AUSTRALIAN MACADAMIA SOCIETY

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Merry Christmas



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Front cover. Garry Sheppard, the AMS Grower of the Year 2020, in his orchard 'Ozmac' south of Gympie. See our article on page 18.

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Hort Innovation Strategic levy investment | MACADAMIA FUND

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Our Mission

The Australian Macadamia Society Limited is established to promote all aspects of the macadamia nut industry; to encourage a free interchange of ideas and information amongst macadamia growers and marketers of macadamia nuts and by-products; and to foster and promote goodwill among members of the Society in furtherance of its objects.

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CEO's report



It is with great sadness that the industry received news of the death of the AMS Chair Richard Doggett in a farm accident in late September. Richard and his wife Chrissie have been macadamia growers for over 20 years and Richard had served on the board for 10 years, six as Chair. During that time Richard made a huge contribution to the AMS overseeing improvements in membership, financial strength and the profile and respect for the AMS. His tenure as Chair covered some very prosperous times for the industry with the crop, prices and new plantings all reaching record levels.

On behalf of the AMS Board, members and staff we acknowledge his contribution and give our heartfelt sympathies to his wife and family. A tribute to Richard and his life and contribution to the industry can be found on page 14.

With the 2020 harvest virtually complete it is clear the 2020 crop will exceed the modest expectation held for it at the beginning of the season. Some early predictions were that the prolonged drought across all growing regions could see a crop of little more than 30,000 tonnes. Fortunately, hard work by growers to improve their soil health and substantial and widespread rainfall in January helped to ease the extreme conditions and subsequent dry and mild weather provided favourable harvest conditions. The most recent forecast is for a crop of over 45,000 tonnes, up around 15% on the initial forecast of 39,000 tonnes.

While this is a good result, it is still well down on the record 2018 crop of 52,900 tonnes. The effect of the prolonged drought is clear and we are yet to see how long it will take to return to crops of 50,000 plus tonnes. Initial indications are that the 2020 flowering is patchy at best. Hopefully the focus on improving soil health and raising organic matter levels in the orchard floor will pay dividends over coming seasons.

Dr Yolande Kliese has joined the busy Australian Macadamia Society team as its Research and Innovation Manager. Yolande will be based at Maryborough and will be an additional and local contact point for members in Queensland. She can be contacted on 0437 487 523 or Yolande.kliese@macadamias.org. Learn more about Yolande in the article on page 25.

The AMS Board has worked hard to put the Society on a sound financial footing and this means that we can now invest in people and initiatives focussed on assisting members. Yolande is fully funded by the AMS and will work closely with Industry Development Manager, Leoni Kojetin, to promote the adoption of Hort Innovation levy-funded research and development. Yolande will focus on working with innovative AMS members to help them identify new technologies and practices and do their own on-farm trials and research. Yolande will help members to access grants and other support, and act as a point of contact and resource between the industry and government initiatives such as new regulations in Queensland and Clean Coastal Catchments program in New South Wales.

As I discussed in my last Bulletin column and covered in the webinar in August, the AMS is continuing to work towards an industry marketing fund to support increased consumer awareness and demand for macadamias ahead of forecast strong supply growth. However, the legal and administrative structures and requirements are proving more complex than initially anticipated. We are still working towards an early 2021 implementation and we will be providing members and others in the industry with more information and detail as we are able to confirm it. Please call me if you have any questions or concerns.

To end the year on a high note we have organised MacGroups in December. Check the AMS website for details. We are keen to see as many of you as possible for what will be a relaxed and informative catch-up. There will be some restrictions on numbers so make sure you book your place quickly. Meet Yolande and most of the AMS team and hear the latest updates on industry initiatives.

COVID-19 has also taken its toll on the AusMac Conference despite months of careful planning and negotiations. We are now set to hold the conference a year late, from 2 to 5 November 2021. Hopefully this delay will mean we can plan and participate with confidence. We will also be returning to the hugely successful and popular venue of Royal Pines on the Gold Coast. Put these dates in your diary now and stay tuned for further updates.

Jolyon Burnett, CEO

What's on

DATE	EVENT	LOCATION	CONTACT
MacGroups			
Fri 11 Dec, 4 to 6pm	Bundaberg	TBA	AMS: 1800 262 426, office@macadamias.org
Sat 12 Dec, 3 to 5pm	Gympie		
Mon 14 Dec, 10am to 12pm	Glasshouse Mountains		
Thur 17 Dec, 10am to 12pm	Nambucca		
Fri 18 Dec, 10am to 12pm & 1 to 3pm	Northern Rivers		
24 Dec–4 Jan	AMS Office closes		
16 Feb	AMS Board Meeting	TBA	AMS: 1800 262 426

Nufarm resources for macadamias spray application and record keeping



Keeping accurate Agricultural Pesticide application records is a legislative requirement and a key part of best practice for all growers. If pesticide applicators are not keeping accurate spray records, they are breaking the law and are fully exposed to legal action should an undesirable event such as off-target spray drift occur.

Nufarm is here to help growers meet these legislative requirements. **Nufarm Spray Record books** are available for the recording of this vital information, including operator, grower and property location details. The time of application, wind speed and direction, temperature, Relative Humidity and Delta T are able to be recorded, in addition to other important information such as the pesticides used, batch numbers and spray calibration details.



Nufarm has also developed a comprehensive spray manual, specifically designed for horticulture.

The **Nufarm SprayWise® Horticulture Application Handbook** is an invaluable reference for all segments of horticulture, containing information on key aspects to be taken into consideration for effective pesticide application, such as:

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- Air Assisted machinery options and points to consider.
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- Distance Based and Area Based Calibration, taking into consideration travel speed, spray pressure, fan speed and the appropriate water volume for dilute or concentrate spraying.

Nufarm subsidiary Croplands also has a wealth of information available, such as the Croplands Nozzle Selection Guide.

For further information on how to obtain the Nufarm SprayWise Horticulture Application Handbook or other material detailed above, please contact Matthew Mayle - Nufarm Territory Manager matthew.mayle@nufarm.com or the Australian Macadamia Society.

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Australian industry rising to the challenges of 2020

Jacqui Price Market Development Manager, AMS **P:** 02 6622 4933 **E:** jacqui.price@macadamias.org

Supply

Global supply expectations have shifted as the season nears completion, with production now forecast to come in slightly below 2019 volumes. While the South African crop is expected to be down 16%, the Australian crop forecast is higher than originally anticipated, and all other origins are on track to achieve projected volumes.

The 2020 Australian macadamia crop is now forecast to reach 42,000 tonnes in-shell at 3.5% moisture (45,000 tonnes at 10% moisture); 15% higher than the original estimate of 36,500 tonnes in-shell at 3.5% moisture (39,000 tonnes at 10% moisture).

Growing regions impacted by unprecedented dry conditions have generally performed better than anticipated. The quality of nuts is very good despite the drought conditions leading into the season.

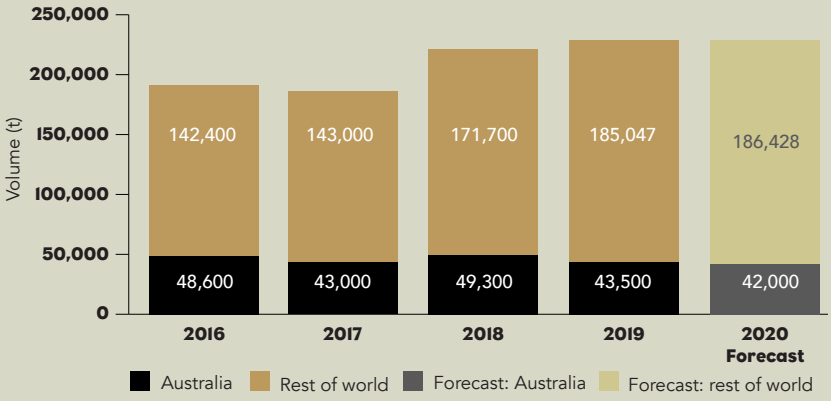


Figure 1. *Global macadamia crop volumes 2016–2020 (tonnes).* Source: INC. All volumes are at 3.5% MC.

Demand

While it is evident that the current coronavirus-led environment is having an impact on imports when compared to 2019, overall demand is ahead of the prior 3 years. The pattern of buying to shorter horizons has continued due to the ongoing uncertainty caused by COVID-19. However, there have been improvements in sales reported in Q3 (third quarter) in key markets.

Despite this challenging environment, the Australian industry continues to grow its market share of kernel imports in many of its key markets. In fact, market share in all four of the priority Asian markets has increased, highlighting the quality standing of Australian macadamias and the strong commercial relationships in place.

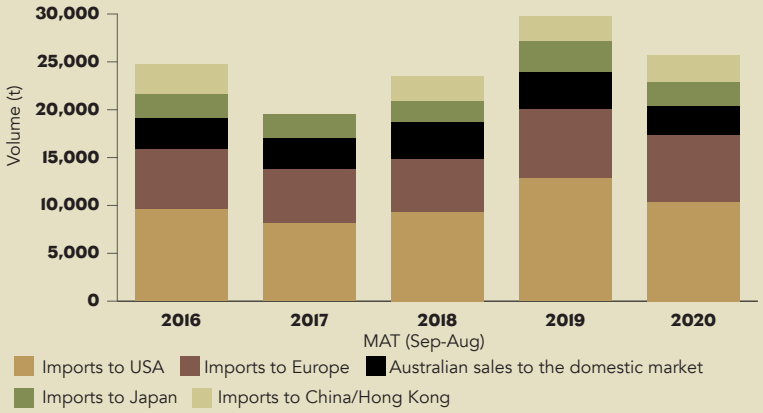


Figure 2. *Macadamia kernel imports to top 5 markets (tonnes) MAT September to August.* Sources: USDA, Eurostat, Japan Customs, China Customs, Hong Kong Census & Statistics Department via HIS Markit Inc, AMHA.

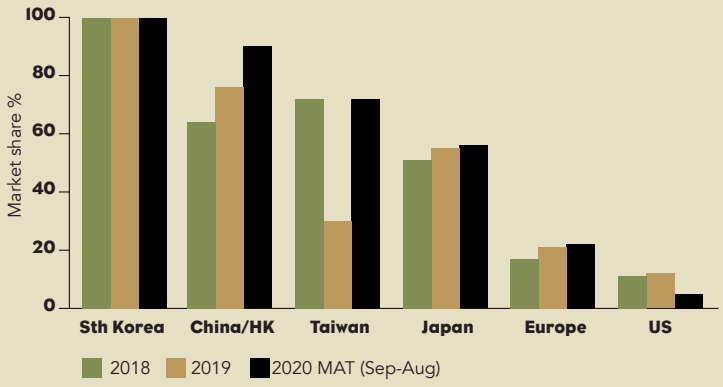


Figure 3. *Australian market share of macadamia kernel imports (tonnes) MAT September to August.* Sources: USDA, Eurostat, Japan Customs, China Customs, Hong Kong Census & Statistics Department via HIS Markit Inc.

Australian sales

Australian kernel sales to many of our key markets increased after a softening in Q2 (second quarter) and are slowly returning to pre-pandemic levels. Asian markets are performing well, with China and Other Asia up +30% and +21% when compared to 2019. Sales to Japan are expected to lift in early 2021 now that additional inventories built up for the expected 2020 Olympics demand are reported to have been consumed.

Ingredient sales to the domestic market have felt the impact of the extended lockdown in Victoria, Australia's largest manufacturing hub, and the loss of trade experienced by tourism-aligned businesses. However, confidence is improving as restrictions on gatherings are reduced and internal borders are re-opened.

The greatest impact on total Australian kernel sales has been the challenging coronavirus-led situation in the USA. Reports indicate the US economy has contracted, resulting in high unemployment rates and COVID-19 containment measures continue to negatively impact the manufacturing sector and reduce foot traffic into food service and smaller retailers. Conversely, sales to larger retailers remain positive in line with the consumer trend towards home baking and snacking.

