from NZ-grown junipers. Propagation by cuttings and in vitro have shown better strike rates than seedlings. Future studies will include more research into the sensory attributes of these unique New Zealand junipers and to further explore pre-requisites to successful juniper plantation development.

Floral bud type influences fruit quality in 'PremP009' pear

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Key Words: Leaf area, fruit set, flowering structures

Floral bud morphology can influence fruit size and quality. Identifying the most productive floral bud types for new cultivars is essential to guide canopy management for fruit quality and yield optimisation. We characterised different floral bud types in the new pear cultivar 'PremP009' (Piqa™Boo™) to understand how different floral bud types modified productivity and fruit quality. In winter, terminal and spur bud types were selected within canopies of planar cordon trees located in Tasman and Hawke's Bay research orchards. After leaf expansion, leaf number was recorded, and laminar length and width were measured on every leaf for each bud. Leaf area was measured non-destructively on the tree, and calculated using a fitted correlation between laminar length x width. At harvest, fruit colour and size were quantified using a COMPAC® Invision grader, and dry matter concentration (DMC) and total soluble solids content (TSS) were assessed destructively in the laboratory. Fruit size on terminal buds was larger than spurs (177.4 cf. 167.2 g), despite a smaller total leaf area (1021.9 cf. 1680.2 cm^2) and multiple fruit on some terminal buds. Total red skin coverage over the fruit surface was similar between terminal and spur fruit (68% cf. 70%). Fruit DMC and TSS were similar between bud types. We conclude that 'PremP009' fruit size is largely independent of fruit bud leaf area, and that commercial thinning strategies should retain two fruit on terminal buds and single fruit on spur buds, because terminal buds can carry multiple fruit of greater weight than spur buds.

Comparing light interception and productivity in two modern apple-growing systems

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Key Words: 'Scilate', fruit quality, yield, leaf area index, dry matter production

Fruit yield in apples is positively related to total whole-canopy mid-season light interception. In New Zealand, mature high-density apple trees intercept 55 to 60% of incoming light, with new innovative growing systems aiming to intercept >85% to increase yield per ha. Fruit yield, light interception, and leaf area index were investigated in young (fifth leaf) 'Scilate' apple trees trained as Tall Spindles or Washington Vee systems, on 'M9' rootstock, with row widths of 3.5 m, and tree spacings of 1.3 m and 0.5 m (densities of 2198 to 5714 trees/ha^{-1}) respectively. Although we have an understanding of dry matter production, fruit yield, and light interception in Tall Spindle orchards, we have little understanding of how they compare with high density plantings of Washington Vees. The Washington Vee resulted in greater whole canopy fractional light interception (55% vs 49%), leaf area index, (3.2 vs 1.6), fresh fruit yield (135 t ha^{-1} vs 108 t ha^{-1}) and fruit dry matter yield (14.6 t ha^{-1} vs 10.8 t ha^{-1}) than the Tall Spindle. In both growing systems, fruit yield and fruit dry matter production followed the same linear response to light interception indicating that greater yield in the Washington Vee system was the result of a greater proportion light intercepted. We discuss why the light interception:yield relationship was steeper in this work than that published elsewhere.

Can summer pruning strategies produce more compact rabbiteye blueberry plants grown in tunnels?

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Key Words: *Vaccinium virgatum* Ait., plant vigour, plant growth, canopy management

Rabbiteye blueberry plants (*Vaccinium virgatum* Ait.) grow very vigorously and can be challenging to manage and harvest, particularly when grown under tunnels. Summer pruning may have the potential to develop more compact plants that would still produce good yields of high quality fruit the following season. Our aim was to examine the effect of summer pruning timing on shoot development during that season.
Four-year-old plants of 'Velluto Blue' and 'Sky Blue' growing in 30-L pots under plastic tunnels were used in the trial. New season shoots greater than 1 m in length were halved in length in either early- (December), mid- (January) or late- (March) summer pruning treatments, or received no summer pruning (controls). Early- and late-summer pruning treatments were also applied to individual shoots on mature plants of several cultivars growing in the ground.
Whilst there was a great deal of variability within treatments, early- and mid-summer pruning tended to develop several long axillary shoots, whereas late-summer pruning developed only a few short axillary shoots. The effect of timing of summer pruning for different cultivars on developing a more compact plant and the potential effect on fruiting in the following season will be discussed.

Can reflective mulch improve light conditions to reduce fruit quality variability in very narrow-row planar cordon cherries?

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Key Words: *Prunus avium*, PAR, DLI, irradiance, orchard systems, productivity

New cherry planting systems are being investigated in New Zealand, using designs that reduce inter-row distances to increase canopy light interception and thereby increase yield. However, reduction of inter-row spacing risks reduced within-canopy light transmission, compromising fruit number and quality. To improve light transmission within closer row spacing, narrow planar configurations were designed. In 2014, trees of 'Sweetheart' on 'Colt' rootstock were planted 3 m apart in the row and either 2-m and 1.5-m inter-row spacings. In 2020/21 the aim was to investigate whether using white reflective mulch (Extenday™) in the alleys between the rows would improve the uniformity of canopy light distribution, and consequently improve the fruit quality uniformity within planar canopy systems. Photosynthetically active radiation (PAR) at four vertical positions within these canopies was measured to better understand light transmission and reflection within each treatment. Both total soluble solids (TSS) and size of fruit were significantly less in lower canopy positions in the 1.5 m row, and TSS alone in 2 m row treatments without reflective mulch, but there were no significant differences in treatments with reflective mulch.
This suggests that the 1.5 m row spacing in these systems is at the limit of light in New Zealand conditions. But the reflected light that would otherwise hit the ground can make a difference to improve the uniformity of fruit quality between the upper and lower canopies.

Future challenges at the border. The next generation of plant biosecurity researchers

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Key Words: Plant border biosecurity, future challenges, capability development

New Zealand's productive and natural plant systems are subject to a range of threats from invasive invertebrates, pathogens and weeds. New Zealand's biosecurity system aims to reduce the establishment of high impact species but is under growing pressure from increased trade and tourism, and climate change. Solutions are required for enhanced border biosecurity over the pre-, at- and post- border continuum (pest risk assessment, pathway risk management, surveillance and eradication). Science and scientists will play an important role in meeting current and future challenges from invasive species and New Zealand will require significant investment to develop the next generation of plant biosecurity researchers versed in both western science and Mātauranga Māori.

Facing unfamiliar new biological threats: a risk assessment framework for Aotearoa

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Key Words: Biodiversity, biosecurity, kauri dieback, myrtle rust, mana whenua, kaitiaki

The importance of our biological heritage and the contribution this makes to human and ecosystem health and wellbeing, and to the wellbeing of the earth, is increasingly recognised by the global community. Within Aotearoa New Zealand widespread awareness regarding protection and enhancement of our biodiversity is also occurring as we acknowledge the relationship between healthy and diverse ecosystems and the health of our society. Kauri dieback and myrtle rust diseases present considerable biological threats to our taonga plant species and to the ecosystems they inhabit. This is concerning for our communities, particularly for mana whenua and kaitiaki. For Māori, the health of our native flora and associated forest ecosystems is intimately bound to the health and wellness of the people. Whakapapa underpins the Māori worldview and includes genealogical links to physical and metaphysical elements of the natural world; hence kauri dieback and myrtle rust diseases also present a significant cultural threat. Despite an extensive focus on biological heritage protection, not least of which includes protecting our iconic tree species, a national framework to assess and prioritise species and ecosystems at-risk of pathogen incursion does not currently exist. The development of a risk assessment framework underpinned by a Māori worldview, whereby human-nature relationships are premised upon respectful and reciprocal behaviours that acknowledge the interconnectedness of all things, will assist in addressing these threats. This research therefore prioritises a complementary approach that recognises the important role of kaitiaki and mana whenua, along with science-based solutions, in biodiversity protection and biosecurity issues.

A Case Study of the New Zealand Response to the Introduction of Myrtle Rust

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Key Words: Myrtle rust, *Austropuccinia psidii,* invasive species response

The introduction of myrtle rust to New Zealand in May 2017 tested the country's response to invasive pathogens. Initial efforts to contain and eradicate the pathogen centred on infected nurseries in Northland, Taranaki, and Waikato. Tracing data collected from the infected nurseries were compiled and networked. The resulting network did not indicate that sale of infected plants by nurseries played a role in the dissemination of the pathogen through New Zealand. Newly identified myrtle rust cases were investigated by the Ministry for Primary Industries (MPI) between May 2017 and April 2019. The investigation of new cases included a 500m delimiting survey around an infected property; a practice that led to the detection of half of all reported myrtle rust cases. Spatiotemporal analyses of the spread of myrtle rust through New Zealand identified long-distance jumps (defined as a distance of 80 km between the newly infected site and its closest infected neighbour), which, alongside seasonal data, present the possibility of human mediated dispersal of myrtle rust to the Wellington region within the first year of the incursion. The identification of myrtle rust in multiple regions within three weeks of the first confirmed positive case suggests that it had already established in New Zealand by the time of its discovery. Despite evidence of possible establishment, MPI continued containment and eradication efforts until myrtle rust was positively identified on New Zealand's South Island, at which point containment was no longer feasible.

Detecting volatile organic compounds using an insect odorant receptor device

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Key Words: *Insect odorant receptors (iORs), Drosophilia melanogaster,* Lipid nanodisc, *CNT network field-effect transistor (CNTFET), graphene field-effect transistor (GFET), Olfactory sensor, Electronic nose*

The invasive Queensland fruit fly poses a serious biosecurity threat to New Zealand's horticulture industry. It is currently difficult to identify infestations of the Queensland fruit fly maggot by sight, as the outer layer of infested fruit often appears intact and undamaged. Our research aim is to develop a novel insect odorant receptor-based field effect biosensor technology for the remote detection of these infestations. This biosensor technology would be designed to specifically detect gas-phase volatile organic compounds characteristic to the fruit fly. We have previously demonstrated that selective and sensitive biosensing using a *Drosophilia melanogaster* iOR functionalised thin-film field-effect transistor is possible in a liquid environment. These findings showed that we expect different ORs to selectively respond to specific odorants in liquid. We now hope to create selective sensor devices with the ability to detect specific airborne ligands characteristic of Queensland fruit fly infestations. To achieve this, we will test CNTFETs and graphene FETs functionalised with a variety of iOR types in a gas-phase environment, and investigate whether selective sensing of a mixture of compounds can be performed successfully with multiplexed iORs attached to the same transistor device.

No evidence of genetic bottlenecks following the accidental introduction of three agricultural weeds into New Zealand

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Key Words: Biological invasions, genetic admixture, genetic bottleneck, next-generation sequencing, population genetics, *Rumex* spp., single-nucleotide-polymorphism

It is generally expected that during introduction to a new region, weeds suffer a genetic bottleneck and thus exhibit less genetic diversity than in the native range. This should limit the opportunities for further adaptation. The genus *Rumex* has multiple species among the world's worst weeds, as they are fast-growing species with high seed output. Three such species, *R. conglomeratus*, *R. obtusifolius*, and *R. crispus* were introduced to New Zealand in the mid-1800s as grass-seed contaminants, and have since become persistent agricultural weeds. This study investigated the genetics of these species compared with representatives from their native range, Europe. To understand the success of these species in NZ we compared the amount of genetic variation, genetic admixture and differences between specific geographic locations including how variation is partitioned within and between plants from these locations and whether the partitioning was similar between the locations. Genotyping-by-sequencing was chosen to obtain a high number of SNPs to be used in population genetics analyses. The results show little variation both within plants taken from a single location, but also little differentiation between them. In addition, the results show admixture, indicating multiple introductions from different sources. This suggests that there has been no bottlenecks but rather the generation of admixture has maintained high genetic variation within New Zealand. Many weed species already established in NZ continue to be accidentally introduced without facing quarantine restrictions. However, each introduction brings increased genetic diversity that could lead to currently benign weeds becoming more invasive in the future.