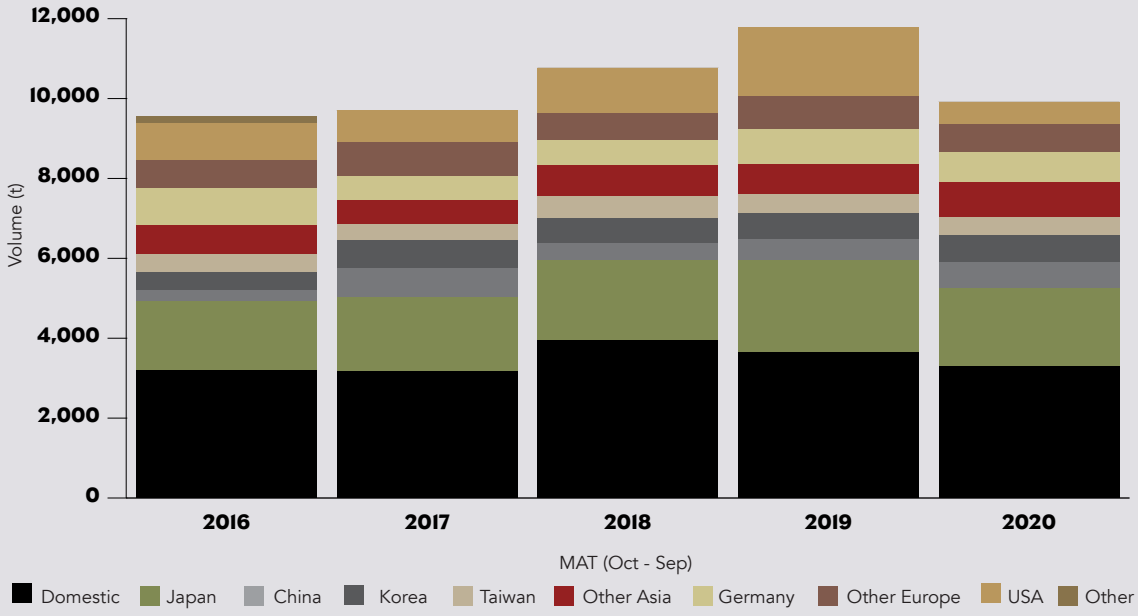


Figure 4. *Australian macadamia sales (tonnes) MAT (October to September).* Source: AMHA. In-shell sales quoted at 3.5% MC. AMHA represents 97.5% production, sales are adjusted to represent non-AMHA members

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Lorraine Gorza joins the AMS Board

Having established a new macadamia orchard and running a successful business in Bundaberg's CBD, Lorraine brings a wealth of knowledge and experience to her new position on the AMS Board.



Lorraine's orchard started with small steps in 2014, planting 1,200 trees on her Bundaberg farm with the help of close family and friends. This was followed up the next year with the construction of a shade house where Lorraine grew out small trees to establish the rest of her orchard.

As Lorraine explains, "I was inspired by the confidence shown in the industry. It looked like it had a great future and I wanted to be part of that."

Lorraine is the first to admit that the last 6 years have been a lot of hard work, but she also believes that growing macadamias is a great business venture to be involved in.

"Where else can you start your day's work in a beautiful environment, use a variety of different skills, multitask and know that you will never be bored?" she said.

"There is a huge sense of satisfaction from initiating the transformation of a barren landscape and witnessing the establishment of a quality macadamia orchard," she said.

Over the years Lorraine has been helped by many in the industry who have provided information and advice about growing macadamias. This willingness to share information and support growers is a feature of the industry and Lorraine is keen to 'give back' a little.

Of her new role on the AMS Board, Lorraine says, "I am looking forward to relaying the flow of knowledge and ideas between the men and women of the industry".

Lorraine is positive about the future and it is impossible not to be influenced by her enthusiasm.



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Leoni's orchard rounds

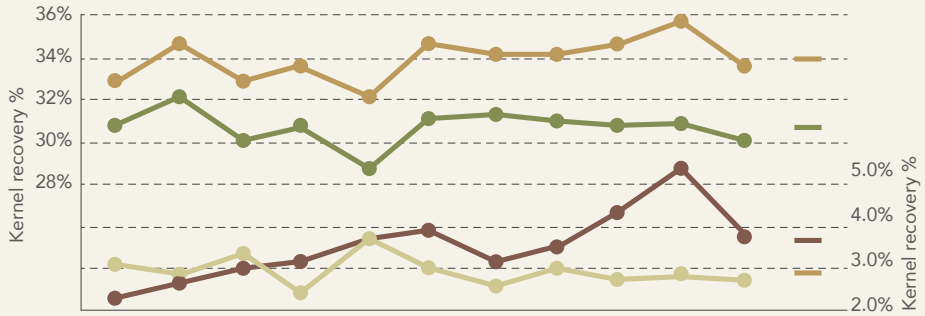
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As the year draws to a close and we look back on 2020 there seems to be so much to take in. Many growers were unsure of what to expect from a difficult 2019–2020 growing season which included drought, bushfires, flooding, severe storms, new pests and clear operational challenges due to COVID19. Pleasingly, the November 2020 crop forecast is up 15% on the previous forecast.

Another welcome and somewhat surprising result given the season, has been the higher kernel recoveries achieved. Final industry kernel recovery data will be reported by the Australian Macadamia Handler's Association (AMHA) in early December 2020 and it looks possible that the industry is going to achieve a record high. In addition, figures from independent laboratory Cropwatch, which analyses kernel samples from all the major growing regions, reported a seasonal NSW average SKR of 37.6% and Qld average SKR of 38.2%. This, when put into context with the last 10 year's kernel recovery results (2009 to 2019 benchmarking report, see Figure 1) is a great result and certainly welcome with current industry record prices.

Growers achieved kernel recoveries higher than that of 2018 which was a particularly favourable growing season. This industry trend could be attributed in part to new plantings populated with generally higher kernel recovery cultivars coming into bearing, but even those with mature orchards have reported the increase.

In many ways this highlights that there is much we need to understand in relation to macadamia crop development, and the way physiological factors interact in response to both environmental conditions and orchard management. We know that cultivar selection has an obvious impact on kernel recovery but know much less about the environmental or management factors affecting this crucial factor. In general, the stages of macadamia nut development are shown in Figure 2.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	09–19
Premium KR%	30.76	32.20	30.08	30.76	28.78	31.05	31.34	30.95	30.76	30.86	30.19	30.68
Saleable	32.88	34.71	32.88	33.67	32.20	34.67	34.22	34.15	34.76	35.75	33.62	34.01
Commercial	2.13	2.51	2.80	2.91	3.42	3.62	2.89	3.20	4.00	4.89	3.43	3.34
Reject KR%	2.83	2.60	3.05	2.28	3.41	2.78	2.43	2.76	2.53	2.61	2.47	2.70

Figure 1. Average kernel recovery 2009-2019. Source: Macadamia Industry Benchmarking Report 2009-2019 Seasons, project MC180002

Anthesis	Nut Growth/Sizing			Oil Accumulation	Maturity	Abscission
Full open flowering	**Match head then pea size**	**Nut shed**	**Shell hardening**	**Conversion of sugars to oils**		**Nut drop**
Less than 5% of flowers set nuts and many fall off in the first few weeks after fertilisation	Rapid growth stage. Nuts can be susceptible to disease at this critical stage	Immature nuts prematurely shed from 10 weeks after nut set	Usually complete by mid December when final nut size is determined	Period of high energy demand	21 to 24 weeks (March). Nuts are mature when kernels reach at least 72% oil content	Harvest of early cultivars begins from February with peak harvest during the months of April to June

Figure 2. Stages of macadamia nut development.

In looking for research that could explain this year's high kernel recoveries, I found limited work on nut development and the factors influencing each stage. One research paper that was particularly interesting though was from an experiment done in 1983–84 by Russ Stephenson[1], one of Australia's most well-known and prolific macadamia physiology researchers. I have summarised the experiment and its outcomes below.

Effects of temperature on nut development, growth and quality

Experiment method:

- 5-year-old trees of three different cultivars (246, 660 and 344) were placed in a controlled environment glasshouse in mid-December, at the end of rapid nut growth and at the start of **oil accumulation.**
- Trees were subjected to four different day time temperatures: **15°C, 25°C, 30°C and 35°C** and consistent night temperatures of 15°C for all trees for 11 weeks.
- In the second week of March all trees were placed in simulated ambient conditions with mean monthly day/night temperatures of 28/17°C changing to 21/11°C in June.
- Abscised nuts were collected weekly and kernel assessments done.

Experiment results (see Figure 3):

- Nut growth was higher @ 25°C to 30°C, reflected in higher dry weight and kernel recovery.
- Oil accumulation was most rapid at 25°C and reflected in the highest percentage of first grade (72% oil content) kernels.
- Kernel growth, recovery and oil content was lowest at 15°C and 35°C.
- At higher temperatures, kernel weight and recovery was lower and most kernels at 35°C were inferior.
- Temperatures during early oil accumulation have an important influence on nut development and that effect persists even after trees are returned to a more moderate ambient temperature.

At the time this research was done it was already known that higher temperatures were detrimental to macadamia photosynthesis and growth, though not fully understood. This experiment doesn't deliberately control for humidity but we now know that a relationship between temperature and humidity (vapour pressure deficit) is an important environmental regulator of macadamia's physiological processes and many growers are measuring VPD as part of their crop monitoring and irrigation scheduling.

Stephenson's experiment, although only a small sample size and only preliminary research, shows a potential sweet spot for macadamia production. Day time temperatures between 25°C and 30°C appear ideal, but when heading toward 30°C and worse down the slippery slope to 35°C, nut quality, dry weight and kernel recovery is affected. This corresponds with frequent high performance achieved by more coastal orchards or those situated in a humid belt and the resulting effect that has on canopy temperature. Obviously, there are a range of contributing orchard design and management practices that underpin this performance.

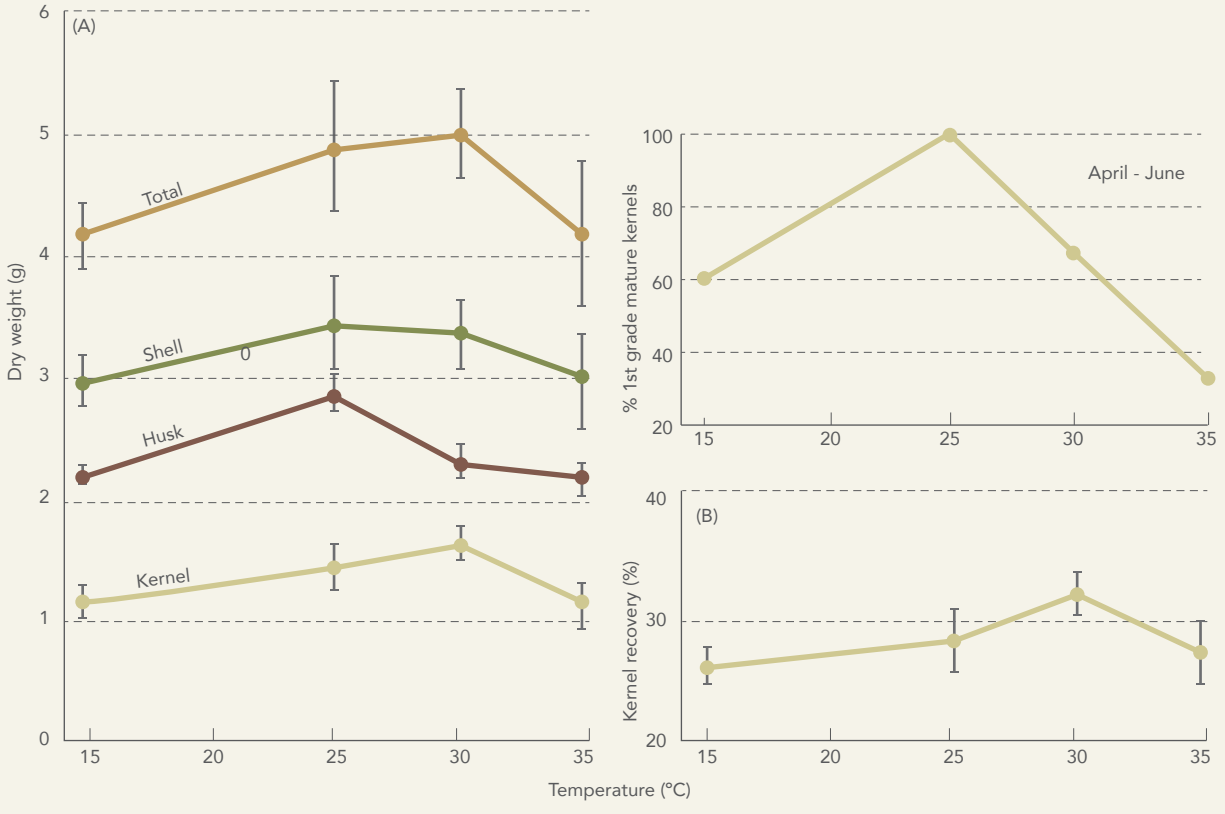


Figure 3. Effects of temperature on nut development, growth and quality. Source: Stephenson[1]

Another interesting finding from the Stephenson experiment is the partitioning between kernel, husk and shell at different temperatures, and Stephenson did conclude the paper with a call for more work on the subject. This year's generally thinner shells and higher kernel recovery have many speculating on which crucial nut development stage this was decided, and by which environmental factors. To be honest, we don't know. With more research and a greater understanding of the physiological factors at play, there are far reaching implications for regional and cultivar selections, orchard design and management practices, including the progression of innovative ways growers are attempting to ameliorate the weather. Many are doing this successfully with the 2019–20 season a testament to that. The AMS initiative to collate weather station data from growing regions as well as the early season nut sampling program in collaboration with processors and the ongoing industry crop forecasting project all promises to shed more light on crop development.