Can sterile parasitoids be employed for eradication by mitigating potential risk of non-target impacts?

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Key Words: Sterile insect technique; Classical biological control; Irradiation; Synergy; Biocontrol preparedness; Eradication; Risk

Ongoing pest management costs can be avoided through eradication. Classical biological control (CBC) involves the release of imported natural enemies to control pests. The sterile insect technique (SIT) involves the mass release of sterilised insects to disrupt fecundity in a pest population. The combination of SIT and CBC can exert a synergistic impact on pest populations and improve eradication. However, owing to perceived risk of non-target impacts, regulation surrounding the release of CBC agents limits their use in eradication. We propose a novel tool comprising the combined application of sterile parasitoids with SIT. Sterile parasitoids could mitigate the risk of ongoing non-target impacts as their population will not persist, and regulatory constraints to CBC releases in eradication could therefore potentially be bypassed. To assess the feasibility of this technique, we investigated irradiation-induced sterility in the egg parasitoid *Trissolcus basalis*. Irradiated females killed *Nezara viridula* host eggs without the emergence of their own offspring. We are currently examining the host-searching ability and longevity of irradiated *T. basalis*. Future experiments will investigate whether the combination of sterile parasitoids and SIT exerts a synergistic impact on the pest. Sterile parasitoids could facilitate the contribution of CBC agents to improve insect eradication programmes globally.

Aggregating ‘Hass’ Avocado Fruit Before Packing

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Key Words: *Persea americana*, quality, rots, storage, temperature

An important element for the postharvest handling of ‘Hass’ avocado fruit for export is the timeframe within which harvested fruit are packed and cooled for storage. Usually, fruit are packed the day after harvest and then immediately cooled and held no more than a few days before export. This procedure is considered to maximise the storage life and quality of the fruit. However, for packhouse logistics, there are times when it may be advantageous to aggregate fruit over a period of days before packing. It is hypothesised that the time at which fruit are cooled may be more significant for fruit quality than the time of packing. The impact of holding fruit at 7°C for 1, 2, 4 or 6 days before packing and cooling to storage temperature (5°C) was investigated. In comparison with fruit held overnight at ambient conditions before packing and cooling, holding fruit at 7°C for up to 4 days before packing did not diminish the quality of the fruit markedly, either immediately out of storage (4 weeks after harvest) or after ripening at 20°C. Extending the holding period to 6 days may increase slightly the risk of fuzzy patches, stem end rots and body rots. However, there was as much variability in the incidence of disorders among orchards as there were differences among treatments.

Severity of Scuffing Discolouration of SunGold™ Kiwifruit as Influenced by Maturity

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Key Words: Kiwifruit, *Actinidia chinensis,* Mechanical damage, Susceptibility, Skin discolouration

Kiwifruit (*Actinidia chinensis* var. *chinensis* 'SunGold') have a relatively long harvest season, where fruit will change in maturity and hence attributes. Harvest may be followed by a long postharvest storage period. Skin scuffing is the discolouration of kiwifruit skin in response to an injury. This injury is observed throughout the supply chain to some extent and thus, it was of interest to identify possible reasons that predispose kiwifruit to skin discolouration. In this work, maturity as influenced by harvest date and estimated through quality measures was investigated as a potential contributing factor to scuffing susceptibility. SunGold™ kiwifruit were sampled from 13 different orchards in New Zealand on three occasions during the 2020 harvest season. Ninety fruits per grower were couriered to Massey University within 24 h of harvest. Upon arrival 24 fruit from each grower were non-destructively assessed prior to artificial damage induction through scuffing exposure and subsequently stored for two weeks, to allow for symptom development. Of the at harvest maturity indicators, firmness at harvest was found to be the strongest indicator of severity and occurrence of damage. This influence of firmness at time of scuffing on scuffing symptom severity was further demonstrated using fruit that was softened postharvest prior to scuffing exposure. Further work is required to understand the physical or physiological reasons that cause susceptibility.

Consequences of sustainable packaging systems on kiwifruit weight loss and quality maintenance

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Keywords: Sustainability, plastics, supply chain, fruit loss

Packaging plays an integral role in fruit supply chains as it protects the product, maintains quality, and most importantly reduces food waste. Conventional plastic packaging has many advantages, including excellent mechanical and barrier properties, light weight and very cost effective. In general, emissions associated with food loss and waste are a bigger contributor to carbon footprint than emissions associated with the life of the plastic packaging. However, there is a global demand to reduce plastic use. Zespri is committed to using 100% reusable, recyclable or compostable packaging in the kiwifruit supply chain by 2025. Currently plastic packaging is used in the kiwifruit industry as liners in boxes, pocket trays, consumer packs and bags. Current packaging has been effective in preventing moisture loss (which leads to visible shrivel) in kiwifruit, consequently extending storage life and reducing losses throughout the supply chain. New packaging materials and formats will affect the dynamics of weight loss in kiwifruit and potentially lead to the increase in fruit loss. The purpose of this research is to determine kiwifruit moisture loss and kiwifruit shrivel in different packaging types during storage. To determine the effects of packaging on the weight loss of kiwifruit a storage trial was carried out. SunGold™ kiwifruit was stored in four different packaging types for 13 weeks (liners, no liners, vented consumer pack and non-vented consumer pack) and the relative amount of weight loss was measured under refrigerated storage conditions (0^{o}C, 75%RH). Weight loss from fruit stored in liners after 13 weeks was 1.47 $\pm$0.32% which was much lower compared to fruit stored with no liners (8.52$\pm$0.38%), vented consumer packs (5.58$\pm$0.19%) and non-vented consumer packs (3.79$\pm$0.32%). Visible shrivel occurred at the same critical weight loss limit for all packaging types. The data collected in this storage trial will be used to validate a moisture loss model for different kiwifruit packaging configurations. The kiwifruit shrivel data will be used to validate a risk model to predict when kiwifruit will express shrivel based on packaging configuration and storage conditions.

Influence of storage technologies on mechanical properties of blueberry

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Key Words: *Vaccinium* spp. Postharvest quality, Texture Profile Analysis, Puncture test

Excessive postharvest fruit softening can negatively impact commercialisation and consumer acceptance of fresh blueberries. Storage technologies such as high humidity (>95 % RH) and controlled atmosphere (CA) have been recommended to assure quality after long-term storage. However, the CA effect on softening rate can vary as a result of the atmosphere conditions and cultivar. In addition, instrumental methodologies used to assess softening vary widely, compromising the cross-validation of the research community and industry results. This work aims to identify mechanical properties to study the storage technologies that influence the mechanisms that result in softening. Blueberries 'Nui' (Highbush) and 'Rahi' (Rabbiteye) were stored for 42 d at 5 °C in two air environments (99 % or 81 % RH) or in three CAs (5 kPa, 10 kPa, or 20 kPa of CO_2 in combination with 4 kPa of O_2). After storage, two mechanical tests, Texture Profile Analysis (TPA) and a puncture test, were used to assess softening. The chord stiffness or slope of a straight line drawn between trigger force and maximum force obtained by TPA or puncture test differentiated the storage conditions of both cultivars best. The lowest chord stiffness was observed in berries stored at 20 kPa CO_2 and in lower RH air. Consequently, chord stiffness was able to differentiate soft berries independent of the mechanisms of induction (i.e. water loss or high CO_2). These results strongly indicate that the development of a standard instrumental test for tracking quality changes of stored blueberry is feasible.

Considerations for developing a physical scale model of a refrigerated container to study airflow and temperature control

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Keywords: Refrigerated transport; airflow; temperature variation; modelling

Refrigerated containers (RC) play a vital role in maintaining fresh produce quality in the global supply chain, offering a temperature-controlled environment for fresh produce during transport. Studies have shown that when RCs are loaded with pallets, on occasions, temperature control is insufficient, likely due to poor airflow distribution. This can result in substantial temperature variation within the produce in the stow which can manifest as variable quality on outturn, or worse, cause losses via advanced senescence, or induction of chilling and/or freezing injuries. Reducing incidences of poor temperature control in RCs requires extensive monitoring of airflow and temperature inside a fully loaded RC. However, these experiments are expensive, time-consuming, and labour-intensive and tend to provide limited data due to instrumentation and access challenges. In contrast, a reduced physical scale model of an RC loaded with pallets has the potential to save cost and time, enables the application of advanced measurement techniques and should allow future examination of many factors. This presentation will provide a discussion of the important considerations in developing a scale model of an RC loaded with pallets. Preliminary steps to establishing similarity in terms of geometry, airflow and heat transfer between the full-scale RC and the scale model will be discussed.

A survey of conditions in the kiwifruit supply chain in India and Singapore

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Keywords: Temperature, ethylene, tropical climate, shelf life

Kiwifruit is New Zealand's major contributor to fresh produce export, selling into nearly 60 countries globally. In developed countries dominated by modern retail, kiwifruit quality is managed in a consistent cool chain through to the consumer and hence expected to reach consumers in a state of high quality. However, in other regions, traditional retail conditions (e.g. wet markets) continue to have a considerable share of fruit sales. In India, 80% of the fruit sales to the final consumer occur at street vendors. The limited adoption or availability of refrigeration and the relatively high ambient temperature and humidity conditions has the potential to present a considerable challenge in maintaining product quality. To understand potential kiwifruit marketing conditions in regions dominated by traditional retail pathways, a case study survey was conducted in India and Singapore. Environmental conditions (temperature, relative humidity and ethylene concentrations) were monitored at street vendor locations in major kiwifruit marketing cities across India and around wet markets in Singapore. It was found that at the point of sale, temperatures frequently exceeded 30 °C and ethylene concentrations were as high as 120 nL L^{-1}. The observations from this case study indicate the necessity to understanding kiwifruit physiological responses to these high shelf-life temperatures and ethylene concentrations that may occur under traditional market conditions.

Insights into the biosynthesis, control and function of red pigmentation in plants

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Key Words: Anthocyanin, betacyanin, auronidin, pigmentation, regulation, biosynthesis, salt stress, polyphenol oxidase

Plants have evolved different ways of producing red pigmentation, which provides a way to communicate with animals for pollination and seed dispersal and mechanisms to counter a variety of stresses. The flavonoid pathway provides at least two types of red pigment, anthocyanin and auronidin. Anthocyanins are by far the most common red pigments, and they are frequently the basis of the diverse pigmentation patterns we see in flowers. Auronidins are key stress-responsive pigments of liverworts, one of the bryophyte lineages. Another red pigment is betacyanin. Betacyanins are alkaloid pigments restricted to core families of the Caryophyllales, which include many plants growing in challenging environments such as deserts and salt exposed coastal regions. They are often characterised as anthocyanin replacements; they seem to fulfil the same roles as anthocyanin and the two types of pigments have never been reported to occur in the same plant, even though the production of other flavonoids is conserved. This talk will focus on insights into different aspects of red pigmentation, with an emphasis on the control of pigmentation patterning in flowers, the betacyanin pathway and salt stress amelioration, and the role in bryophytes of polyphenol oxidases in auronidin formation and other pathways.