Being a young industry and early in our research understanding, it makes sense to tailor management to what we do know. We know that macadamias are essentially a wild species, evolved over many years to an east coast subtropical rainforest setting.

There are inherent traits which, if we can understand them, we can manage better. This edition of the *AMS News Bulletin* has a host of information about the history of macadamia cultivation, the family trees that seeded the cultivars you grow, cultivar characteristics and suitability. You will also find articles about grower innovation and long-term growing practices reaping rewards. In our next edition we will provide foundational information about macadamia's unique ecophysiology and how this can inform more strategic management that works with nature.

COVID-19 restrictions have meant a curtailing of many face-to-face AMS events in 2020. The AMS team are inviting you to join us at more informal MacGroup meetings from the 11 to 18 December 2020. Join us along with other growers and industry participants to hear how we have all managed a challenging and unique year.

We look forward to seeing there!

Leoni

References:
Stephenson RA & Gallagher EC 1986, 'Effects of temperature during latter stages of nut development on growth and quality of macadamia nuts', *Scientia Horticulturae*, 30: 219–225.



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Vale Richard Doggett

Fate broke Richard Doggett's stride in late September. He was just 72.

He leaves behind his wife Chrissie and their children, Abbey, Polly, Gabrielle and Jacqui, sons-in-law Shane and Rueben and grandchildren Ned, Matilda and Will as well as many, many friends made over a life well lived.

His arrival in Australia from the UK marked the start of a great adventure for Richard. He worked as an outback jackaroo, the general manager of Richmond Tigers AFL club, a senior executive at Conrad Jupiters Casino on the Gold Coast, a fish and chip shop owner and most recently, a macadamia farmer in Numulgi, NSW. And these roles are just the ones we know of; those who knew him longer and better could add many more to this list.

Richard was an AMS member for more than two decades and was first elected to the Board in 2010. He served as Chair of the audit committee and as Company Secretary, becoming Deputy Chair in 2013 and taking the Chair in 2014. He also served on the industry marketing committee and was an international ambassador for the Australian macadamia industry, leading many tours and campaigns.

This year marked a decade of service to the Society by Richard. And what effective service it has been. Over the last 6 years as Chair, Richard steered the AMS through some of the most successful and prosperous times the Society has experienced. Under his leadership, the Society has never been more engaged with members and the broader industry or more highly regarded by key institutions and government.

But to measure Richard just by his deeds is to miss the real mark of him. He was kind, compassionate and polite to everyone he encountered. Our staff have fond memories of the casual chats they would have with him in the office.

He was articulate, clever and well-respected. He had the ability to bring calm and reason to any discussion. And above all, he was a gentleman. In his time on the Board he never raised his voice, despite considerable provocation on occasion. He always looked for the good in everyone and everything, and, like Lord Nelson, would put the telescope to the blind eye when it came to faults and failings.

His vast and impressive list of career achievements illustrate the enthusiastic sense of adventure and love of life that flowed through Richard. The world of macadamias seems less bright, the possibilities not quite as boundless now that he is gone.

Richard Doggett made an outstanding contribution to the Society and to the Australian macadamia industry. On behalf of the Board, the staff and the members we say thank you and farewell.



At home on the farm at Numulgi, NSW Northern Rivers.



Attending the inaugural Australian Macadamias campaign launch event in Guangzhou, China in November 2015.



Richard and his wife, Chrissie, relaxing at the macadamia conference in Lismore, 2014.



At the AusMac18 conference with celebrity chef Ben O'Donoghue and former AMS market development manager Lynne Ziehlke.



Toasting the industry at the 2018 conference gala dinner.

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AMS Awards: Celebrating grower excellence

The winners of the 2020 season competition have been announced and the AMS is very proud to recognise the excellent results for this difficult season.

The AMS major award winners for 2020 are:

- **Grower of the Year** – Garry & Andrea Sheppard (Ozmac)
- **Innovation Award** – Daniel and Belinda Blanco
- **Young Achiever of the Year** – Jarrah Coates.

See our feature articles on these winners on the following pages.

Our 2019 season regional winners were shortlisted by the QDAF Macadamia Benchmarking Team using yield and quality data collected from the 2019 season. The awards are regionally based and separated into small and large farms.

- In Central Queensland (Bundaberg) small farms are those <50 ha, and large farms are ≥50 ha. For all growing regions other than Central Queensland, small farms are ≥5 ha to 30 ha, and large farms are ≥30 ha.
- Best quality for all regions is the lowest reject kernel recovery (RKR) and achieving or exceeding industry average productivity of 0.83 tonnes of saleable kernel per hectare.

Regional winners are listed below. The two stars ✶✶ indicate this is the second year running that these growers have won this award!

A big congratulations to all our winners.

2019 season regional winners

Region and category	Winners, orchard	Details
Mid North Coast		
Best productivity		
Small farms	Fern Hinchcliffe	1.21 t/ha SKR
Large farms	Chris Cook, Thurgoods	1.10 t/ha SKR
Best quality		
Small farms	Tim Zeck & Dru Marshall, Wirrimbi ✶✶	0.80% RKR
Large farms	Victoria Thynne, Elanora ✶✶	1.31% RKR
Northern Rivers NSW		
Best productivity		
Small farms	Wally & Hildegarde Carter, Waratah	1.83 t/ha SKR
Large farms	David & Sharon Wardrop, Poligolo ✶✶	1.55 t/ha SKR
Best quality		
Small farms	Steven Starkey, SW & JL Starkey ✶✶	0.55% RKR
Large farms	Martin Forer & Graeme Fleming, Knockrow Macadamia	1.56% RKR
Glass House Region		
Best productivity		
Small farms	Henry Agostinelli & Jarod Agostinelli, Coastal Produce QLD	1.65 t/ha SKR
Large farms	Michael Cooper, Mr Macadamia ✶✶	1.20 t/ha SKR
Best quality		
Small farms	Ted & Tracey Benjafield, TNT Civil Contracting	0.45% RKR
Large farms	Fullerton Farms	0.91% RKR
Cympie Region		
Best productivity		
Small farms	Bruce Maguire, Cladani	1.76 t/ha SKR
Large farms	Garry & Andrea Sheppard, Ozmac	1.61 t/ha SKR
Best quality		
Small farms	Gary, Julie & Mitchell Davis, Kilfenora	0.57% RKR
Large farms	Garry & Andrea Sheppard, Ozmac	1.00% RKR
Central Queensland		
Best productivity		
Small farms	Macadamia Farm Management, Quamby	1.45 t/ha SKR
Large farms	Jason & Fiona Klotz, Red Rock Macadamias	1.66 t/ha SKR
Best quality		
Small farms	Macadamia Farm Management, Cambewarra ✶✶	0.89% RKR
Large farms	Macadamia Farm Management, Burrawang	1.08% RKR


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Garry & Andrea Sheppard (Ozmac) awarded AMS Grower of the Year 2020

Megan Boote Suncoast Gold Macadamias
M: 0484 099 462 **E:** Megan.Boote@suncoastgold.com.au

The Sheppard family have been part of the macadamia industry in the Bundaberg and Gympie regions since 1989. For over three decades they have been involved in many facets of the industry from developing new orchards, managing large farms, contracting, growing nursery trees and macadamia processing (Goldmac Australian Macadamias).

Orchard: 'Ozmac'

Owner: Garry and Andrea Sheppard

Location: Tandur, south of Gympie, Queensland

Total size: 31 ha with 10,000 mature trees

Cultivars: 741, 344, A4, A16; planted at 8 x 4 m spacing

Soils: Mostly shallow clay loam (brown lithosol) over shale. Undulating to steep.

Garry and Andrea Sheppard purchased the Ozmac orchard at Tandur, 16 km south of Gympie, in mid-2016. The 31-hectare orchard, planted in 1990, has 10,000 mature trees on 8 x 4 m spacings. The farm is divided up into Hawaiian and A blocks with 6,000 trees planted to alternate rows of 741 and 344 and a further 4,000 planted to alternate rows of A4 and A16.

Garry and Andrea have won the 2020 Grower of the Year Award which awards the most productive and consistent orchard over a 5-year period. The farm won the same award in 2017 and has since been impacted by a number of hail and severe storms. Hail storms in November 2017 affected the 2018 crop volumes, and another hail event in September 2018 affected the 2019 crop. The 2019–2020 season continued to be a challenge with severe storms in mid-November last year that ripped through the area bringing torrential rain, hail and gusts of wind that twisted the tops out of trees. Dry conditions have prevailed for more than 2 years and this has been tough on the trees.

"The extremes of weather have been a real challenge. We are now applying a lot of compost and have treated every tree with a Phos Acid truck spray in August this year."

As Garry and Andrea are based in Bundaberg, and Garry is away a lot with the contract pruning business, the farm has been fortunate to have consistent staff with Randall and Karen Couch working on the farm for the past 25 and 23 years respectively. "We are very lucky to have Randall and Karen here, we couldn't do it without their help," said Garry.

Pruning

Regular pruning is a major contributor to the consistently high productivity of this orchard. The pruning regime has been ongoing since the farm was purchased and the aim is to prune about 25% of the orchard per year, being mindful of the tree health and weather conditions at the time and never pruning

too hard. Most pruning and skirting is done with the Afron mechanical pruners Garry uses in their Austmac contracting business, however, the plan is to also do some limb reduction in the Hawaiians with a cherry picker and pole saws.

Most blocks are pruned by doing either a low or a high cut on alternate rows every other year. This year however, only a light pruning was done in the Hawaiians as the orchard had already been opened up by the storm and the flowering was very light. "'Natures pruning' was one small positive outcome from the storm and helped get a lot of light into the orchard," said Garry.

Garry considers the management of each variety individually and only prunes where necessary. "I like to leave the outside rows and ends unpruned if I can, and using small gear means I don't need to prune for access every year."

Machinery and equipment

Running low profile tractors such as the Antonio Carrero and smaller orchard tractors with low profile wheels has a lighter impact on the orchard floor and reduces the need to prune for access. "It's best to have the machinery to fit the orchard, not the other way round," said Garry.

"We have shaken for the past two seasons on this orchard and I plan to shake them all again next season and use Ethrel as well on the As if the conditions and tree health are right," said Garry. After first shaking in 1996 through to 2009 on the Wingfield orchards in conjunction with CSIRO trials, Garry has full confidence in tree shaking and doesn't see any ill affects to tree health, as long as you have a well set up and maintained unit and an experienced operator. Their plan, starting from the nursery, was always to grow the right type of tree with mechanical harvesting and tree shaking in mind, ideally with a single leader and the first branch around 800 mm off the ground.

For harvest, a Weis-McNair self-propelled sweeper sweeps out into the centre row then a Weiss/Ramacher harvester will pick up the bulk volume of nut-in-husk and is followed by a Monchiero which does a final mop-up.

Irrigation

Water is the most important factor in being able to grow a good crop consistently in the shallow soils and hills of Gympie. The orchard has been irrigated since planting, but a major upgrade was done after purchasing the orchard in 2017 which included replacing all the sprinklers to 90 L/hour sprinklers. In a normal year around 600 L/week/tree is used at peak moisture usage, but with the dam almost dry they are down to just 150 L/tree/week this season. They are installing MAIT and G-Dot moisture sensors to help with future water usage and irrigation scheduling.

A large dam used for irrigation was cleaned out this year while water levels were very low and this will allow for an additional 10 ML of storage in the future. "Water security is going to be our focus coming into 2021 to secure more storage and supply," said Garry.