Near infrared spectroscopy and Aquaphotomics for non-destructive fruit quality measurement

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Key Words: Fruit quality, Near Infrared spectroscopy, Aquaphotomics, Brix, Dry matter

Near infrared (NIR) spectroscopy is a fast, non-destructive, and non-invasive technique that is used to predict the quality parameters of fruits such as dry matter and soluble solids content (SSC). Fruits like apples and kiwifruit are more than 80% water. The NIR spectrum (800–1100 nm) of the whole fruit is dominated by a water peak at 970 nm. This water peak shifts with changes in temperature or sugar and can create a bias deteriorating the model performance when predicting quality parameters. To overcome this problem and to understand how the structure of water changes with these variations, a new field “Aquaphotomics” focuses on absorbance patterns related to water bands and the effects of perturbations due to variation in temperature, the concentration of solutes, environment, and other factors. The first overtone band of water (1300–1600 nm) is a good discriminator in aqueous solutions and has aided the understanding of the role of water in biological systems. We have investigated this concept for the quality assessment of fruit juice using an FT-NIR spectrometer in the 1300–1600 nm region and later on applied the methodology for whole intact fruit quality prediction in the 800–1100 nm region. We have also studied the effects of sample temperature on the performance of the prediction model and water spectral pattern.

Spectrally distinguishing kiwifruit chilling injury from other tissue damage types in high-speed grading applications

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Key Words: Chilling injury, kiwifruit, laser, NIR, impact injury, rot

Chilling injury is a physiological disorder that can develop in kiwifruit during prolonged cool storage at a temperature of 0 – 1 °C. At an early stage, symptoms are not apparent and can only be visually assessed by cutting the fruit open. Development of non-destructive methods for early stage detection of chilling injury has been a recent research focus, leading to the promising development of a prototype system for high-speed grading applications. The system involves spatially scanning a laser beam, consisting of two distinct near-infrared (NIR) wavelengths, across the fruit surface, and is capable of achieving greater than 90 % accuracy for detecting chill-damaged fruit. During the system's development, some surprising spectroscopic observations were made, particularly that chilling injury fruit were spectrally distinguishable from otherwise visually similar tissue damage types such as those caused by impacts and rots. The initial expectation had been that the main tissue damage symptom in all cases, water-soaked tissue, would dominate the spectrally observed characteristics. This proved not to be the case, the presence of granular and/or corky tissue with chill-damaged fruit being distinctive, even when otherwise visually masked to the naked eye by water-soaked tissue. These observations and others are discussed within the context of the successful development of the laser system.

Kiwifruit storage breakdown disorder detection using laser backscattering image system

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Key Words: LBI, absorption coefficient, reduced scattering coefficient, chilling injury, nondestructive

Kiwifruit storage breakdown disorder (SBD) is a form of chilling injury damage that occurs after long term storage at low temperature. Kiwifruit with SBD begins with symptoms of white corky spots developing to granular tissue and later water soaking. Currently, SBD assessment is destructive. Severe cases of SBD are not accepted by consumers. As a potential non-destructive approach to detect SBD injuries, the laser backscattering image (LBI) technique was tested. LBI records the emitted light after a single laser beam interacts with the fruit tissue in the visible and near-infrared (NIR) region. In LBI, the symptoms related to cell structure and chemical composition are represented through the interaction of two optical properties: absorption coefficient (μ_a) and reduced scattering coefficient (μ_s'). This study investigated whether μ_a and μ_s' at 532 nm could detect SBD injury for 'SunGold™' and 'Hayward' kiwifruit. LBI images and quality attributes of kiwifruit were collected for sound fruit, and fruit that developed moderate and severe SBD symptoms. An SBD prediction model was created using the estimated μ_a and μ_s' after pre-classification based on reference objects (phantoms) with predicted μ_a and μ_s'. For 'SunGold™', the classification model had a moderate true-positive rate for kiwifruit with severe SBD symptoms: 91.6% and 75 % when the subsampling method was applied using LBI parameters and optical properties respectively; the false-negative rate was 0 for using both variables. For 'Hayward', the true positive rate for classifying fruit with severe SBD using LBI parameter was poor at 46.4% and the false-negative rate was 8.3% when the subsampling method was applied, which was assumably due to the additional interference caused by the long trichomes on the fruit surface. Several options can be used to potentially strengthen the predictive capability of the LBI technique including accounting for the "point" measurement nature that introduces sampling error; removing data noise that is introduced due to other differences in quality; improving the pre-classification of μ_a and μ_s'; and increasing the sample size of the population.

The Role of *DAM* and *SVP*-Like Genes in Regulating Dormancy Cycle in Temperate Fruit Trees

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Key Words: Apple, budbreak, dormancy, DAM, SVP, RNAi

Dormancy is an important agronomical trait that allows plants to survive adverse winter conditions and ensures synchronised budbreak and flowering in spring. MADS-box genes with similarity to Arabidopsis *SHORT VEGETATIVE PHASE* (*SVP*), the *SVP*-like and *DORMANCY ASSOCIATED MADS-BOX* (*DAM*) genes have been implicated in regulating flowering and growth-dormancy cycles in perennials. We identified and characterized three *DAM* and two *SVP*-like genes from apple (*Malus x domestica* 'Royal Gala'). The expression of *MdDAM* and *MdSVP* genes indicated they may play a role in triggering autumn growth cessation and maintaining bud dormancy. Ectopic expression of *MdDAMb* and *MdSVPa* in 'Royal Gala' apple plants resulted in delayed budbreak and architecture change due to constrained lateral shoot outgrowth. To further study their role and mode of action in the regulation of bud dormancy, budbreak and flowering, RNAi interference (RNAi) technology was used to simultaneously target all apple *DAM* and *SVP* genes. Reduced expression of *DAM/SVP* genes resulted in plants delayed leaf senescence and abscission in autumn, failure to enter bud dormancy in winter, and continual growth of new leaves regardless of the seasons. Precocious flowering but normal flower morphology, and possible parthenocarpic/seedless fruit development were observed. The non-dormant phenotype was associated with modified phytohormone composition. This study provides functional evidence for the role of *DAM/SVP* genes in vegetative and reproductive phenology of apple, and paves the way for production of low-chill and seedless apple fruit varieties suitable for growth in warming climates.

Molecular regulators of masting in *Celmisia lyallii*

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Key Words: Flowering pathway, gene expression, masting, *Celmisia lyallii*, transcriptomic profiling

Mast flowering (or masting) is synchronous, highly variable flowering among years in populations of perennial plants. Despite having widespread consequences for seed consumers, endangered fauna and human health, masting is hard to predict. The ΔT model hypothesises that the size of the temperature difference between the two preceding summers determines the current year's flowering intensity. However, the molecular mechanism behind the role of temperature-induced mast flowering is still unknown. In model plant species, the flowering process is induced by the *SUPPRESSOR OF CONSTANS 1* (*SOC1*) gene homologues and regulated by various transcription factors which are responsive to temperature and/or photoperiod. The current study deals with the identification of essential flowering pathway genes that might have a role in the masting syndrome of *Celmisia lyallii* (snow daisy) plants. We used a range of *in-situ* and transplantation experiments to obtain leaf samples from plants which subsequently remained vegetative or flowered. Transcriptomic sequencing and gene expression analysis of key floral integrator genes showed conservation of the model flowering pathway in *C. lyallii.* Differential expression analysis showed elevated expression of *ClSOC1* and *ClmiR172* (promoters of flowering) in leaves of plants that subsequently flowered, in contrast to elevated expression of *ClAFT* and *ClTOE1* (repressors of flowering) in leaves of plants that did not flower. Upregulated expression of epigenetic modifiers of floral promoters also suggests that plants may maintain a novel "summer memory" across years to induce flowering and provide evidence of their ability to imprint environmental cues to synchronise flowering.

Functional characterization of tomato (*Solanum lycopersicum*) *SlPDX1-3* reveals a role for vitamin B_6 in regulation of fruit ethylene biosynthesis

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Key Words: Fruit ripening; tomato; ethylene; vitamin B_6

Fruit ripening is a genetically-programmed biological process that requires the plant hormone ethylene in tomato and other climacteric species. We used genomics to identify genes associated with ripening in tomato, looking for novel regulators and/or necessary components of the process. *SlPDX1-3* expression positively correlated with ethylene biosynthesis in ripening wild-type fruit at onset of ripening. Also, *SlPDX1-3* expression was lower in the ripening-impaired mutants *rin*, *nor* and *Nr* than wild-type fruits of the same developmental age. The function of SlPDX1-3 was hypothesized by phylogenetic analyses as a vitamin B6 biosynthetic enzyme, and confirmed by complementation analyses in the yeast auxotrophic mutant *snz1*. Silencing of *SlPDX1-3* by RNAi caused plieotropic effects including increased susceptibility to abiotic (salt) stress in germinating seedlings and altered plant development. Application of pyridoxal 5'-phosphate (PLP) rescued the RNAi lines from these effects. Exogenous application of either PLP or the ethylene analogue propylene resulted in the rescue of normal ripening of fruit that were suppressed for *SlPDX1-3.* Transcriptome analysis by RNAseq indicated reduced expression of a suite of ripening regulated genes in the RNAi lines compared with wild-type late during ripening. ACC synthase is dependent on PLP as a co-factor for its activity. These experiments confirm the requirement of this vitamin for ethylene synthesis during ripening in tomato and demonstrate *SlPDX1-3* is the gene responsible for fruit PLP accumulation during ripening and additional aspects of plant development.

Post-storage softening of ‘Zes008’ kiwifruit

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Key Words: *Actinidia*, ethylene, fruit, kiwifruit, softening, temperature

Actinidia chinensis var. *chinensis* ‘Zes008’ is a recently commercialised red-fleshed kiwifruit from New Zealand. The fruit has a vibrant appearance and a more complex berry-like flavour than the traditional green- or yellow-fleshed kiwifruit. The fruit has a sigmoidal softening pattern typical of kiwifruit. On removal from storage, the fruit softens rapidly when warmed to room temperature. This research investigated the response of ‘Zes008’ fruit to temperature after a short period of storage. After 3 weeks of storage at 1°C, softening was faster at higher temperature, but with little difference between fruit at 10 and 20°C. After 1 week of storage, fruit at 10 or 20°C were of a similar firmness (~3 kgf) but only the fruit at 20°C were producing ethylene. This ethylene production was associated with the activities of 1-aminocycopropane-1-carboxylate synthase (ACS), 1-aminocycopropane-1-carboxylate oxidase (ACO) and the ethylene precursor 1-aminocycopropane-1-carboxylic acid (ACC), along with specific *AcACO* and *AcACS* expression. As a further check on the roles of temperature and ethylene on softening control, results from ethylene treatments of fruit at different temperatures suggested that the temperature response was considerably stronger than the ethylene response. In conclusion, it appears that the softening of ‘Zes008’ fruit that occurs on warming after storage is not obviously mediated by ethylene, and that the softening response of ‘Zes008’ fruit to temperature appears to be greater than to ethylene.

Quantifying ethylene production magnitude and timing in SunGold™ kiwifruit as influenced by ethylene exposure

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Key Words: *Actinidia*, modelling, supply chain, ripening

Softening of kiwifruit is known to accelerate in the presence of low concentrations of ethylene (< 30 nL L^{-1}). These low concentrations are technically challenging to measure with the current sensor technology in the commercial coolchain environment, leading to difficulties in directly associating fruit softening to ethylene conditions. In an appropriately operated commercial environment, the most likely source of ethylene within a package is from the fruit itself or adjacent fruit that are producing ethylene. Mathematical modelling can provide guidance into the cause and effect of possible ethylene environments within a commercial packaging scenario. However, in order to develop useful models, the data for the timing and amount of ethylene production from fruit is critical. In this study ethylene production timing and rates were measured for previously long term stored SunGold™ kiwifruit. Ethylene production of individual fruit at 20 °C was measured continuously in a flow through system at ethylene concentrations of 1000 or < 10 nL L^{-1}. Firmness was also monitored non-destructively to determine the critical firmness when fruit initiated autocatalytic ethylene production. Bell curve shaped ethylene production rate data was observed for each individual fruit. The resulting data suggests that there is a firmness range when fruit dramatically increase ethylene production, although the difference in critical firmness was not significant for ethylene treated (17.00 - 28.26 m s^{-2}) and untreated fruit (18.98 - 29.04 m s^{-2}). A large variability in timing and the magnitude of kiwifruit ethylene production was identified. The total amount of ethylene produced from ethylene treated fruit (855 ± 159 pmol kg^{-1}) was not significantly different to non-treated fruit (690 ± 143 pmol kg^{-1}) nor was the maximum ethylene production rate (96 ±12.44 pmol kg^{-1} s^{-1} versus 169 ± 34 pmol kg^{-1} s^{-1}). Further data for ethylene production of kiwifruit at coolchain conditions is required to develop within kiwifruit packaging ethylene concentration models.

Early stages towards understanding the genetic basis for maintaining fruit quality at high ambient market temperatures

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Key Words: Apple, postharvest, internal browning, high temperature stress

The expansion of fresh fruit exports into countries with limited refrigeration infrastructure has resulted in quality challenges not previously seen in markets with robust cool chains. The exposure of apple fruit to high ambient market temperatures (≥30°C) directly out of cool storage significantly increases the incidence of internal browning, although this problem seems confined to one cultivar, indicating genetic susceptibility as a dominant factor. Most published postharvest studies have limited the evaluation of fruit quality to 20°C, which means there is a paucity of knowledge on the responses of fresh produce to high ambient temperatures. To advance knowledge in this area we have completed several studies investigating physiological and genetic factors affecting susceptibility to internal browning. Physiological research found that treatments that slowed ripening increased the susceptibility for internal browning, suggesting the stress response could be due to an impaired ripening process. Phenotypic data from three genetic crosses all using the susceptible cultivar as a parent found that ~25% of the genotypes produced fruit susceptible to the problem, indicating the problem is strongly influenced by genetic factors. We will use this physiological and genetic knowledge to develop novel postharvest protocols, and select future cultivars that are more resilient to high ambient temperatures.

Quality and cell wall characteristics in specialty tomatoes during extended shelf-life

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Key Words: Tomato, cell wall, quality

We have studied shelf life quality and cell wall factors associated with textural change in a grape-type and a cherry-type specialty tomato line harvested at commercial maturity for the ready-to-eat market. The typical harvest point for the grape-type line was fully red ripe (H° 42.8, Brix 9.5%), while the typical harvest point for the cherry-type line was slightly under-ripe (H° 53.4, orange/pink, Brix 5.3%), similar to large loose tomatoes. Fruit were stored for up to 4 weeks at 22°C, with high humidity (>88% RH) and were assessed and sampled weekly. Under these conditions, the visual quality was >90% flawless for both lines after 4 weeks and fruit lost <2.6% fresh weight over this time. Fruit of both lines did not soften after harvest, and this is reflected in the negligible change in most cell wall characteristics, including pectin molecular size distributions, despite slight increases in typical cell wall enzyme activities such as pectinmethylesterase and polygalacturonase. This resilience in postharvest quality is unusual in tomato fruit, and is the more remarkable because the lines reported here were picked at or close to eating ripe. Further molecular work will tell us much more about how these lines can maintain post-ripe quality.

How pre-harvest foliar potassium nitrate improved at-harvest fruit quality of 'Zesy002' kiwifruit?

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Key Words: Nutrient management, foliar sprays, nutrient uptake, photosynthesis, fruit quality

Mineral nutrients regulate photosynthetic performance of plants, for example Nitrogen (N) and potassium (K) are known to increase the leaf chlorophyll, transpiration (tr) and stomatal conductance (gs) and photosynthetic assimilation (A). The improved photosynthetic performance may translate to increased fruit size and sugar concentration. A study was conducted to evaluate how the combined application of foliar N and K effects nutrient uptake in the leaf and fruit tissues, photosynthesis, and at-harvest fruit quality. Three foliar treatments, control, Urea and potassium nitrate (KNO_3) with ten replicates in a randomised block design were used in two commercial orchards in Bay of Plenty. All foliar treatments received soil applied N and K fertilisers at similar application rate and time. Five foliar sprays were applied after full bloom through to harvest. Data was analysed statistically with the help of IBM SPSS Statistics 24 version. Treatment differences were tested at 95 % confidence interval ($P \leq 0.05$) using ANOVA. Results showed that the foliar KNO_3 significantly increased N and K concentration in the leaf and fruit tissues of 'Zesy002' kiwifruit vines compared to the foliar Urea and foliar control. The leaf chlorophyll, A, gs, and tr were also significantly increased by the foliar KNO_3 compared to other foliar treatments. The foliar KNO_3 significantly increased at-harvest fruit quality such as fruit size (137g±4.1), sugar concentration (10.71g±0.16) and fruit firmness (6.86KgF±0.11a) compared to the other foliar treatments. The fruit dry matter concentration was maintained (17.57±0.11) by the foliar KNO_3. In conclusion, the foliar KNO_3 has the potential to increase the photosynthetic efficiency and consequently, improve the fruit quality at-harvest. This understanding may potentially help to establish the canopy and increase the fruit size in other fruit crops where the small fruit size is the issue. In addition, supplementing the foliar sprays with the soil application offers a promising way to reduce the risks of N leaching and excessive vegetative growth.

Exploring the regional effect of pollinisers on fruit set and quality of 'PremP009' (PIQA™BOO™) pear

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Key Words: Polliniser, fruit set, pear, fruit quality, seed count, fruit size

'PremP009' (PIQA™BOO™) is a recently commercialised 'interspecific' pear with both European and Asian pear parentage. Growers have reported that fruit set and fruit quality (size and shape) may vary among regions in New Zealand. Previous work on 'PremP009' has suggested that pollen source (polliniser) may affect fruit set and fruit quality. Five potential polliniser genotypes were identified and tested as pollinisers of 'PremP009'. In spring 2020, pollen was harvested from these pollinisers at orchard sites in three regions (Hawke's Bay, Tasman and Central Otago). In each region, flower clusters of 'PremP009' were thinned down to two flowers; these clusters were each then either hand pollinated with pollen collected from one of the five pollinisers or left to be open pollinated. Hand-pollinated clusters were covered with pollinator-excluding mesh bags. Initial and final fruit set were recorded, and fruit were harvested at commercial maturity. At harvest, fruit were assessed for fresh weight, shape, locule number and seed development. Both initial and final fruit set varied considerably among regions and pollinisers, ranging from 31 to 100% initially, dropping to 0–68% at harvest. Low fruit set was associated with a reduced number of fully developed seeds. Polliniser and region also affected fruit size and shape, with percentage of misshapen fruit varying from 0% to 75% among regions. Overall effects were not consistent for each region or polliniser, suggesting that the most effective polliniser for 'Prem009' may differ depending on the growing region and/or seasonal weather conditions.

‘Scifresh’ apple fruit size and colour remain high as trees age in a planar cordon orchard design

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Key Words: Light interception, tree architecture, productivity, fruit size, fruit colour.

In apple orchards, yield is directly correlated to light interception. Therefore, new 2-dimensional orchard designs to increase light capture and yield are being tested. To be commercially successful, new orchard designs must also maintain or improve fruit quality, including size and red skin colour. Presently, it is unknown how narrow inter-row 2-dimensional planar cordon orchard designs modify fruit size and colour as trees age. ‘Scifresh’ trees on ‘Malling 9’ rootstock were planted in 2014 (3 m between trees) at two inter-row spacings of 1.5 m and 2 m and planar cordon tree designs (vertical and vee). A Compac Invision and weight sizer were used to quantify skin red colour and size of entire fruit populations. From years 2 to 7, fruit size declined (40–50 g) for all treatments as fruit number per tree increased. The proportion of fruit meeting export grade for red colour (≥40% red blush coverage) did not decline with tree age. In 2021 (year 7) when trees approached full canopy, 98% and 99% of fruit achieved export red colour for the 1.5-m and 2-m inter-row spacing, respectively. While fruit size decreased as the trees aged, a mean fruit weight of 164–168 g was achieved across the four treatments in year 7, higher than the commercial industry average (~160 g). We discuss the commercial implications of the measured fruit colour and size responses.

Chilling requirements of an extensive apple germplasm set based on two bud-break phenotyping approaches

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Key Words: Single-node cuttings, chilling hours, endo-dormancy

Chilling requirement (CR) is the minimum amount of low temperature (measured in chilling hours) that a bud needs to be exposed to, to overcome the physiological block called endo-dormancy. Insufficient CR negatively affects bud-break, resulting in a reduction in flowering. A warming climate may pose a threat to apple production in Hawke's Bay as the anticipated 2.5°C increase of the average winter temperature at the end of this century. Developing low chill cultivars with reduced CR to overcome endo-dormancy repression is a possible solution. Typically, CR assessments are based on bud-break in the field, a measure of the combined effect of the fulfilment of CR for endo-dormancy release and the heat requirement (HR) to overcome eco-dormancy inhibition controlled by environmental conditions. We observed bud-break in the field, complemented by a single-node cutting technique in the laboratory to specifically measure the CR for endo-dormancy release. A total of 447 genotypes, within The New Zealand Institute for Plant and Food Research Limited's apple repository held at the Hawke's Bay Research Centre, were assessed using this single-node cutting technique. A few low CR cultivars were identified by using single-node cutting technique and observing the bud-break in the field, including 'Anna', 'Ein Shemer' and *M.* ×*robusta* No. 5. Comparing data from the field and laboratory observations, enabled the CR and HR of each genotype to be determined. These data will be applied to genome-wide association studies to identify the genomic regions related to low CR.

Reflecting on light in kiwifruit orchards

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Key Words: Light interception, kiwifruit, photosynthesis, fruit quality, reflective cloth.

Typical kiwifruit vine canopy architecture can generate a large degree of self-shading, as the uppermost leaves intercept the vast majority of photosynthetically active radiation (PAR) and shade the lower layers of the canopy. Reflective cloth is a tool that can be used to reflect the light that passes through large gaps between plants, falls onto the ground and back up onto shaded leaves. The current study assessed the effects of two different reflective cloth installations (Full: reflective cloth covering the majority of the inter-row sward, and Strip: 1m wide strips of reflective cloth laid on the sward underneath the gap between male and female canopies) on fruit quality and on light distribution around the vine at two commercial *Actinidia chinensis* var. *chinensis* kiwifruit orchards (Orchard M and Orchard S). At Orchard M, both Full and Strip treatments increased the proportional changes in fruit fresh weight per square metre and dry weight per square metre by 12–17% and 5–10%, respectively, compared with a Control (i.e. grass). However, no effects of treatment on fruit quality were observed at Orchard S, despite both treatments increasing light dispersal under the canopy, compared with a Control. This difference may have been because reflective cloth at Orchard S reflected approximately half the light reflected at Orchard M, probably caused by less incident light falling onto the cloth. This study highlights the value of small increases in light distribution in a plant canopy, and indicates the potential for further improvements in kiwifruit vine architecture to optimise whole-canopy photosynthetic activity.

Crop load influences fruit quality more than canopy structure in 'Zesy002' kiwifruit

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Key Words: Fruit quality, horticulture, kiwifruit, pruning, crop load

There are diverse opinions on the best strategies for growing high quality kiwifruit in New Zealand. To investigate which orchard management factors have the greatest effect on fruit quality, a two-season multifactorial trial was established on two Actinidia chinensis var. chinensis 'Zesy002' kiwifruit orchards in the Bay of Plenty, New Zealand. The management factors tested in this trial were cane spacing (wide or narrow), pruning intensity (intensive or minimal) and crop load (high or medium). Vines with narrow cane spacing developed more leaf area early in the season, but pruning intensity subsequently became the significant driver of canopy density. Crop load did not significantly affect canopy density, but was the primary driver of fruit quality at harvest. High crop loads significantly delayed fruit maturity, and significantly reduced both fresh weight and dry matter content. High crop load vines also tended to produce fewer king and lateral flowers in the subsequent season. These results suggest that on vines with excess flowers, growers should focus their efforts on setting even crop loads in spring, therefore reducing between-vine variability and avoiding production of low quality fruit on overloaded vines.