Nutrition

The orchard nutrition program consists of small, frequent applications of solid fertiliser, liquid fertigation, some foliar applications as well as a lot of compost and mulch. The orchard is limed every year with either ag-lime, gypsum or dolomite, depending on the soil and leaf analysis, and the orchard nutrition program which is developed in conjunction with consultants.

Garry has been accumulating product from a range of different sources to make compost on site from chook and feedlot manure, husk, pine bark, mulched branches and cut grass from the farm. This was mixed with silt from cleaning out the dam and then hilled up into windrows about 2 m tall to age.

Future plans

With their contract pruning business growing each year, a new farm in Gympie recently planted with 8,000 trees from their own Bundaberg nursery, and plans for a further 8,000 trees in early 2021, Garry and Andrea's passion for and commitment to the macadamia industry is clear.

Congratulations to Garry and Andrea on winning the 2020 Grower of the Year!

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The Blanco's mobile harvester takes out AMS Innovation Award

Megan Boote Suncoast Gold Macadamias **M:** 0484 099 462 **E:** Megan.Boote@suncoastgold.com.au

Daniel and Belinda Blanco, macadamia farmers based at Wolvi near Gympie, set themselves very high standards for production, efficiency and safety. Megan Boote caught up with Daniel and Belinda to find out about their AMS award winning mobile dehusking and sorting plant.



In the 7 years since the Blancos purchased their first orchard with 6,200 trees, their holdings have grown to over 39,000 bearing trees across three farms in the Gympie region, with a further 3,000 trees planted in 2019, and there are another 12,000 trees on order for 2020 and 2021 planting.

The Blancos have three farms:

- **Home farm at Wolvi:** 22 ha with 6,200 trees, varieties are mixed and interplanted
- **North Deep Creek farm:** 32 ha with 7,100 trees, mainly Hawaiian varieties
- **Boreen Point farm:** 80 ha with 26,000 bearing trees. Has had a major IOM overhaul, currently undergoing tree height reduction and new plantings.

Both North Deep Creek and Boreen Point farms are a 30-minute drive from the home farm, in opposite directions.

The issue: Increased processing capacity needed

The rapid increase in the number of trees to manage and the distance of the two additional farms from the home farm brought about a number challenges for harvesting and processing the crop within the Blanco's ideal timeframe. The sorting plant on all three farms needed upgrading or replacing, which would have been a very expensive project. Harvest runs for 16 weeks, usually starting in the first week of March with the aim of being finished by July.

A key tool in ensuring a short harvest period, and one of the main things leading to the inception and success of the mobile dehusking plant, is the use of Ethrel.

Daniel said, "We have a very short window where Ethrel is effective – only about 3 weeks during April and May. I can see why people are hesitant in using it, but Ethrel has been used for the past 11 years on the home farm and we have never had an issue". He adds, "You do have to get the rates spot on and if your shed, harvester and staff aren't up to it, it can be a disaster."

Their condensed harvest period allows for a significant IOM program on all three farms which is crucial for ongoing productivity. The IOM program includes major drainage works, deep ripping, pruning, skirting, tree height reduction, profiling, spreading fertiliser and soil amendments and this year spreading over 100,000 m^3 of mulch onto the orchards.

The Blancos simply did not want their increasing tree numbers to force the harvest to go for longer because this would reduce their ability to complete IOM works after harvest. Neither did they want to have harvest interfering with the flowering period.

The solution: A mobile dehusking and sorting plant

The Agri-Mac 20 mobile dehusking and nut sorting plant in an ingenious solution for the Blancos growing macadamia enterprise and fits with their expectations for production, efficiency and safety across the three properties. The AMS spoke to Daniel and Belinda last year about the prototype machine and their initial thoughts on its success (see summer *AMS News Bulletin*, p. 49). Now, having completed their second harvest and undertaken various upgrades to the unit, the benefits are clear.

The Agri-mac 20 (built by Argi-Con Equipment in Bundaberg) is a fully integrated, standalone post-harvest macadamia dehusking and sorting plant. Towed between farms with a John Deere 6155 tractor, it is easily set up and can be moved between blocks, following the harvesters and leaving all husk and debris behind to be later spread back under the trees. The machine is powered by a diesel hydraulic engine and a diesel generator which power all facets of the machine via hydraulic and 3-phase electric power. As no connection to mains power is needed, the unit can be used anywhere and is not affected by rising power costs.

Receival and pre-clean

The receival bin holds two Monchiero bins of nut-in-husk (NIH) and has been upgraded after the first year to hydraulically tip, to avoid manual handling of NIH. The first elevator has been widened and hungry boards added to increase its capacity. Approximately 2 tonnes of NIH, stick, rock and leaf is received for every 1 tonne of in-shell that is produced. The product goes through a 65 mm x 65 mm rock and stick chain, then through a variable speed blower to remove leaf and light material.

Sorting

Next, the positive drive, shortened double trommel with 16 mm external slots and internal 50 mm holes with helicoil, takes 6 seconds to push product through, separating most of the NIH and nut-size rock and debris out and delivering it to the top pre-sort room. Two people are required to remove rock from the sort belt in the top air-conditioned sorting room and there are plans to automate this process in the future. Flappers have been installed on the trash chutes on both sides to throw the husk and trash further from the unit.

The dehusker needs to do everything normally required of a dehusker but under field conditions. Made by Keba Engineering in Gympie, the dehusker is a hydraulically driven, 3-wheel drag tyre dehusker. "The dehusker is the heart of the machine. It's the only one of its kind in the industry," Daniel said. A walk platform was installed for safety above the dehusker and this doubles as a cover, keeping rain off the tyres. Nut is all dehusked green, often at high moisture, so having three tyres allows for a gentle and thorough process with minimal nut damage.

The in-shell trommel takes off excess husk and nut that is less than 16 mm in diameter. Then a high capacity, variable speed air-sorter removes light, immature and rat-eaten nut. The final sort room is also climate controlled, has two doors and space for four sorters who remove black nut, germination, insect damage and other defects. The entire unit can be controlled from the cab with the CBUS electronic control panel, alarms and kill switches for efficient and safe operation and in case of breakdowns.

The machine can operate at an output of 4 tonne of in-shell per hour, usually operating for 8 hours per day, and in-shell can be directly loaded into a truck and dispatched to the processor the same day.

The machine is running more efficiently and processing faster now and will go into its third season in 2021.

Upgrades have improved efficiency and operation

The 2020 harvest was the second year running the machine. "We are confident that we can handle the amount of nut coming through and we have our schedule worked out so that we arrive at each farm 14 days after the Ethrel application," Belinda said. The original machine was a prototype. A lot of upgrades have already been completed and there are a few more planned for the future.

Belinda explained, "We have done a few upgrades to make it safer and more workable and also upgraded to more robust parts and materials." Upgrades include steps, rails, jack stands for stability, an additional exit in the main sorting room, and improved lighting so they can operate in lower light conditions.

For the 2021 season, one of the Monchiero harvesters will be upgraded to the 20125 Ferox to increase harvesting capacity to keep the product up to the Agri-mac 20.

Around 9 L of diesel per hour are needed to run the two main engines which provide all hydraulic and electric power to run the entire unit. Running costs were down this year compared to last year (72 v 100 L/day), but it is expected to fluctuate with the season depending on nut size and the amount of leaf and debris coming in from the field.

A great team striving for perfection

A small, tight-knit team is used for harvest and the Blancos are committed to promoting a safe and happy team environment. "We have a lot of fun together and everyone enjoys themselves," said Belinda.

During harvest, four seasonal staff are brought in to help the four local permanent staff. Six sorters and Belinda are needed to operate the Agri-Mac 20. There are two harvester drivers, and at least two stick pickers in front of the harvesters (which increases harvest efficiency and reduces downtime). Most of the staff are rotated through different jobs on a daily basis to help with team morale and enthusiasm.

The machine is cleaned down with compressed air daily using a mobile unit with a COMPAIR C42 compressor. Maintenance is done every 150 hours which takes about half a day, allowing for a full clean down at the same time.

The Agri-mac 20 machine is innovative and allows the Blancos to operate their farms in a way that suits them and their production system, and will allow them to continue improving their farms, develop and support their team and reach their productivity goals.

Daniel's final word, "I am after perfection. It might not be for everyone, but it works for us."

Jarrah Coates: Young Achiever of the Year

Pest consultant Jarrah Coates is almost an industry veteran and he's only just turned 40!



Northern Rivers-based Jarrah has worked in the Australian macadamia industry for almost two decades, alongside his father, renowned IPM consultant Alan Coates.

Jarrah runs the NSW arm of pest and nutritional consultancy Coates Horticulture, working collaboratively with researchers and other industry experts to help Australian macadamia growers farm productively and more sustainably.

He is highly respected for his passionate commitment to pest monitoring as a key IPM tool, as well as his support for low impact solutions and biocontrol agents where possible.

This, together with his enthusiastic participation in ongoing experimental trial work on farm and his willingness to share his wealth of knowledge with growers and at industry events, earned him the AMS Young Achiever of the Year award.

Jarrah was "pleasantly surprised" to receive the prestigious honour. "It feels really good to be recognised and acknowledged by the industry," he says.

"I love learning, being involved with research projects and interacting with knowledgeable academics."

Over the years, Jarrah has made valuable contributions to several macadamia research projects, including the industry-wide IPM project and the interrow sub-project, alongside Richard Llewelyn and the BioResources team.

He was also heavily involved in trial work using the targeted, softer control indoxocarb for macadamia seed weevil, which proved a big success.

"It's been fantastic to see the reduction in spray applications to control seed weevil."

Recently, he's been trialling the practicalities and usefulness of spray drop sheets to better monitor late season spotting bugs and avoid unnecessary spraying.

"Richard (Llewelyn), entomologist Christopher Carr and I decided to build on the original work done in this area. Because I'm IPM minded I'm reluctant to do a late FSB spray if it may not be required," says Jarrah.

"I really endorse the holistic approach that IPM encompasses. It's about using the whole suite of tools available to you, whether that's cultural controls, softer targeted chemical control options or a combination of these."

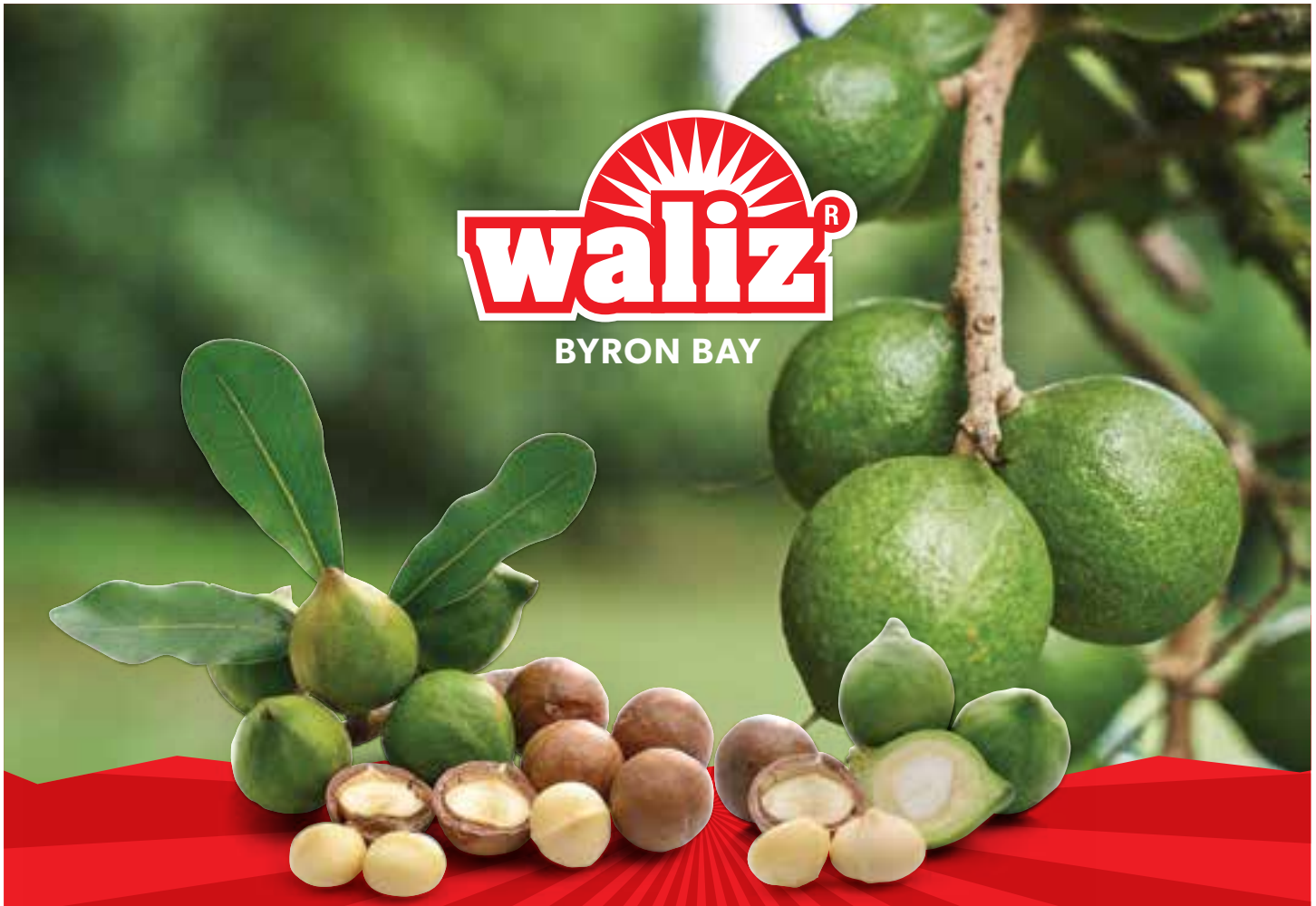
Northern Rivers grower Ross Arnett has worked extensively with Jarrah and describes his approach as "conscientious and methodical".