Over-expression of a *VcMYBA* anthocyanin transcription factor in *Vaccinium corymbosum* produces dark red shoots *in vitro*

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Key Words: Blueberry, genetic transformation, *Agrobacterium tumefa*ciens, anthocyanin transcription factor, *Vaccinium corymbosum*

Blueberries (*Vaccinium corymbosum*) are rich in flavonoids, which may confer health benefits on certain cancers, diabetes, vascular diseases and neurodegenerative diseases of aging. However, in contrast to bilberry, blueberry flesh is not pigmented and does not contain the phytochemicals associated with the skin. As part of a programme to understand the molecular basis of phytochemical difference between blueberry and bilberry flesh, we have stably transformed a blueberry 'Draper' x 'Legacy' hybrid with the anthocyanin transcription factor *MYBA* from *V. corymbosum*. We genetically transformed leaf lamina explants of this hybrid, using a disarmed strain of the soil bacterium, *Agrobacterium tumefaciens*, GV3101. We noted that the transformed lines produced deep red calluses from which deep red shoots were produced. Anthocyanin content of the green control and deep red transgenic shoots were compared by ultra-high performance liquid chromatography, followed by liquid chromatography, mass spectrometry to identify the anthocyanins. Molecular analyses confirmed the presence of *nptII* and *VcMYBA* transgenes. Shoots will be rooted, exflasked, acclimated and grown to flower and fruit. We will then examine the effects of overexpression of *VcMYBA* on the anthocyanin biosynthetic pathway in the flesh of blueberry fruits. This research contributes to understanding of the genetic regulation of plant phytochemical production and why the mesocarp in blueberry fruit, and other fruit such as apples, pears and grapes, does not contain high concentrations of anthocyanins. Such knowledge can inform breeding strategies to increase phytochemicals in fruit flesh and thus improve their nutritional dietary benefits, as well as adding consumer novelty.

Evolution of Cytonuclear Coordination in *Tragopogon* (Asteraceae) Allopolyploids

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Key Words: Allopolyploidy, Cytonuclear interactions, RNA CaptureSeq, *Tragopogon miscellus*

Allopolyploidy is considered a major pathway for diversification of species and has generated many of the world's most important crops. In allopolyploids, the duplicated and biparentally inherited nuclear genomes interact with only one set of maternally inherited cytoplasmic (mitochondrial and plastid) genomes, which results in an altered cytonuclear stoichiometry. However, cytonuclear genome interactions in allopolyploids remain underexplored. Synchronization between nuclear and cytoplasmic genomes is essential for regulation of important developmental processes, such as respiration and photosynthesis in plants, and thus is an important aspect to allopolyploid genome stability. The aim of this study is to determine how these potential genome imbalances hinder or aid speciation in allopolyploids. In this project, we are employing RNA CaptureSeq to examine expression differences in *Tragopogon miscellus* allopolyploids. These are young, naturally occurring allopolyploids that have formed multiple times, including reciprocally. Using the parental *T. dubius* draft genome, we developed probes for ~310 loci involved in nuclear-mitochondrial and nuclear-plastid complexes. We also used annotated genomes of *Arabidopsis thaliana* and *Lactuca sativa* to determine protein coding sequences. The gene expression data from RNA CaptureSeq experiment will be presented. As these allopolyploids formed recently and recurrently, they offer a window into the potential for repeated evolution of cytonuclear coordination. Using this model system, we will be able to determine how organellar and nuclear genomes coordinate to facilitate speciation in plants.

Stable genetic transformation of *Papaver somniferum* increases capsular morphinan alkaloid concentrations

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Key Words: Opium poppy, benzylisoquinoline alkaloids, stable genetic transformation

Opium poppy (*Papaver somniferum* L.) produces a large number of important medicinal compounds in the morphinan alkaloid class, including morphine, codeine, thebaine and oripavine. Genomic tools have allowed the recent identification of several genes involved in the biosynthesis and regulation of the benzylisoquinoline alkaloid pathway in opium poppy. We produced numerous lines of stably transformed poppies of three chemotype x gene of interest (GOI) combinations. Capsules were collected and freeze dried from 25 'Tasman' salutaridinol-7-O-acetyl transferase (*SaLAT)* lines, 12 'Tasman' codeinone reductase (*Cor*) lines and 18 'Ted' *SaLAT* lines. Codeine and thebaine concentrations in the capsules were analysed by ultra-high performance liquid chromatography-high resolution mass spectrometry. Four transgenic T_0 lines of 'Tasman' *SaLAT* had capsule concentrations of thebaine higher than those of any non-transgenic lines. One transgenic T_0 line of 'Tasman' *Cor* had a capsule codeine concentration greater than those of any wild-type lines. Reverse transcriptase PCR results on the expression of *SalAT* or *Cor* in four T_1 seedlings lines from each of the three GOI-chemotype combinations were conducted. These results show that GOI transgenes were stably inherited and transgene expression continued in the second generation. Survival of T_1 seedlings of fourteen lines from the three GOI x chemotype combinations was tested on phosphinothricin (PAT) selection media. Most seedlings survived, which suggests that multiple copies of the PAT/*bar* selectable marker transgene were inserted at two or three independent loci. Further investigations of the morphinan concentrations in capsules of all T_1 plants in both glasshouse and field trials are warranted.

Understanding Pollen Abortion in Female Kiwifruit

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Key Words: Plant reproduction, kiwifruit, dioecy, pollen, anther development

Kiwifruit (the genus *Actinidia*) is unusual amongst crop plants in that it is dioecious, meaning there are separate male and female plants. The dioecious nature of kiwifruit reduces breeding efficiency and impacts upon commercial production as growers must dedicate orchard space to non-fruiting males.

Sexuality in kiwifruit is controlled by two genes in an approximately 0.5 MB male-specific sex-determining region (SDR). One of these genes, known as *Friendly Boy* (*FrBy*), encodes a fasciclin-like arabinogalactan protein (FLA) and has been shown to be crucial for male fertility. The absence of FrBy in female kiwifruit causes delayed programmed cell death (PCD) of the nourishing tapetal cell layer of the anther, resulting in pollen sterility. However, the mechanism by which FrBy acts to sustain pollen development in male kiwifruit is unknown.

By performing low-input RNAseq on single male and female kiwifruit anthers and their isolated meiocytes/microspores at key developmental stages, we have developed an overview of gene expression throughout the early steps of male reproductive development in kiwifruit. Further, by analysis of differential gene expression between sexes, we identified a male-specific upregulation in peroxidases and other redox-related genes. We therefore propose a model for FrBy function, whereby it acts as an indirect inducer of a tapetal reactive oxygen species (ROS) burst that is essential for precise execution of PCD.

Understanding the role FrBy plays in anther development will increase understanding of the role of FLA proteins in signalling pathways, and may guide the development of hermaphroditic kiwifruit capable of self-fertilization.

Nitrous oxide and ploidy changes in a model crop

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Key Words: Nitrous oxide, whole genome duplication, ornamental plants, autotetraploid

Limonium is an herbaceous perennial plant used as ornamental worldwide and with potential to be used as a model crop. Breeding is currently constrained by a low hybridisation rate and hybrid sterility. Polyploidy is used to restore fertility in these hybrids, typically adding a year to any hybridisation program. The induction of whole genome duplication (WGD) through the treatment of zygotes during their early development with nitrous oxide (N_2O) was explored as an alternative strategy to somatic doubling of *in vitro* plants to address those constraints. Intraspecific crosses between *L. sinuatum* plants were conducted on each of 10 consecutive days before the pollinated flowers (on plants) were treated with N_2O in a pressure-tolerant cylinder. A month after the pollination, the embryos were rescued and grown in tissue culture, with the ploidy confirmed by flow cytometry, combined with morphological evaluation within the same growing season as the crosses were conducted. Application of N_2O for 48 hours induced WGD when it was applied between three and five days after pollination. In comparison with their diploid counterparts, tetraploid plants showed pollen grains that were 1.2 times larger, guard cells that were 1.4 times longer, and with 0.6 times lower stomatal density. At flowering tetraploid plants had a stem diameter that was 1.4 times larger than that of those from diploid progeny, 1.5 times greater leaf thickness, and 1.6 times leaf area. We conclude that the production of tetraploid *Limonium* plants using N_2O shortly after pollination creates new opportunities to speed increasing germplasm diversity.

Automated identification of blueberry flowering buds using RGB-depth cameras

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Key Words: Deep learning, image augmentation, precision horticulture, plant phenotyping, *Vaccinium*

Bud initiation is a critical growth stage for blueberry (*Vaccinium* spp.) plants. The generative buds produce clusters of flowers which will later develop into fruit. The number of generative buds prior to full bloom can be used as an indicator for flower estimation and ultimately crop yield. Manual bud and/or flower counting is labour intensive, prone to error and can potentially cause mechanical damage to plants. Non-destructive techniques have been utilised to help with on-orchard plant monitoring and growth measurements. RGB-depth (RGB-D) sensors are a recent development which can acquire colour and spatial data of the plant object in real-time. Aside from the low cost and high portability of the device, the resulting data can easily be integrated with advanced modelling techniques to enable the development of prediction models for rapid detection and screening purposes. The aim of this work is to investigate the feasibility of these cameras to provide a means of blueberry bud and flower identification through appropriate image analysis techniques and the development of deep learning models. RGB-D images of blueberry plants were captured at multiple time points between August and December 2020. Image augmentation was utilised to increase sample size. A deep learning architecture was utilised for supervised learning to develop classification models which can automatically identify and quantify blueberry bud and flowers from the plant at an overall accuracy of approx. 90%. Automated quantification of flowering buds in real-time can enable non-destructive monitoring of plant growth and prediction of fruit number and crop load in order to assist with orchard practices.

Non-powered cool storage solutions

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Key Words: solar, off-grid, smallholder, perishable, India

An inexpensive, off-grid, batteryless, cold storage system is needed for perishables to support smallholder farmers in developing countries as the first link in the cool chain. We found evaporative cooling, on its own, was not sufficiently effective and had variable performance throughout the year. This led us to develop an off-grid, batteryless, solar powered refrigeration system we term the Pusa Farm SunFridge (Pusa FSF). Developed at by IARI in collaboration with MSU and with funding from USAID, the Pusa FSF is cooled by combination of solar refrigeration and evaporative cooling. The structure can be self-built, although it employs unique materials for construction. A mini split inverter air-conditioner (AC) supplies refrigeration and a specialized inverter supplies power directly from solar panels without the need for batteries or a grid-tie. The evaporator coil shunts cooling to a thermal reservoir suspended from the ceiling in the cold room, which provides a highly energy-efficient and low cost means of cooling at night, thus replacing batteries. A blower/evaporator unit cools the room during the day, but its sensors are replaced to enable operation of the coil near 0 °C. A pyranometer, placed on roof, is used to sense solar intensity and reduce the demand of the AC compressor when sunlight is low.
A loaded room approaches a minimum of 4 °C during the daytime when the ambient temperature is near 40 °C and nighttime temperatures range from 6 to 10 °C when the ambient is approximately 30 °C.

Posters


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NZ Society Plant Biologists
NZ Institute Agricultural & Horticultural Science
PLANT SCIENCE
CENTRAL

P1

The Role of DUF247 in Ryegrass Self-Incompatibility

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Key Words: Plant breeding, self-incompatibility, ryegrass.