"Jarrah plays an integral part in all our farm management practices regarding tree health and insect control. He's helped us integrate biocontrol agents and without his monitoring expertise I probably would have sprayed unnecessarily for lace bug and fruitspotting bugs," says Ross.

For Jarrah, the highlights of his career thus far are many and too long to list, however one of the main ones is "getting to know all the different growers and working through the decision-making process together."

For the full story, go to www.australianmacadamias.org/industry.





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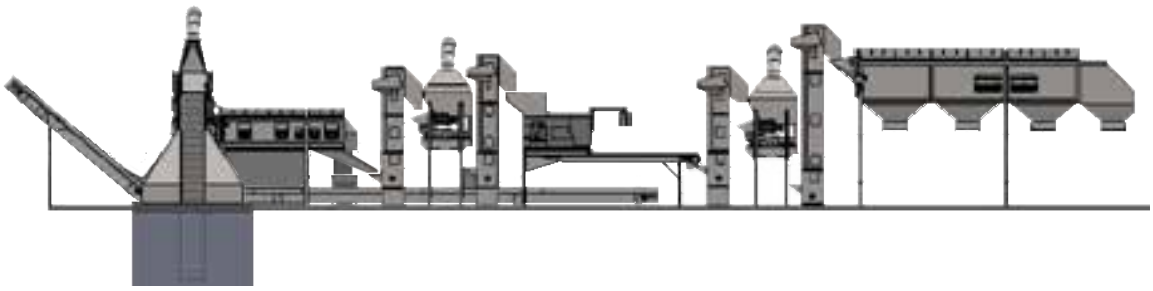
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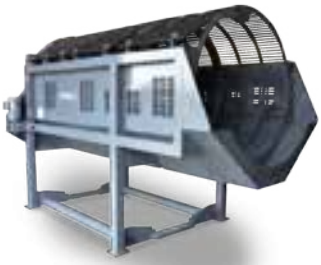




The Aspirator is used to separate out light debris and to grade nuts by weight. It is available in 24", 36" & 48" widths.



This pre-cleaning assembly incorporates a Pre-vac, Stick Remover, Sizer/Cleaning Reel, and a Trash Conveyor. Available in three different size configurations.



The Sizer can be used to size macadamias and as a cleaning reel. It is available with 36", 48" and 60" diameter reels.



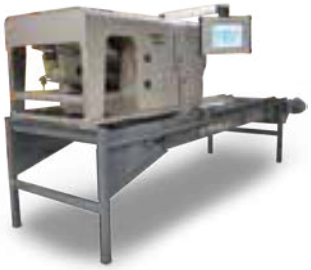
Savage makes a wide variety of belt and bucket elevators and many types and sizes of bins.



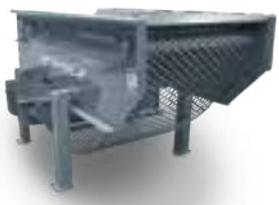
The Pit Elevator is the first stage of many cleaning plants. Savage makes them in several sizes.



The Stone Remover has two stages: one that removes heavy debris and one that takes out light debris. Available in 36" and 48" widths.



The sorting table is availabe in various sizes. This one has the Vision, dual-spectrum sorter mounted on it.



The Stick Remover uses a rotating sizing chain to remove sticks from the harvested nuts. It is available in 36", 48" & 60" widths.



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Welcome to Yolande Kliese, our new Research and Innovation Manager

Dr Yolande Kliese has joined the Australian Macadamia Society as its Research and Innovation Manager, a new role funded by the AMS. The *News Bulletin* caught up with Yolande to find out more about this important new position.



Research and Innovation Manager Yolande Kliese with John Middleton (left) and Scott Allcott of Macadamia Farm Management (right).

Bulletin: Can you tell us about your background?
For the last 20 years I've worked in commercial agricultural enterprises. I started as a rural finance officer with Wesfarmers Dalgety and have worked in sugar for the last 14 years in various roles with MSF Sugar, including manager of company farming operations.

I have always been passionate about soils and interested in the dynamics of soil organic matter and nutrient cycling. My PhD research was on nitrogen dynamics following piggery pond sludge application to grain crops on the Darling Downs. My parents took great delight in telling their friends I am a Dr of Pig Poo! But seriously, it's great to see soil health becoming more of a focus these days with more and more people understanding the importance of soil organic matter and nutrient cycling for resilient and sustainable production systems.

Bulletin: What will your main focus be initially?
As I'm new to the industry, my main focus will be meeting with and listening to the people who grow and process macadamias. Growers understand better than anyone else the production challenges they face, where the knowledge gaps are and where the biggest gains are to be made both in the short and long term.

There are so many growers, large and small, with great ideas but they don't necessarily have the time to drive research projects. So I'll help with connecting people and getting projects up and running and keeping them on track. This includes grower-initiated/funded projects as well as levy-funded projects.

Macadamia is such a young commercialised crop and there is so much to learn. From the few discussions I have already had with growers there is a clear need to better understand growing conditions and their impact on both yield and quality. Irrigation timing, amount and efficiency are also a large focus.

Bulletin: What else will you be doing?
I'll be representing the AMS in Queensland and will work closely with Industry Development Manager, Leoni Kojetin, to ensure people are influencing and aware of research being undertaken, as well as outcomes they may be able to adopt in their enterprises. I will support growers to be aware of and understand government programs and regulations.

Bulletin: What have you enjoyed about your new role?
It's been wonderful working with the AMS team and they've really helped me settle in. I'm really looking forward to connecting with and learning more about the industry. I've been out meeting growers already.

Feel free to contact me, otherwise I'll see you at the MacGroups.

M: 0437 487 523 **E:** yolande.kliese@macadamias.org



Which variety is which?

Choosing a variety or varieties to plant is a task that requires research and consideration of factors specific to you and your orchard, for example, location, environment, physical characteristics such as soils, and your management system.

When looking at candidate varieties for your orchard, there are some key characteristics that can help you narrow the search. These are:

- performance, i.e. yield and kernel recovery
- identifiers, i.e. tree habit, flowering and nut drop pattern
- management features, e.g. susceptibility to pests and diseases and consistency of production.

This article summarises key characteristics for 18 popular varieties and should help you get started on identifying the most suitable new or replacement trees for your orchard. The article draws on a range of information sources including the *Macadamia Grower's Handbook*, the *Macadamia Variety Identifier*, recent genetic research and comments from industry consultants.

There are distinct regional differences in varietal performance and these should be taken into account when selecting varieties. Talking to growers and consultants in your area is a helpful way to get first-hand varietal information when making any selection. Research into the pollination requirements of macadamia varieties is ongoing and the indications of either self-compatibility or self-sterility are preliminary.



Figure 1. *Typical macadamia tree shapes.*



In A Nutshell . . .

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A4

A very precocious, early bearing, medium sized tree with a spreading to rounded open canopy. Nuts are large, even sized and thin shelled. Flowering is condensed and late. Leaves are medium length and very spiny.

Performance	42 to 48% SKR
Nut drop	Mid to late season (May to September)
Management	Slightly susceptible to husk spot, and young trees prone to phytophthora when conditions are wet. Needs special nutrition and higher management attention than Hawaiian varieties, particularly as trees age, when performance can wane. Mature trees require limb removal to avoid dead centres. Susceptible to wind damage. Tolerant to abnormal vertical growth disorder (AVG). Further research is required but shows little self-compatibility.
Consultant comments	Popular, high kernel recovery variety in New South Wales and Queensland and worth including in the overall variety mix. Thin shelled so is more prone to fruitspotting bug (FSB) damage (March to May) compared with thicker shelled Hawaiian varieties. On shallow topsoils, older trees can decline earlier than other A varieties but appear to respond well to staghorning limbs to stimulate new vigour. Higher returns outweigh the negatives.

A16

A small upright tree with a moderate to dense canopy. Nuts are thin shelled and vary in size from small to large. Flowers are borne on long racemes over a short period mid-season. Leaves are short and wide and have few spines.

Performance	39 to 45% SKR
Nut drop	Very late (May to November) and nuts hang on trees long after they are mature. Not highly sensitive to ethephon but effective in combination with tree shaking.
Management	Moderate to highly susceptible to husk spot. Prone to sticktights, particularly when trees are stressed. Trees are hardy and suit higher density planting. When mature, require limb removal to improve air flow and light penetration to combat disease susceptibility. Further research is required but shows little self-compatibility.
Consultant comments	A small tree suited to higher density orchards. Not precocious. Very dense canopy requiring canopy management, particularly on good soils in NSW where it has lost favour due to poor nut set in some seasons. Performs better on marginal soils in Qld where the late nut drop pattern can be managed with tree shakers. Needs high degree of management and shows tolerance to AVG. Reported to show some frost tolerance.

A38

A medium sized, slightly upright precocious tree with a moderate to open canopy. Nuts are uneven in size, varying from medium to large, and husk and nut have a rough surface. Flowering is late, short and intense. Leaves are long and narrow with one spine at the tip.

Performance	36 to 40% SKR
Nut drop	Mid-season (April to August)
Management	Highly susceptible to husk spot and a moderate rating for sticktights. Susceptible to phytophthora and to wind damage in exposed areas. Trees grow vigorously and need training and pruning to size. Consistent producer and high yielding, producing high percentage wholes. Kernel quality is variable, particularly in Qld, and discolouration can be an issue, depending on season. Potentially suited to higher density planting.
Consultant comments	Consistent yield performer in NSW coastal regions and south-east Qld. Responds well to ethephon to shorten harvest when application rates and timing are targeted accurately. Trees suffering moisture stress on some sites with lighter textures soils have had kernel quality and size issues.

A203

A small to medium, slightly upright tree with a moderate to open canopy. Nuts are uneven in size and vary from medium to large, and husk and nut have a rough surface. Flowers are borne on long racemes and flowering is intense and late. Leaves are narrow, long with a slightly pointed tip and few spines.

Performance	33 to 37% SKR
Nut drop	Mid-season (April to July)
Management	Not a widely planted variety until recently, when more trees have been established, especially in the Bundaberg region and on NSW coastal floodplains. Information on long-term management is limited. Hardy trees that are very precocious and can bear a harvestable crop in their third year although kernel recovery can be variable. Seemingly tolerant to AVG but susceptible to wind damage. Further research is required but shows some self-compatibility.
Consultant comments	Does not perform well on vertisols and needs good drainage and attention to soil management. Reasonable tolerance to root diseases. Susceptible to leaf diseases, particularly yellow halo leaf blight and flower pests, e.g. can be affected by flower caterpillar as it flowers two weeks later than most varieties. Potentially less susceptible to insect damage because of its thick shell. Can lose branches in high winds and canopy management is required from an early age. Smaller nuts have very low kernel recovery.

A268

A medium to large tree with a spreading habit and moderate to open canopy. Nuts are large and even sized with a slightly rough surface. Short, mid-season flowering with flowers borne on long racemes. Leaves are long and wide with many spines and a pointed tip.

Performance	35 to 40% SKR
Nut drop	Mid to late season (May to August)
Management	An early bearing tree that produces consistently. Prone to wind damage, especially in coastal areas. Susceptible to husk spot. Because of its spreading habit, it is suited to wide spacings. It is often used as a polliniser tree in orchards. Further research is required but shows very little self-compatibility.
Consultant comments	Produces large kernels but has some kernel quality problems in central to south-east Qld. Nuts are prone to quality loss if left for any time on the ground. AVG tolerant. Often used as a replant in orchards where trees have been removed because of AVG. Needs good cross-pollination.

246

A large tree with a spreading growth habit, a moderately dense canopy and extended, heavy flowering. Nuts are medium to large. Leaves are long and wide with a rounded tip and moderate spines.

Performance	31 to 41% SKR
Nut drop	Early to mid-season (April to August)
Management	An old variety widely planted in the 1960s and 1970s and with a reputation of cropping heavily and consistently. Not early bearing. Highly susceptible to husk spot and to wind damage. Heavy leaf fall can be an issue and hamper harvest. Prone to open micropyle.
Consultant comments	A large tree prone to wind damage and suited to low density orchard design. Heavy nut set and consistent heavy bearer of sub 40% KR nut, but subject to some regional variability. Open tree canopy allows good light penetration and air flow. Suited more to southern Qld and northern NSW. Not tolerant of hotter environments. Kernel quality is sometimes questioned with shorter shelf life and darker roasting. It is often used as a polliniser tree in orchards.

344

A large, upright, conical tree with a dense canopy (compact and very dense when young). Moderately precocious. Mid to late light flowering with medium length racemes. Leaves are short and narrow with few spines and pointed tip. Popular in the 1980s and early 1990s. Planted less now but still favoured for coastal floodplain orchards.

Performance	32 to 39% SKR
Nut drop	Early season in Qld (April to July) and later in NSW (May to September)
Management	Hardy tree that performs well in a range of climates and bears by year 5. Low kernel recovery is a disadvantage. Moderately tolerant of husk spot although susceptible in hot climates and highly susceptible to husk rot. Susceptible to nut borer and AVG. May need higher level of nutritional management. Further research is required but shows very little self-compatibility. Prone to brown centring.
Consultant comments	Performs well in early years. While branches are wind tolerant, whole trees can blow over in high winds. Does not respond well to regular mechanical hedging. Requires good light, and once light levels drop so does yield. Yield can also be erratic in some seasons. Can be planted in marginal soils where it performs well.

660

A medium to large upright tree with a moderate to dense canopy and a 'turkey's neck'. Flowering is concentrated and timing is variable (mid to late). Flowers are borne on medium to long racemes. An early bearer with best yields in NSW and south-east Qld. Medium length leaves that are narrow at the base with a rounded slightly pointed tip. Popular in the 1970s and 1980s.

Performance	35 to 39% SKR
Nut drop	Very early season (February to June)
Management	Slightly susceptible to husk spot. Nuts can germinate on trees in wet conditions. Large number of reject nuts and nuts can vary a lot in size. Nuts dehusk on the ground making fingerwheel harvesting difficult. Prone to brown centring. Further research is required but shows some self-compatibility.
Consultant comments	Not a popular variety anymore. Very early nut fall: in northern NSW can be finished by early June. Very small nut so in some seasons could be below acceptable size. Very high kernel recovery. Prone to a higher-than-normal germination percentage. Lower baseline leaf N levels compared to other varieties.

741

A large upright tree with a moderate to open canopy and a turkey's neck, particularly when young. Flowering is usually late, concentrated and light, with flowers borne on medium length racemes. Leaves have distinctive spurred basal spines and are medium length. Widely planted from late 1990s. Not precocious (trees take up to 7 years to bear).

Performance	36 to 44% SKR
Nut drop	Early season (April to June)
Management	Reliable, hardy and wind resistant variety although crops variably in NSW. Early nut drop an advantage. Very susceptible to husk spot although its impact is reduced by the tendency to early nut drop. Highly susceptible to AVG. Further research is required but shows self-compatibility.
Consultant comments	Widely planted variety (likely the most planted currently). Good wind tolerance but whole trees can blow over. While it tolerates poor soils, attention to nutrition, soil management and drainage will result in better performance. Premature nut drop can be a major problem in heatwave conditions. In some years flowering can be erratic, particularly as trees age. Produces a large range of nuts sizes and smaller nuts have a very low KR.



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816

A medium to large, moderately upright tree with a moderately dense canopy. Flowering is late and light with flowers borne on long racemes. Medium length leaves, lime green with a rounded tip and very few spines. Nuts are large with high kernel recovery. Not an early bearer.

Performance	42 to 47% SKR
Nut drop	Early to mid-season (March to June)
Management	Performs variably in different locations so research for local performance is essential. Susceptible to husk spot and phytophthora, as well as insect damage. Needs careful nutrition management and very good drainage.
Consultant comments	A big, 'hungry' tree. Often looks pale, an indicator of higher nutritional requirements. A good producer of high quality kernel with good shelf life. Good drop pattern but does suffer from sticktights. Highly susceptible to root diseases such phytophthora and husk spot susceptible. Trees tend to hollow out in centres as they age. Responds very well to increased levels of organic matter on the orchard floor. Highly sensitive to ethephon.

842

Medium to large, spreading to moderately upright tree that has an open canopy when young, becoming denser with age. Intense flowering: usually one of the earliest cultivars to flower. Flowers borne on long racemes. Nuts are small to medium and round. Long, very wide leaves that are very spiny and with rounded tips. Early bearer that performs well in all regions, particularly in central Qld.

Performance	36 to 41% SKR
Nut drop	Extended, mid to late season (April to September)
Management	A hardy tree that is precocious and has good yields. Seems suited to warmer areas. Slightly susceptible to husk spot and its long, late nut fall can be an issue for some growers. Some nuts hang late and can pre-germinate. Further research is required but shows some self-compatibility.
Consultant comments	Very sensitive to ethephon. Beige brown kernel that is ideally kept separate from cultivars with white kernel. Susceptible to wind damage but seems heat tolerant. Susceptible to AVG and to branch dieback.

849

Medium to large spreading tree with a moderately dense to dense canopy. Light and later flowering over a short period with flowers borne on medium racemes. Long, wide, dark green leaves, wide at the tip, with many spines and very undulating margins. Does not bear early.

Performance	40 to 46% SKR
Nut drop	Extended, mid to late season (May to October)
Management	Good yield performance enhanced by high kernel recovery but not precocious. Very susceptible to husk spot and insect damage. Some nuts hang late and can pre-germinate.
Consultant comments	Medium sized tree with a dense, spreading canopy. Late set and drop pattern. Can be susceptible to flower blight on flowers in the middle of the dense canopy. Good quality kernel that can be affected by discoloured rings. Drops late but is a consistent producer, continuing into its later years. Worth considering in a variety mix.



Daddow

A medium to large, moderately upright tree that has a very dense canopy. Short racemes with moderately intense mid to late flowering. Wide, undulating, moderately spiny leaves with some rolling and mottling on older ones. Later bearing.

Performance	37 to 40% SKR
Nut drop	Extended, mid to late season (May to September)
Management	An older, hardy variety characterised by reliable yield performance. Suited to marginal conditions. Very susceptible to husk spot and slightly prone to nut borer. Susceptible to flower diseases and potentially insect damage as spray penetration can be difficult. Further research is required but shows little self-compatibility.
Consultant comments	Brittle trees susceptible to wind damage. Highly suited to poor soils; not suited to slopes as dense canopy prevents grass growth. Nuts need to be picked up regularly as they discolour rapidly and look old, making sorting difficult. Reasonably ethephon sensitive. Susceptible to AVG. May need careful nutrition management, i.e. do not over fertilise.

MCT I

Compact tree with an open canopy. Mid-season flowering. Leaves are moderately long and spiny. A newer variety that is very precocious and highly productive. It has only been tested long-term in Gympie and Bundaberg. Growers in other areas should test small batches of tree before committing to large areas.

Performance	42 to 50% SKR (based on varietal trials)
Nut drop	Mid to late season (mid-April to late August)
Management	A precocious variety that has produced a commercial crop at year 3. Responds well to ethephon. Appears resistant to pre-germination, husk spot and AVG. Further research is required but shows little self-compatibility.
Consultant comments	Being widely planted in both Qld and NSW because of its compact size, high kernel recovery and precocity. May be susceptible to husk spot. Will need good management to consistently bear good crops and seems to have a much higher nutritional requirement.

Recently released varieties

Four elite varieties were released in 2019 after testing for 9 years in regional variety trials. These varieties are described below, however, there is not enough information on their performance in commercial orchards to make definitive comments.

Variety G

A medium to large tree with a moderately open canopy. A newer early variety that performed well in trials at Bundaberg and Alstonville. Nuts cluster mainly in singles and doubles and drop mid to late in the season. Bears early.

Performance	42.6% SKR (based on varietal trials)
Nut drop	Early to mid-season (May to mid-August)
Management	A precocious variety. Susceptibility to husk spot is low. Some possibility of sticktights. Early trials suggest resistance to AVG.

Variety J

A tall, slightly spreading to round tree with a moderately dense canopy. Nuts are of medium thickness and cluster mainly in singles and doubles. Kernels are large. Bears early.

Performance	44.8% SKR (based on varietal trials)
Nut drop	Mid to late season (mid-May to mid-August)
Management	A precocious variety. Susceptibility to husk spot is low. Some possibility of sticktights. Early trials suggest resistance to AVG.

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Variety P

A short, round tree with a small, slightly dense canopy. It is an early bearer and nut drop pattern is consistent with a late peak. Nut clustering is variable on flower racemes and husks are very thin.

Performance	34.8% SKR (based on varietal trials)
Nut drop	Late season (July to end September)
Management	A precocious variety. Grows as a shorter tree on shallow soils at Bundaberg so could be planted at higher density. Low susceptibility to husk spot and husk rot. Appears resistant to AVG. Prone to sticktights.

Variety R

A short, slightly spreading, generally round tree with a medium to large, dense canopy. Nuts cluster in compressed to slightly open bunches and kernels are medium sized with medium to thick husks.

Performance	37.8% SKR (based on varietal trials)
Nut drop	Late season (June to mid-September)
Management	A later bearing variety. Low susceptibility to husk spot and husk rot. Appears resistant to AVG. Few sticktights.

Acknowledgments

Thanks to Bob Maier, Lindsay Bryen, Eddy Dunn, Kim Wilson, Chris Searle and Steve MacLean for providing comments on varieties.

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Hidden Valley Plantations website @ www.hvp-macadamias.com, accessed 4 November 2020.

Varieties G, J, P, R: See the AMS factsheets under Industry Resources on our website: https://australianmacadamias.org/industry/resources

MCT1: https://australianmacadamias.org/industry/resources/mct1-new-elite-macadamia-varietyMCT1



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Genetic variation in macadamia cultivars

Cathy Nock Southern Cross University

It's being dubbed the Ancestry.com project for macadamias, as researchers build up the family tree of Australia's most famous native food tree. The genetic diversity and structure of wild and domesticated macadamia trees is being investigated in a new Hort Innovation research project delivered by Southern Cross University (MC18004).

"By understanding the origins of the macadamia varieties grown in orchards, we expect to find where there is untapped variation that could drive future productivity," said lead researcher Dr Cathy Nock.

Australia is the centre of macadamia diversity (Figure 1). Wild populations are found only in the rainforests of subtropical eastern Australia. This means that Australia is in a unique position to use the natural variation that has evolved over 30 million years for breeding.

Recently, Cathy Nock, Craig Hardner and a team at the University of Queensland sequenced the chloroplast genome of Hawaiian varieties and trees from wild *Macadamia integrifolia* populations in Australia[1]. The chloroplast genome is maternally inherited so it is especially useful for tracing seed dispersal. The results provide evidence for a maternal genetic bottleneck during early macadamia domestication, and pinpoint the likely source of seed used to develop the Hawaiian cultivars to sites near Gympie and at Mt Bauple. The extensive variability and structuring of *M. integrifolia* chloroplast genomic variation detected in this study suggests much unexploited genetic diversity is available.