Abstract

Manipulation of a plants innate ability to inbreed or outcross is often crucial to improving outcomes in crop breeding programs. Inbreeding is useful to fix desirable or purge deleterious traits, while outcrossing allows introduction of genetic variation and heterosis. Perennial ryegrass (*Lolium perenne*) is a plant which has both male and female reproductive structures but is an obligate outcrossing species due to self-incompatibility (SI). Ryegrass possesses an SI system governed by two loci, *S* and *Z*, where fertilisation is inhibited when the *S* and *Z* alleles are matched in both the pollen and stigma. Evidence suggests that a *Domain of Unknown Function 247 (DUF247)* is the gene encoding the male component of SI at the *S* locus in ryegrass. It is also hypothesised that *DUF247* could be the female component of SI at the *S* locus, suggesting two DUF247 proteins may form a homodimer to trigger the SI response. This research aims to test the hypothesis by investigating DUF247's subcellular localisation, expression in reproductive tissues, allelic variation and potential to form dimers. Characterising the genes involved in the reaction will provide future opportunities to manipulate SI for improvement of ryegrass breeding programs, such as by generation of F_1 hybrid crops that display uniform traits and benefit from heterosis.

P2

Antioxidant Nutrients Evaluation of Hass Avocado By-products Extracts

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Key Words: Avocado by-products, antioxidant capacity, procyanidin B_2

Avocados are consistently the third-largest horticultural export from New Zealand (NZ). 'Hass' is the most dominant cultivar of avocado grown in NZ primarily for fresh fruit export. The utilization of avocado seed and peel could lead to a reduction in waste disposal costs and added-value products. Furthermore, the phytochemicals in NZ avocado by–products have not been extensively studied. Therefore, this study explores the antioxidant properties of NZ 'Hass' avocado by-products. The total antioxidant capacity was evaluated by 2,2′-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) assays, and the procyanidin B_2 content was investigated by high–pressure liquid chromatography (HPLC). Using flash chromatography two fractions were created based on polarity, the low polarity (FLP), and high polarity fraction (FHP). The FLP of the ripe peel had the highest ABTS scavenging capacities (93 ± 0.05%). Procyanidins may be the main phenolic compound in avocado by-products to provide antioxidant capacity. However, HPLC studies indicated that procyanidin B_2 is not the major procyanidin in NZ 'Hass' avocado that contributed to the antioxidant capacity. A further study of major antioxidants in NZ 'Hass' avocado by-products is needed. So far, according to the chemical characteristics of 'Hass' avocado by-product, the present study showed that the non-edible parts of the avocado (seed and peel) could be used as a phenolic source in food manufacturing to improve the antioxidant ability of nutraceuticals.

P3

Functional characterisation of candidate genes modulating anthocyanin biosynthesis in *Vaccinium*

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Key Words: Anthocyanin, anthocyanidin synthase, blueberry, bilberry, chalcone synthase, phenylalanine ammonia lyase, transient expression

Blueberries (*Vaccinium* spp.) are rich in anthocyanins, a major group of red-blue plant pigments with many health benefits. In cultivated blueberries, anthocyanins are found in the skin (10% of the fruit) while absent in the flesh. Compared with the skin, transcript abundance of anthocyanin biosynthesis genes is significantly lower in blueberry flesh. Three key enzymes (phenylalanine ammonia-lyase, chalcone synthase and anthocyanidin synthase) are hypothesised to be the bottlenecks of anthocyanin production in blueberry flesh. In contrast, undomesticated bilberries produce anthocyanins in both skin and flesh with the three candidate genes highly expressed in both tissue types. These three candidate genes from bilberry show high identity to their blueberry orthologues (96–99%) and were cloned to functionally characterise and study their concerted action for anthocyanin production. To assess the functionality of cloned genes, in vitro enzyme assays were performed. In vivo transient expression assays were carried out in tobacco and fruits to test the effect on anthocyanin production of transfecting genes encoding each enzyme alone and in combination. The outcome of this project will improve our understanding of anthocyanin production in *Vaccinium* and inform future breeding schemes for generating more nutritious and high-value blueberry products.

P4

Identification of metabolites associated with good and bad potato flavour

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Key Words: Potato, sensory, metabolomics, flavour

Flavour is a key determinant in consumer decisions to purchase fruits and vegetables. Potato flavour is considered mild compared with the flavour of most fruits and vegetables, and there is limited evidence that consumers can distinguish or describe potato flavour, despite global potato production being around 380 million metric tonnes annually. A metabolomics approach to breeding potatoes with desired flavour may increase market share; however, relatively little is known about what metabolites contribute to potato flavour, both good and bad. In previous consumer-driven research we have established a desired flavour 'map' for potato; we now seek to understand what metabolites are associated with desired or off-flavours. Thirty-four potato lines/cultivars, including several commercial cultivars and potato breeding lines, were grown at Plant & Food Research (PFR) Lincoln, and transported to PFR Palmerston North for testing. It was noted that aspects of the growing season resulted in stress, giving us the opportunity to explore the effects of plant stress on sensory flavour profiles. Each line/cultivar's metabolome was determined using LC-MS and GC-MS. The flavour results of benchtop assessments from each line/cultivar by a group of experienced potato tasters were aligned with the metabolomics profiles to identify potential compounds associated with interesting or novel flavours, both good and bad, and those associated with plant stress. This knowledge will help inform the results of our upcoming consumer trials on potato flavour and inform PFR's potato breeding programme to help develop potato cultivars with desirable flavour.

P5

Assessing the impact of self-fertility in ryegrass

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Key Words: Self-fertility, inbreeding, heterozygosity, ryegrass

The ability to inbreed plants is an important aspect of plant breeding as it provides the ability to purge deleterious alleles and fix beneficial traits. In species where self-pollination can occur, high performing inbred lines can be developed with selected traits. These inbred lines can then be crossed to create F1 hybrid varieties that benefit from heterosis; plants are more vigorous than either parental line. However, in self-incompatible (SI) species that rely on outcrossing, selection is done at a population wide level making it difficult to select for individual lines with desired traits. *Lolium perenne* is a key forage crop in NZ that has a two-loci SI system (*S* and *Z*) that generally prevents self-pollination. The inability of *L. perenne* to self-fertilise means it cannot fully exploit heterosis, which has led to lower genetic gains compared to other self-compatible (SC) grass crops such as maize. It is not uncommon for SI to be overcome, and although a rare event in 2-loci systems, there have been three independent SC *L. perenne* populations identified that can inbreed. A causal self-fertile (*SF*) locus has been mapped and shown to act separately from the *S* and *Z* loci, enabling pollen containing the locus to self-fertilise. In this project we have introgressed the *SF-locus* from European germplasm into elite NZ germplasm and are using Genotyping-by-Sequencing (GBS) to assess the reduction of heterozygosity and concurrent phenotypic impacts of inbreeding in *L. perenne*.

P6

The response of three banana hybrids to drought and simltaneous drought and pathogen stress

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Key Words: *Musa spp*, Genome, Hybrids, Polyploids, Effectors

The edible banana (*Musa* spp) emerged out of South East Asia as *inter* and *intra* specific hybrids; polyploids of diploid parental types, *Musa acuminate* Colla (A genome) and *Musa balbisiana* Colla (B genome). Research indicates that parthenocarpy evolved in the A genome prior to these hybridization events and that the B genome contributes improved resistance to biotic and abiotic stresses. Bananas, under natural and cropping systems, are continuously challenged by abiotic and biotic stresses. Drought and the fungal pathogen, *M. fijiensis*, were identified as main abiotic and biotic stress factors, respectively, that limit plant growth and yield. Under natural growing systems, plants are seldom exposed to just a single stress factor. Plants exposed to simultaneous abiotic and biotic stress exhibit complex stress responses. The outcome of this combined stress may result in positive or negative effects on plants. This research project seeks to elucidate different stress response pathways in three distinct banana hybrids -- specifically AAA, AAB, and AAAB, and to determine the contribution of the B genome to drought and *M. fijiensis* stress adaptation. Banana plants of different genomic compositions were propagated through tissue culture, and drought stress conditions were forced on the cultured plantlets. The stress response is being evaluated by monitoring morphological, physiological and gene expression parameters. To mimic pathogen stress, *M. fijiensis* effectors will be imposed and analysed. Understanding the stress-response pathways of different banana genotypes will provide insight and tools for selection and breeding of drought and *M. fijiensis*-tolerant varieties.

P7

Stable transformation of *Solanum muricatum* with a *MYBA* anthocyanin transcription factor from *Vaccinium corymbosum* produces fruit with purple skin and flesh

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Key Words: Pepino, blueberry, genetic transformation, *Agrobacterium tumefa*ciens

Pepino (*Solanum muricatum* Aiton) is a small, diploid (2n=24), subtropical, perennial shrub in the potato family. The fruit are generally have a skin (exocarp) which is yellow with purple stripes, although purple skinned cultivars exist. The flesh (mesocarp) is yellow in all cultivars though. The fruit are grown commercially in Southern and Central Amercia, Japan, Kenya and Australia. Pepino is a useful model fruit crop with a short life cycle and is relatively easy to genetically transform. The genomes of its closest relatives, tomato and potato, have already been sequenced, which helps further molecular research. We therefore used pepino to test anthocyanin MYB transcription factors and how they affect traits such as the colour of fruit flesh. In this study we genetically transformed etiolated hypocotyl explants of ‘El Camino’, using a disarmed strain of *Agrobacterium tumefaciens*, GV3101. We engineered the T-DNA of a pART27 binary vector to house a *VcMYBA* anthocyanin transcription factor from blueberry and a neomycin phosphotransferase II (*nptII*) selectable marker. We produced numerous transformed lines and assessed their fruit phenotypes in comparison to regeneration control lines. Some VcMYBA lines had increased anthocyanins in the fruit exocarp and mesocarp layers. Anthocyanin content was analysed by ultra-high performance liquid chromatography followed by liquid chromatography, mass spectrometry to chemically identify the anthocyanins. This research contributes to understanding why the mesocarp in pepino fruit and other fruit such as blueberries, do not contain anthocyanins. Such knowledge can inform breeding strategies in fruit with colourless flesh to improve nutritional dietary benefits.

P8

Changes in lycopene content in powdered Red (‘Merlice’) and Orange (‘Moonglow’) tomatoes during freeze-drying and long-term storage

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Key Words: Freeze-dry, lycopene, nitrogen, storage

The carotenoid lycopene is responsible for the characteristic colour of tomatoes. It is sensitive to heat, light, and oxygen which affects bioavailability. Lycopene exists in two isomeric forms: all-*trans*- and cis-. Red tomatoes like ‘Merlice’ contain >90% lycopene in all-*trans*- form; orange heirloom ‘Moonglow’ tomatoes contain >90% lycopene as *cis*-isomers. We evaluated changes in lycopene content in ‘Merlice’ versus ‘Moonglow’ tomatoes after freeze-drying and storage at -20^{0}C in aluminium foil bags with or without nitrogen flushing for up to 90 days. Dry matter content of ‘Merlice’ (5.9%) was significantly lower ($p<0.001$) than ‘Moonglow’ (7.0%) tomatoes. ‘Merlice’ and ‘Moonglow’ contained 16.1 and 11.7 mg lycopene /100 g fresh weight equivalent respectively. Lycopene content reduced to 10.9 (‘Merlice’) and 9.3 (‘Moonglow’) mg/100 g after freeze-drying. Lycopene content in tomato powder continued to decrease dramatically during storage with only 18-35% lycopene remaining after 90 d. Overall there was no significant difference in the stability of *cis*- and *trans*- lycopene in long term storage ($p>0.05$). Nitrogen flushing was effective in reducing lycopene loss at 60 d in both tomato varieties ($p<0.05$) but the benefit from nitrogen did not continue to 90 d. We conclude that both freeze-drying and long-term storage reduce the content of cis- and *trans*-lycopene in freeze-dried tomato powder, and storage under nitrogen can partially mitigate this loss.

P9

Exploring the transcriptome basis of cold tolerance signals of grafted apple stem vasculature using RNA-seq workflow

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Key Words: RNA-seq, cold tolerance, apple

Cold tolerance is an essential factor for perennial trees not only to overwinter but to prepare the annual growth properly. Apple (*Malus* × *domestica*), as one of main fruit crops covering a large portion of world fruit industry, endure cold temperatures by entering/releasing the state of dormancy during the winter. In grafted apple trees, the cold tolerance of scion is influenced by that of rootstock. However, little is known about molecular mechanisms underlying their signals. To understand this further, we conducted transcriptome analysis on stem vasculature of grafted apple trees sampled over the winter. A total of 48 RNA-seq libraries were established using Illuminar Novaseq 6000 platform, 691 differentially expressed genes (DEGs) were commonly detected with a criteria of |fold change| greater than 1.5 and false discovery rate (FDR) less than 0.05 between 14,737 rootstock and 1,261 scion DEGs. The expression dynamics of scion DEGs were further categorized into different groups representing seasonal flow after filtering of highly correlated 552 DEG set based on Pearson correlation analysis. To validate the tissue-specific signals, DEGs were validated by detecting single nucleotide polymorphism (SNP) variants using CLC genomics workbench 21 software. Our results provide the potential candidates of rootstock-derived genes which may mediate the signals for cold tolerance in scion. However, further research needs to be investigated.

P10

Characteristics of a ‘PremA96’ apple skin disorder

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Key Words: Apple skin disorder postharvest ‘PremA96’

Malus domestica ‘PremA96’ apples are most prone to shrivel, a skin disorder affecting the stem end. The standard handling procedure to control this issue is to identify high risk lines and to limit water loss during storage, systems that are providing positive results. Other postharvest issues that seldom arise include lenticel breakdown disorder and a second form of shrivel that affects the body of the apple, not just the stem bowl. However, in 2020, ‘PremA96’ apples presented with a new, previously unknown postharvest skin disorder. Symptoms appeared in apples that had been removed from long-term storage and following grading and packaging without any noticeable symptoms, but once arriving at their destination, showed what was described as a “hammered skin” appearance. Samples from these fruit were analysed for weight loss, fruit firmness, internal ethylene and total soluble solids. A dye infiltration test was done to visualise any breaks in skin waxes. Apples displaying severe symptoms of hammered skin were softer, had higher internal ethylene concentrations and lower soluble solids content than unaffected apples. Dye infiltration tests showed that the lenticels were not more porous than unaffected apples. The cause of the disorder is still open to speculation.

P11

Measurement of density, for the determination of dry matter and brix

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Keywords: Kiwifruit, DM, brix, density

Dry matter (DM) is an important quality parameter for kiwifruit. Accurate estimation of DM is essential to the kiwifruit industry. For many types of produce there is a strong correlation between density and dry matter, which can be exploited to predict dry matter when the density is known. Similar correlations often exist between density and brix. However, these relationships have not been explored for red kiwifruit. In this study This study was carried out utilizing 312 fruit that represent 8 count sizes of 3 different grower lines. The volume, density, dry matter and brix of each red kiwifruit were measured and the relationship between density to dry matter and brix are reported. The usefulness of utilizing density for predictive purposes of other fruit properties will be discussed.

P12

Genetic technologies for developing F1 hybrid ryegrass

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Key Words: Perennial Ryegrass, Brachypodium distachyon, transformation Agrobacterium tumefaciens, F1 hybrid, hybrid vigour

Ryegrass is the primary pasture crop in New Zealand; however, despite this importance, gains in yield through conventional breeding have been marginal. Other significant crops, mainly maize and rice, have benefited from hybrid breeding programmes whereby heterosis has been exploited. Ryegrass presents many challenges to breeders wishing to produce F1 hybrid progeny on a large scale, such as self-incompatibility, inbreeding depression, and a lack of genetic tools for creating and maintaining male-sterile lines for crossing. Many of these challenges have been overcome in other species, providing a basis for addressing them in ryegrass.
We have been developing genetic technologies to allow the adoption of an F1 hybrid system based on the maize Seed Production Technology (SPT). This system involves the use of transgenic plants to produce the parental lines, but both the seed producers and farmers would grow plants lacking the transgene (i.e. null segregants). To optimize this system for ryegrass, we have established methods for transformation for the model grass Brachypodium (*Brachypodium distachyon*) and ryegrass. Using these methods, we are testing the key components of the SPT – markers for sort transgenic vs non-transgenic seeds, prevention of transgene spread through pollen, and reversible male sterility. To generate the male-sterile mutants needed for the SPT system, we are using gene editing.

P13

Expression of the *GUSA* reporter transgene from *Escherichia coli in various organs of stably transformed Solanum muricatum*

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Key Words: β-glucuronidase, pepino, *Agrobacterium tumefaciens* transformation

Pepino (*Solanum muricatum*), also known as pepino dulce, which means sweet cucumber in spanish, is a perennial shrub in the Solanaceae family. It is grown commercially around the world in regions such as South America, Australia, Africa and New Zealand. It can be rapidly grown from seed or cuttings and can flower and fruit in 6 months. It has a diploid genome and genomic information is known from its close relatives, potato and tomato. These attributes mean that pepino is a useful model plant to further our understanding of the molecular basis of various horticultural traits. We genetically transformed pepino with *Agrobacterium tumefaciens* strain EHA105 using the pMOG410 binary vector. This houses the *gusA*-intron reporter transgene under control of a 35SCaMV constitutive promoter and a *nptII* selectable marker under control of the *nos* promoter. We generated 20 independent transformants and confirmed the presence of the *gus*A and *nptII* transgenes by PCR analysis. *In vitro* material was GUS assayed and 75% of these lines were GUS positive. We then exflasked eight GUS-positive lines and grew these to flowering and fruiting in a containment house. The various organs of the mature plants were GUS assayed again. We found *gusA* expressed in the shoot apex, leaf lamina, flower stamens and style, fruit mesocarp, locules and seed of the endocarp. These results mean we can transform pepino with genes of interest to understand key consumer traits in fruit, such as nutritional content, flesh colour, shelf life and flavour.

P14

Gene duplication fate in a genetic pathway context: An examination of the plant epidermal cell fate pathway in the allopolyploid genus Pachycladon (Brassicaceae)

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Key Words: Polyploidy, homeologs, genetic pathway, *Brassicaceae* trichome initiation pathway, *Pachycladon*, Allopolyploid

Polyploidy or whole genome duplication is an important evolutionary force driving plant diversification and speciation. Although polyploidy has become a major research focus, the fate of duplicated gene copies or homeologs included in a genetic pathway remains understudied. The expression patterns of homeologs in regard to their maternal and paternal origins, and homeolog fates associated with gene attributes such as pleiotropy and epistasis within a genetic pathway system continue to be important lines of research. A well annotated conserved genetic pathway such as the *Brassicaceae* trichome initiation pathway is a good candidate to study the fates of individual genes in a genetic pathway. To this end, the New Zealand alpine allopolyploid "*Pachycladon*" genus is an ideal study system. It is a genus that originated from an ancient hybridization event of highly diverged parental lineages followed by polyploidy and rapid diversification. In addition, it is closely related to the model *Arabidopsis thaliana*. Our research aims to analyse the molecular evolution of the *Pachycladon* trichome initiation pathway with regard to its homeologs from the core genes in the pathway. This is fulfilled by isolating sequences from gene homeologs, reconstructing their ancestral parental pathways by phylogenetic analysis, performing gene expression experiments for homeolog differential expression and analysis. This work will result a comprehensive examination of patterns of post-duplication molecular evolution in a genetic pathway context.

P15

Hass avocado yield estimation viability using machine vision

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Key Words: Avocado, estimation, counting, machine vision

The avocado is the green celebrity of the fruit world with exports more than doubling since 2006. Quantitative crop estimation is a critical piece of information in a horticultural supply chain, as it heavily dictates planning of harvest timing, labour, and marketing. Like all fruit crops, the avocado industry has a need to estimate their harvest volume each season. And so forms the question many growers ask; how can they accurately estimate their harvest? However, factors like the close colour matching of the fruit with the canopy and the large size of the production trees create some challenges for crop estimation. This work provides a review of methods for on plant fruit yield estimation (counting and sizing) that have been explored for avocado and similar fruit industries. Technological solution options were rated using a weighting matrix that considers accuracy, availability, cost and relevance in order to identify technologies that are most suited to further development. Future work will look to develop a technology that will assist in yield estimation for avocado.

P16

Why do some fruit store for longer than others? Do oxidative processes play a role?

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Key Words: long-term storage, oxidative stress, kiwifruit

While some Gold3 kiwifruit show disorders after long term storage such as chilling injury and can become very soft resulting in non-saleable fruit, other Gold3 fruit can show few symptoms of disorder and remain firm, even after extended periods of storage. Reductions in antioxidant activities and increased production of reactive oxygen species (ROS), leading to oxidative stress, are known to play roles in the development of postharvest disorders such as chilling injury. This raises the question, do fruit that store for a long periods of time that retain good quality and do not develop disorders have greater antioxidant capacities, that can provide protection against oxidative stress, compared to fruit that do not store well? Differences in oxidative damage and antioxidant metabolism between good and poor quality fruit, stored for extended periods of time, are compared and discussed to address the above question. Understanding what factors contribute to the differences occurring in fruit stored for long periods of time may lead to the development of oxidative biomarkers as a way of identifying fruit that are more susceptible to developing disorders during long term storage.

P17

Hayward kiwifruit responses to modified atmosphere packaging

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Key Words: *Actinidia deliciosa*, postharvest, fruit quality, firmness, MAP

Passive modified atmosphere packaging (MAP) that elevates the concentration of carbon dioxide (CO_2) and reduces the concentration of oxygen (O_2) is used commercially to extend the storage life of fresh produce. Softening is a key quality determining attribute in kiwifruit (*Actinidia deliciosa*) storage. It has been demonstrated that MAP can retain kiwifruit firmness during cool storage. However, the responses of kiwifruit to MAP during room temperature storage after cool storage remains unknown. The aim of this study was to determine if the advantageous delay in kiwifruit softening caused by MAP use in cool storage is maintained during subsequent room temperature storage. 'Hayward' kiwifruit were stored in either polypropylene box liners (control) or commercially sourced polylactic acid modified atmosphere bags (MA) and stored at 1 °C for 5 weeks. After cool storage fruit were allocated to one of three shelf-life bag types: perforated bag, non-perforated bag, and non-perforated bag with ethylene scavenger. Bags were then stored at 20 °C for up to 10 days. The resulting gas composition in MA at 1 °C was 12-15% O_2 and 3-4% CO_2, and that in non-perforated bags at 20 °C was 12-16% O_2 and 7-10% CO_2, respectively. Kiwifruit stored in MA had a higher firmness (2.9 kgf) in comparison to control (2.0 kgf) after 5 weeks of cool storage. This difference remained in the subsequent room temperature storage. At the end of the 10-day shelf life, fruit firmness following cool storage in MA was 2.1-2.3 kgf, while that in control was 1.5-1.6 kgf, irrespective of the shelf-life bag type or ethylene scavenger. This study demonstrates that MAP delays kiwifruit softening in cool storage, and this benefit is maintained during the subsequent shelf life, however applying MAP at room temperature with or without ethylene scavenger does not have a significant impact on maintenance of kiwifruit firmness.

P18

The “how to” guide for molecular breeding of High Metabolisable Energy GM ryegrass

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Key Words: High Metabolisable Energy, Ryegrass, lipids, breeding, plant biotechnology

Ryegrass (*Lolium perenne*) is an obligate outcrossing, wind pollinated, vernalization requiring, long day, pasture species. None of these characteristics make it “user friendly” when it comes to plant breeding and all of these characteristics make it very challenging when it comes to plant biotechnology. Using various molecular and controlled seed production techniques we have developed a robust system for rapidly breeding genetically modified High Metabolisable Energy (HME) ryegrass to a homozygous state, thus stabilising the transgene and allowing for phenotyping something that is close to approaching the desired product. The poster describes the individual steps from generating T0 ryegrass through to the homozygous state using examples from our HME lines to highlight the process.