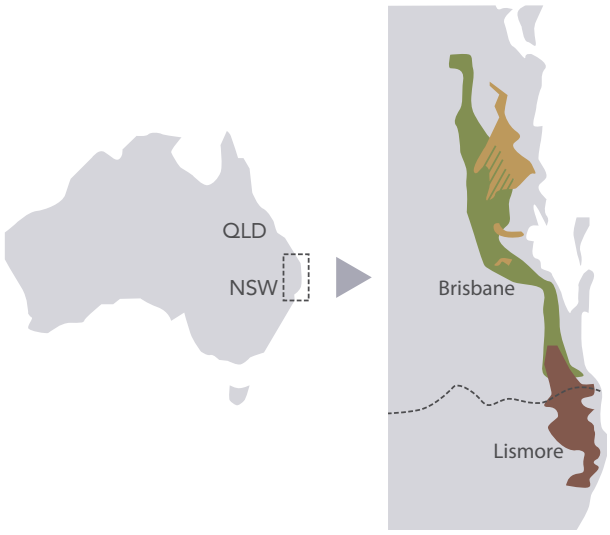


Figure 1. *Approximate distribution limits of the three species of macadamia that have been used in cultivation:* M. integrifolia *(green),* M. tetraphylla *(brown),* M. ternifolia *(gold). Most Hawaiian varieties are pure integrifolia but many of the varieties developed in Australia are hybrids with some tetraphylla content. Only one variety, HAES 791, is known to have ternifolia content.* Distribution map provided by Katie O'Connor.

This research is being expanded through the new Hort Innovation project MC18004 to include all four macadamia species, more cultivated varieties and old trees that may preserve the genetics of extinct wild populations. More than 70 cultivated varieties have been genotyped, along with wild trees in ex situ plantings of the National Macadamia Germplasm Collection comprising trees grown from cuttings of about 300 wild trees.

Over the past few years, Cathy has worked with the Macadamia Conservation Trust and the Wild Macadamia Hunt (https://hlw.org.au/project/the-wild-macadamia-hunt/) to collect leaf samples from many more wild and old trees. "We now have the largest representative collection of macadamia and are using this to characterise genetic diversity across the genus," Cathy said.

The trees are being genotyped using nuclear SSR (simple sequence repeat) markers that can provide information about both the maternal (seed) and paternal (pollen) lineages. These markers are useful for variety identification and have been used to confirm the identity of trees of the new varieties (MCT1, G, J, P and R) to ensure that the grafted trees for orchard planting are 'true to type'.

The MC18004 project aims to trace the ancestry of macadamia varieties including the predominant Australian industry and new levy-funded cultivars. Pedigree reconstruction will be used to confirm and discover interrelationships and improve our understanding of the history of macadamia domestication.

The early results show that *M. integrifolia* is the main species that has been used in cultivation. Most of the Hawaiian cultivars are closely related to one another while the Australian cultivars are more diverse (Figure 2).

Many of the cultivars developed in Australia, including early selections by Norm Greber and the A-series varieties developed by Hidden Valley Plantations, are *M. integrifolia* x *M. tetraphylla* hybrids. Interestingly, two of the new Australian levy-funded cultivars (J and P) and the new variety MCT1 are all hybrids. Breeding records and genetic evidence suggests that all have Renown (D4) and Own Choice grandparents. Renown is a first generation hybrid that is 50% integrifolia and 50% tetraphylla (Figure 3). The SSR data confirms that A16 is a parent of J and P while A4 is a parent of MCT1.

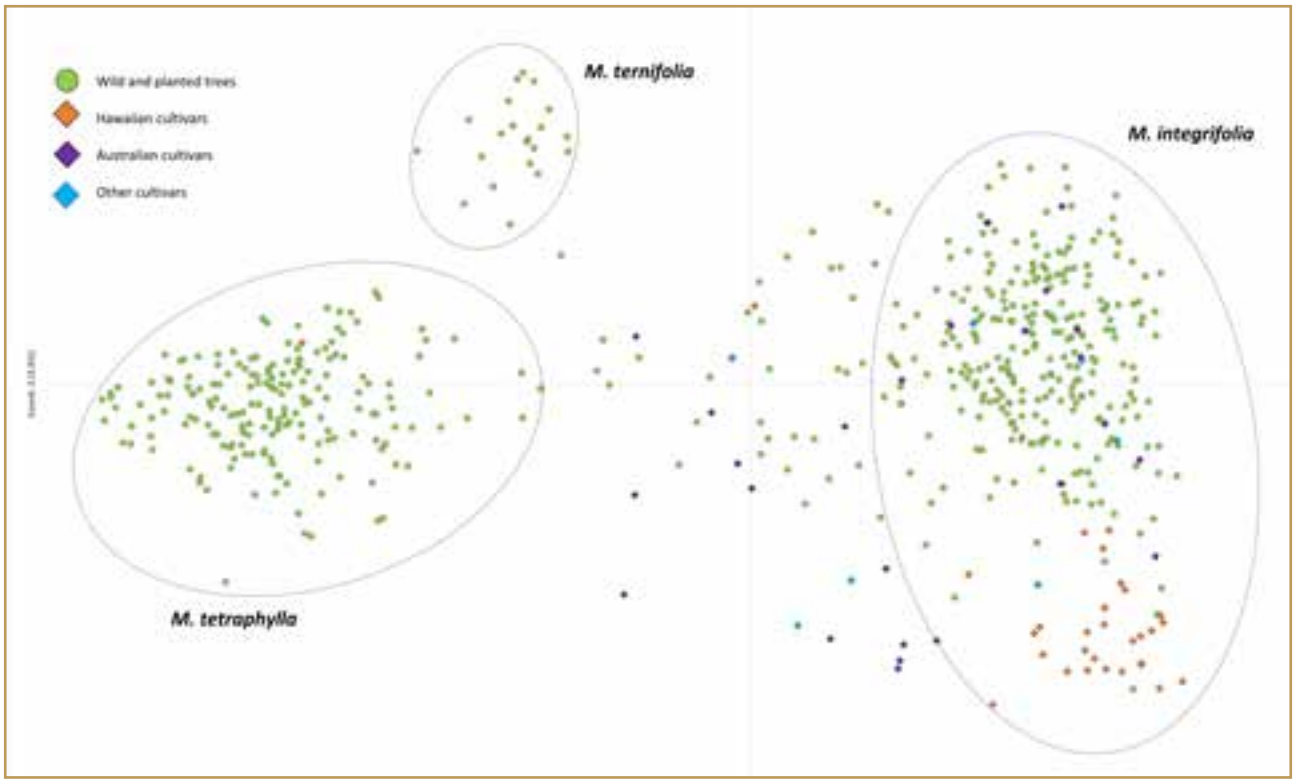


Figure 2. Principal coordinate analysis based on pairwise genetic distance. Many cultivars (represented by the orange and purple diamonds) are within the Macadamia integrifolia *space. The hybrid cultivars fall outside the three species groups (represented by dotted lines). Most Hawaiian cultivars are closely related to one another. The Australian cultivars are more diverse and many are hybrids of integrifolia and tetraphylla.*

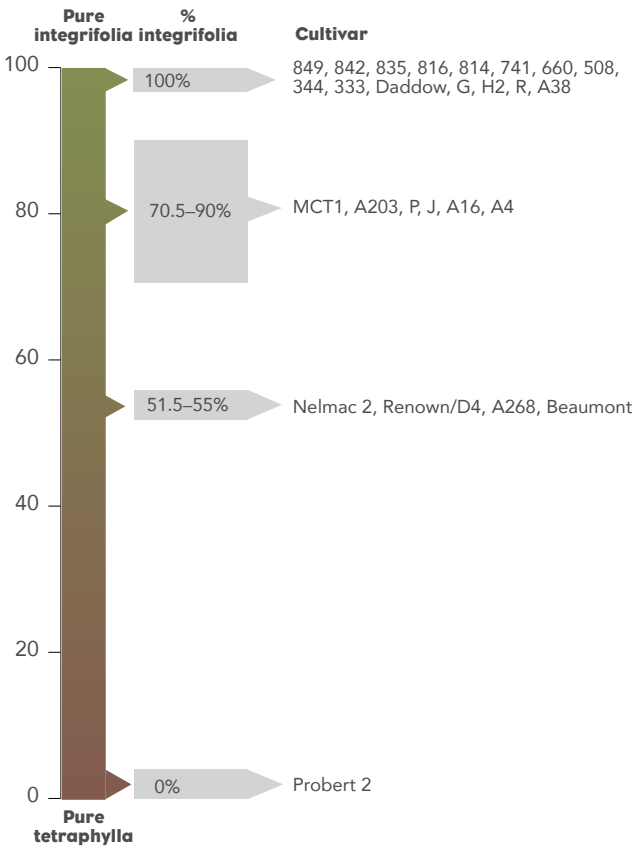


Figure 3. Species composition of macadamia cultivars. Most are M. integrifolia *(green) while others are hybrids with differing* M. tetraphylla *(brown) content. Beaumont, A268, Renown (D4) and Nelmac 2 are first generation hybrids and Probert 2 is pure* tetraphylla.

Despite the millions of trees in orchards around the world, all macadamia species are threatened in the wild. Defining the distribution and structure of genetic diversity in wild, planted and cultivated trees will help to prioritise wild populations for conservation. It is also expected to identify wild populations and trees with genetics already captured in cultivars and breeding programs, and those with novel genetics underrepresented in domesticated germplasm that could be important for future breeding to develop new improved varieties for the orchards of the future.

References:

1. Nock & Hardner et al. 2019, 'Wild origins of macadamia domestication identified through intraspecific chloroplast genome sequencing', *Frontiers in Plant Science,* 10:334, available at: www.frontiersin.org/articles/10.3389/fpls.2019.00334/full.

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Norm Greber: Pioneer of macadamia propagation

Ian McConachie Macadamia Conservation Trust

Norm Greber's contribution to the Australian macadamia industry was massive. From the 1920s to 1954 he pioneered macadamia farming and was the first in Australia to master the art of grafting macadamias.

Norm Greber (1902 to 1993), OAM and first Patron of the AMS was born at Rous, near Ballina in New South Wales. He grew up close to one of the first small-scale macadamia orchards and this was the start of his passion for macadamias which would last a lifetime.

In about 1920 Norm bought 40 acres (16 ha) of scrub in Amamoor near Gympie, cleared it by hand and planted bananas and pineapples. He then set about developing an Australian macadamia industry, searching for thin-shelled nuts. He selected and planted 500 seedlings on his farm, which he named 'Nutty Glen'. By the end of the decade his orchard, large for its time, comprised 1,000 trees.

In the post-war period in Australia conventional grafting techniques had been ineffective and government officers were yet to master the technique. Norm hadn't been told that macadamias were 'ungraftable', so he assessed each tree and tried to graft the better-performing seedlings. Using his skills and powers of observation he became the first Australian to graft macadamias for commercial production. His 'simple side graft' proved the most versatile. The superior varieties he developed included Own Choice, Greber Hybrid, NRG4, and NRG7.

In 1951, when the hills at Amamoor got too steep, Norm and his wife Kathleen moved to 33 acres (13.3 ha) of flatter land at Beerwah, north of Brisbane, and established macadamias and avocadoes. He continued to experiment with all aspects of breeding productive Australian macadamia varieties, investigated methods of improving tree culture, and invented hand tools and basic mechanical equipment.

In 1964, Colonial Sugar Refining (CSR) Ltd engaged him to train staff and bought his farm in the 1970s. Norm and Kathleen excised a 1500 m^2 plot from the farm to build their retirement home, a workshop, rainforest and a varietal experimental plot.

A step back in time

In what can be described as a time warp, the life of Norm Greber has been revealed. Steve and Cherine Lawer purchased Norm's former home and while exploring his workshop they found it untouched and just as it was in the 1980s when Norm's eyesight failed.



Top: Norm Greber, pioneer of macadamia propagation.
Left: The Norm Greber 'simple side graft'.

At their invitation, Peter Boyle and Jan and Ian McConachie were invited to view, photograph and preserve his artefacts. They were thrilled to find much evidence of his life untouched for more than 30 years.

Some of his copious notes from 1961 were still in the cottage, together with his traditional drying racks made of hardwood and chickenwire still containing some nuts and marked in chalk with the variety, such as GH (Greber Hybrid) or OV (Own Venture), and his reference 660.

About 10 of his varietal selections remain as large trees and, because space was limited, he had one tree with the main limbs each grafted to different varieties to save space and allow visual comparison. It is planned to leaf-sample his trees to determine their genetic diversity.

It takes little imagination to picture Norm at his desk, surrounded by all things macadamia, cracking and assessing nuts and envisaging the macadamia industry of the future.



Old hardwood frame and chickenwire drying racks found in Norm's old workshop.