P19

Understanding Peptide Hormone Signalling: a functional analysis of plant peptide-receptor interactions

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Key Words: Nitrogen uptake, CEP, root architecture, interactions

Nitrogen demand signalling in plants is critical for the control of plant growth and crop yield in heterogeneous nutrient environments. In order to mitigate the environmental and social costs of synthetic nitrogen fertilizers, the current method of increasing crop production, we are interested in understanding how we can use endogenous plant nitrogen uptake pathways to increase their nitrogen uptake and utilization. Small systemic messenger peptides known as CEPs (C-terminally Encoded Peptides) have been shown to regulate nitrogen uptake machinery when expressed under nitrogen-limited conditions, driving highly specific plant growth and root architecture phenotypes. To understand how CEPs interact with their receptors CEPR1 and CRA2 in *Arabidopsis thaliana* and *Medicago truncatula* respectively, we aim to set up a fluorescent ligand screen to assess binding affinity of CEPs and other peptides. By comparing the biochemical properties of effective and ineffective ligands, we hope to identify molecular features that drive peptide/receptor binding. Additionally, identifying downstream components of the signalling pathway through protein interaction studies will help us better understand how nitrogen demand signalling is regulated at the molecular level. Finally, to further understand this process, we aim to create a gain-of-function chimeric CEPR1 receptor that can activate the nitrogen uptake pathway even in the absence of ligand.

P20

Intraspecific differences in the transpiration rates of white clover in drying soil

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Key Words: White clover, drought, water stress, stomata, transpiration, soil water.

White clover is a key component in New Zealand's pastures, where it is increasingly exposed to periods of drought. To avoid desiccation stress, plants use stomatal closure to decrease transpiration rates and water loss. This study utilised the large degree of intraspecific variation within white clover to examine drought-induced differences in transpiration. Eighty white clover cultivars that had been released over nine decades were exposed to drying soil conditions in the glasshouse. The fraction of transpirable soil water (FTSW) was used as an expression of daily soil water content. FTSWc was measured as the critical point where stomata showed incipient closure and after which transpiration decreased linearly. We identified white clover cultivars with increased FTSWc under drought and changes in their drought avoidance strategy over time. The findings demonstrate intraspecific differences in stomatal responsiveness to drought in white clover that can be utilised for plant improvement in a warming climate that is increasingly characterised by water shortages.

P21

Characterization of Candidate Genes Associated with Onion (*Allium cepa* L.) Bulb Formation

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Key Words: AcFKF1, Bulb Formation, Onion, Transcriptome

Onion (*Allium cepa* L.) is the most important *Allium* vegetable crop grown globally. Photoperiod requirement to initiate bulbing varies widely among different onion cultivars. The mechanism by which onion bulb formation occurs has not been elucidated yet. However, transcriptome analysis indicates that genes involved in the responses to photoperiod, such as the circadian-clock output gene *FLAVIN-BINDING, KELCH REPEAT, F-BOX1 (FKF1)* and the floral signal gene, *FLOWERING LOCUS T (FT)*. Two onion *FT* genes control bulbing (*AcFT1 and AcFT4*), while the *AcFT2* gene controls flowering.

Experiments to identify the genetic basis for the differing photoperiod requirement of short-day (SD) and long-day (LD) onion varieties suggests that allelic variation in *AcFKF1* might be involved. Sequence analysis of *AcFKF1* from 29 SD and 31 LD onion varieties showed that there are five SNPs in the exon that constitute an amino acid change in the AcFKF1 protein. These SNPs were found to be highly variable among the onion accessions analyzed. A more prominent haplotype was found in the SDs compared to the LD onions. However, further experiments need to be conducted to test the correlation of these polymorphisms to the bulbing phenotype of the varieties. Genetic transformation strategies are being developed in onions to enable the functional characterization of bulb formation genes.

Overall, this study will help to identify bulb formation genes, their regulatory mechanism in response to daylength, and their role in the adaptation of onions. This knowledge will be useful to ongoing molecular research and breeding strategies aimed at improving onion cultivars.

P22

In vitro multiplication of *Juniperus communis* L. from shoot tip explants– preliminary findings

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Key Words: Common juniper, shoot regeneration, tissue culture, micropropagation

Juniperus communis L., also known as common juniper, is a widely spread woody plant species whose berries are the key ingredient for gin production. Although there is high demand on juniper berries for gin production, New Zealand gin makers rely on imported juniper berries at present. Establishing a juniper cropping system locally could ease supply shortage and create a unique selling-point for 100% NZ origin gin. This study aims to develop rapid micropropagation procedures for *J. communis* as an alternative to low efficient and slow seed propagation. Shoot multiplication on three types of basal media supplemented with four concentration of 6-benzylaminopurine (BAP) was studied. The preliminary results from two multiplication cycles showed that different combinations of basal media and BAP concentration significantly affected the survival and browning of explants. While BAP supplementation induced the growth of new axillary shoot, high concentration of BAP reduced axillary shoot length and led to tissue browning and even shoot necrosis. The results of this experiment provide a foundation for further studies on the optimal micropropagation protocols for *J. communis*. The development of *in vitro* regeneration systems using explants excised from mature juniper trees will also enable the establishment of *in vitro* germplasm collection of common junipers in New Zealand, which is beneficial for breeding and genetics studies. Ongoing work with more genotypes over more multiplication cycles as well as a separate *in vitro* rooting experiment will be carried out.

P23

Importing Grapevine Germplasm into New Zealand - Level 2 Post Entry Quarantine

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Key Words: *Vitis*, PEQ, tissue culture, powdery mildew resistance.

Most wine grapes are highly susceptible to a number of pests and diseases. One of these, powdery mildew (*Erysiphe necator*) is increasingly problematic for New Zealand (NZ) growers, and is currently combatted by intensive chemical spray regimes. We note here also that the regulations in Europe and elsewhere governing acceptable spray residues in food and wine are becoming stricter. Importing novel grapevine germplasm with natural resistance to common diseases into NZ, and breeding for resistance, will future-proof the NZ industry. To enable the importation of resistant germplasm, a Post Entry Quarantine Level 2 Facility, comprised of a greenhouse and tissue culture lab, has recently been established at the Lincoln site of The New Zealand Institute for Plant and Food Research Limited. International collaborations have been established to source material with desired traits. Seed of *Vitis* selections reported to have disease resistance genes have been imported in accordance with the Ministry for Primary Industry (MPI) Facility Standard for Post Entry Quarantine for Plants and the Import Health Standard 155.02.05 Seeds for Sowing. A pathway for handling imported seed through the quarantine process has been developed that included surface sterilisation of seed, germination in tissue culture, and embryo rescue. Plants established in tissue culture were planted in the Level 2 Greenhouse for three months of quarantine, during which time they are monitored weekly for unwanted organisms. Virus testing was performed at MPI's Plant Health and Environment laboratory. Once confirmed free of regulated organisms, these lines will be added to a germplasm collection and will be available to introduce into future breeding programmes.

P24

Evaluation of the performance and potential of Industrial Hemp (*Cannabis sativa* L.) cultivars across two environments in the North Island of New Zealand

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Key Words: Industrial hemp, cultivar, Genotype × environment interactions, *Cannabis sativa* L.

Industrial hemp (*Cannabis sativa* L.) is revitalizing as an ideal multipurpose crop worldwide. The stem contains high-quality cellulose, the seed contains high-quality oil and protein, and the inflorescence contains valuable resins. New Zealand Hemp Industries Association estimated this emerging industry could be worth $2 billion by 2030 in New Zealand. This study aims to investigate the effect of genotype, environmental factors and their interaction on the performance among cultivars and different locations in North Island of New Zealand. The cultivars CFX-2, CRS-1, Ferimon, Finola, Futura 75 and Katani were trialled during the 2019/2020 season in two climate-distinct production regions of North Island: Palmerston North, Manawatu and Wairarapa. Best linear unbiased estimates generated from the six hemp cultivars evaluated at both sites showed that there were significant differences ($P < 0.05$) among the cultivars for the traits, biomass dry matter yield, plant height and stem diameter at both sites. The seed yield and thousand seed weight showed significant differences among the cultivars only at Palmerston North. Analysis across the two sites revealed that there were significant differences among the cultivars for the traits, biomass dry matter yield, plant height and stem diameter. The results indicated that there was no change in the relative performance among the cultivars across the sites for these traits. Plant establishment, number of plants at harvest, thousand seed weight and seed yield showed significant effects of genotype-by-environment interaction. Further work is being done to analyse the fibre quality and seed nutritional quality parameters to determine the extent to which genotype and environmental factors influence these economically important traits.

P25

Studying the potential for improved irrigation of apples using Nanobubble technology

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Key Words: Nanobubbles, Apple orchard, Irrigation, Oxygenation

Improvement in the quality of irrigation water through nanobubbles technology has been proven beneficial for healthy growth, yield, and quality of various indoor horticultural crops. The application of nanobubble-treated irrigation water (bubbles of gas with a mean diameter of less than 200 nanometers) is becoming popular in the hydroponic industry in the US and EU. Our research aimed to test and quantify the responses observed in hydroponic systems in an apple innovation orchard. This study was conducted on 4-year old apple trees (*Malus x domestica cv. Jazz*) at Massey Horticultural Unit, Palmerston North, during the 2021 growing season. Nanobubbles (NBs) of oxygen gas (35 ppm concentration) were added into the water. Three treatments and five replications were arranged in a repeated measures split plot; 1) full irrigation with NBs, 2) full irrigation without NBs, and 3) deficit irrigation with NBs. Various physiological (chlorophyll content, net assimilation rate) and yield (fruit dimension) parameters were recorded over the seven weeks of the trial. Plant water status (PWS) and volumetric water content (VWC) were also measured every week. At harvest, fruit quality attributes were tested, such as dry matter content (DMC), total soluble solids (TSS), fruit firmness (FF), colour, %blush, starch pattern index (SPI), fruit weight and dimension. Trees irrigated with NB water under full and deficit regime showed improvements in chlorophyll content, VWC, PWS, DMC, and FF. Further research should focus on the effects of NB irrigation on the onset of flowering and the morphology of the crop before the commercial implementation of this technology.

P26

Phenotypic variation in kiwiberry (*Actinidia arguta*) induced by γ-irradiation

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Key Words: kiwiberry, irradiation, altered phenotype, hermaphroditism

Kiwifruit (*Actinidia)* is a dioecious perennial vine with an XY sex-determination system. Males carry two sex-determining genes on the Y chromosome that are required for male floral development: *ShyGirl*, which acts as a suppressor of feminisation and *YFAS*, which is required for pollen maturation. Rare cases of hermaphroditism have been observed in *A. chinensis* var. *deliciosa* males with the accompanied loss of *ShyGirl*, allowing gynoecium development to proceed normally. We are investigating the impact of γ-irradiation on phenotypic changes in *A. arguta* (kiwiberry), including alterations in floral phenotype. Seed of three lines of *A. arguta* were treated with γ-irradiation at seven different rates ranging from 50 to 200 Gy. After irradiation, seed was surface sterilised prior to culture on water agar in a cool (5°C) room in the dark. After 7 weeks Petri dishes of seed were transferred to a ConViron set at 24°C (day) and 12°C (night) and 80% humidity for initiation of germination. There was clear variation in germination and plant development in response to irradiation. Over 50 plants from different Gy rates have been transferred to soil, and phenotypic variation is apparent. DNA has been collected for molecular analyses.

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