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Short history of macadamia cultivars

Craig Hardner QAAFI UQ, **Cameron Peace** Washington State University,
Cathy Nock Southern Cross University, **Ian McConachie** Macadamia Conservation Trust.

Macadamias are unique in the international nut industry in that commercial varieties are still only one or two generations removed from their wild ancestors and the macadamia industry is in the enviable position of still being able to access the genetic diversity of the remaining wild trees.

Indigenous to the subtropical rainforests of south-east Australia, *Macadamia integrifolia* and *M. tetraphylla* produce large, edible, premium kernels; while kernel from *M. ternifolia* and *M. jansenii* are small, bitter and unpalatable. Genetically elite cultivars propagated through grafting have been important for the success of the world's macadamia industry.

Early Australian utilisation

There is growing evidence of the pre-colonial utilisation of macadamia by first nation Australians and trading with early settlers (McConachie, Kerkhove, pers. comm.). Awareness of the delicacy of macadamia kernels for consumption stimulated cultivation of macadamia trees by early settlers from the mid-1850s, mostly of *M. tetraphylla* seedlings. Remnants of the first seedling orchard (planted 1878–1888) still exist at Rous in northern New South Wales. The nurseryman Walter Petrie was an early champion of improved germplasm and sold seed collected from select mother trees in the early 20th century (such as Smooth Queen).

Hawaiian 1st generation cultivars: 1930s

A few seeds of macadamia were first introduced into Hawaii, USA, in the late 19th century, and seedling orchards were established in Hawaii from 1916, first with *M. tetraphylla* and then *M. integrifolia*. However, *M. integrifolia* became favoured due to perceived higher kernel quality, although this bias might have been due to poor handling of *M. tetraphylla* kernel.

Following the development of grafting technology for this crop, seedling orchards were systematically surveyed from the mid-1930s by the University of Hawaii to identify superior candidates for clonal propagation and further testing.

These surveys produced the following Hawaii Agricultural Experiment Station (HAES) cultivars:

- Ikaika (HAES 333), Kau (HAES 334) and Kakea (HAES 508) selected from the Nutridge orchard
- Keauhou (HAES 246) from the Keauhou orchard
- Keaau (HAES 660) and Mauka (HAES 741) (which appear to be the same genotype) from the Deschwanden orchard.

Honoka'a Special was selected by a large processor from their own orchards. Using DNA fingerprinting, all these cultivars trace back to a single wild population at Mooloo, south-west of Gympie, Queensland.

Greber and early Australian selections: 1940s and 1950s

Norm Greber was a pioneer of macadamia propagation and genetics (see article page 36). He evaluated and selected a range of cultivars in the 1940s, including:

- Own Choice
- Own Venture (an offspring of Own Choice)
- Greber
- Renown (also known as D4)
- a series of cultivars labelled with the prefix X or NG, including NG4 (a hybrid selection of Petrie's) and NG8.

Similar to Hawaii, systematic surveys were undertaken of Australian orchards in the 1950s by state agriculture departments to identify potential superior cultivars for clonal propagation. These surveys identified:

- Release (from Gympie)
- Hinde (H2, from the Gold Coast)
- NSW44 (from Highfield, near Casino, NSW; later referred to as HAES 695 in Hawaii and named Beaumont in California).

Daddow was selected from Maryborough, Qld, in the 1960s.

Advanced generation Hawaiian selections: 1960s to 1990s

Following the success of the 1st generation of cultivar development, the University of Hawaii introduced early Australian selections for evaluation and further breeding. The university continued active breeding to the early 1990s, with notable selections being:

- HAES 781, HAES 800, HAES 804, HAES 842 and HAES 849 (all recorded as offspring of Keauhou as the seed parent)
- HAES 814 (offspring of Honoka'a Special)
- HAES 816 (offspring of Rickard, a selection from Maryborough, Qld).

Others

A macadamia selection program was developed in the 1960s in California, USA, particularly favouring pure and hybrid *M. tetraphylla*. Faulkner was selected from a property at Santa Paula, California, planted in the early 20th century. New selections from Hawaii and Australia were introduced to California in the 1960s, including HAES 695/NSW44/Beaumont.

In South Africa, Nelmak 1 was reportedly selected from trees grown from seed introduced from Hawaii in the

1930s and is the seed parent of further South African cultivars, Nelmak 2 and Nelmak 26. Local cultivars have also been developed in other countries including China, Brazil and Kenya.

Bells and industry-supported breeding programs: 1972 to present

Henry and David Bell of Beerwah, Qld, used predominantly early Australian selections to produce cultivars (prefixed with A) that are grown extensively in Australian and overseas orchards. Own Choice was the seed parent for A4 and A16 (pollinated by Renown) and A38; while Kau (HAES344) is recorded as the seed parent of A268.

Australian and Hawaiian cultivars were crossed in mid-1990s to produce the first breeding population of the Australian Macadamia Breeding Program. In 2017 four new cultivars were released (the prefix MIV1 stands for Macadamia Industry Variety 1st release):

- G (Daddow × Keauhou)
- P (A16 × HAES 814)
- J (A16 × HAES 781)
- R (HAES 842 × Daddow).

The new cultivar MCT1, released by the Macadamia Conservation Trust to support conservation of wild macadamia populations, was selected by Ian McConachie from seed collected from the Hidden Valley selection A63 (progeny of Renown), supplied by Calvin Winks from the Queensland Department of Primary Industry in the 1980s.

Further reading

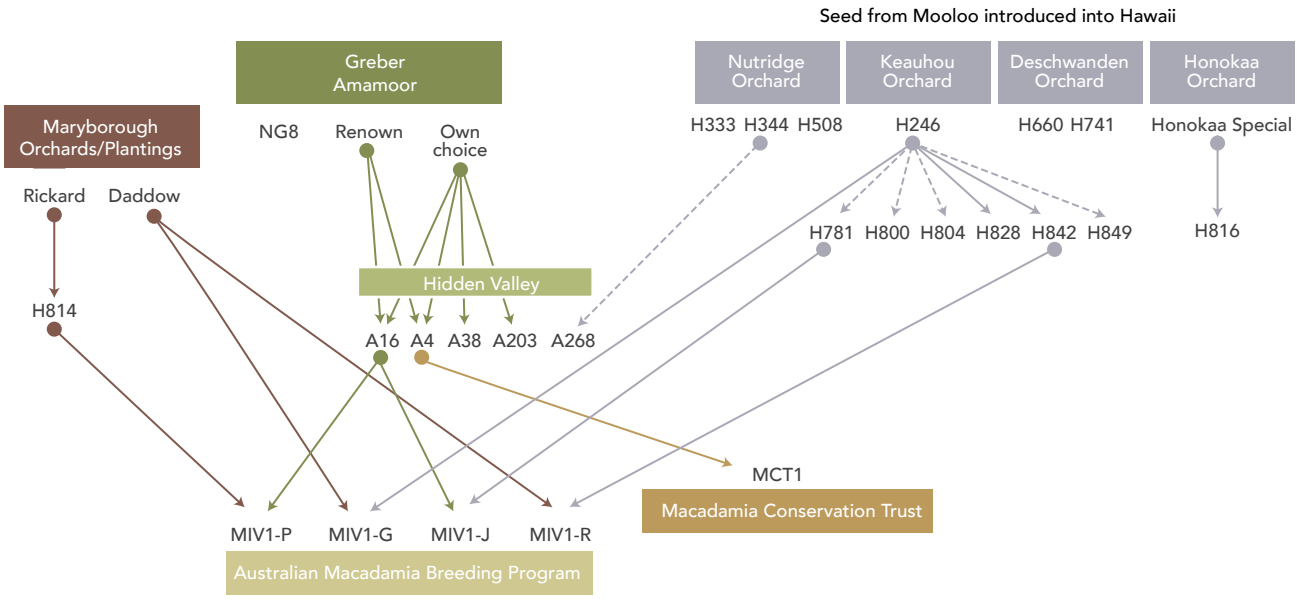
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Current understanding primarily derived from historical records and molecular studies of pedigree of major cultivars used in the Australian industry. Dashed lines indicate uncertainty of historical pedigree due to recent molecular studies. Suffix 'H' represents 'HAES' used in text.

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Regional variety trials – Testing the performance of new varieties since 1983

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All commonly grown varieties have been tested, and are being tested, in the regional variety trials (RVTs). With planting of the latest selections about to commence, it is timely to look back at their history and how they have contributed to the varieties that are commonly grown today.

Regional variety trials (RVTs) have been evaluating the performance of new varieties for the Australian macadamia industry for over 30 years, with the support of Hort Innovation, QDAF, University of Queensland and CSIRO. It is also important to acknowledge the significant contribution of the many growers who have hosted and managed trials on their farms, without whom this work would not be possible.

The latest phase of RVTs (Series 4) is scheduled to be planted in 2020 and 2021. These trials will test the second generation of elite selections from the industry breeding program via a series of comprehensive and supplementary grower trials in a 'rolling front' of evaluation over the next 6 years.

RVTs have historically tested promising macadamia germplasm and, over a number of years, compared yield and quality at randomised, replicated trial sites in a range of typical farm environments. Evaluation over extended periods and in various locations has provided critical performance data for a wide range of conditions, including the capacity to recover after challenging seasons. The availability of regionally specific production data has helped facilitate adoption of a range of varieties across major production regions in Australia.



An elite selection from second-generation progeny showing kernel recovery above 40%. This is one of many elite selections that will be assessed in RVT4.

Variety	Suitability by location					
	Clunes	C'house Mnts	Wolvi	Bauple	Rock-hampton	Walkamin
246	✓					
660	✓					
741			✓		✓	
781	✓					✓
783			✓			✓
814		✓	✓	✓		
816	✓	✓				
842			✓		✓	
849	✓		✓		✓	
Daddow		✓	✓	✓	✓	✓
A16			✓	✓		✓
Total tested	18	40	19	40	19	19

Table 1. RVT series 1 testing locations and suitable varieties based on cumulative saleable kernel (kg/tree).

RVT Series 1: 1983–1995

The first regional variety trials were established in 1983 and were evaluated for 12 years. Testing locations and leading varieties trialled are shown in Table 1. These trials evaluated Hawaiian Agricultural Experimental Station (HAES) varieties, Hidden Valley Plantations (HVP) selections and other Australian varieties. A total of 38 varieties were grown at each location.

RVT Series 2: 1992–2009

The second series of RVTs were planted in expanding regions such as Bundaberg and NSW Mid North Coast. Once again many promising varieties were evaluated, including additional selections from HVP and

other Australian selections made by Backer (B), Ian McConachie (Mc), Misfield (Daddow and Heilscher) and Norm Greber (NG8 and Own Venture). Trial locations and associated top performing varieties are shown in Table 2.

RVT Series 3: 2008–Present

The third series of RVTs were established between 2008 and 2009 and included the first generation of elite selections from the CSIRO breeding project. Twenty elite selections and five HVP selections were evaluated along with industry standards in a range of sites around Queensland and New South Wales. Trees in these trials are now between 11 and 12 years of age and assessment of their performance is ongoing. A summary of the varieties being assessed is shown in Table 3.

A private, grower RVT was also planted in 2012 at Decortes, north of Bundaberg. This trial tested 14 second-generation selections, two RVT3 selections and other varieties including MCT1 and three industry standards. This trial is currently being assessed with analysis and recommendations expected in 2021.

Commercialisation of new macadamia varieties

The performance of all selections in RVT3 were comprehensively and statistically analysed and assessed to age 8 years. A range of varietal traits were economically weighted and assessed to rank the performance of all selections. This process was undertaken by the Macadamia Industry Varietal Improvement Committee (MIVIC) in 2016. These traits included yield, kernel recovery, canopy size, harvest length, sticktights, Ethrel® response and susceptibility to a range of pests, diseases and disorders. This process was used to balance the diverse range of tree characteristics and rank them in an unbiased and transparent manner.

Variety	Rankings by location (cumulative sound kernel yield)			
	Macksville	Forest Glen	Hinkler Park	Winfield
A29	1	1		
A38	2	2	6	
A4	4	5		
A268	5	3		1
A16		4		6
A203	6	6	2	
A422				2
816			3	5
842			1	4
856				3
246	3			
Daddow			5	
Heilscher			4	
Total tested	**14**	**10**	**27**	**36**

Table 2. RVT series 2 testing locations, number of varieties tested, and rankings of top performing varieties based on cumulative sound kernel yield (kg/tree).

Location	Varieties/selections	Source
Macksville Alstonville Bundaberg Emerald Mackay	20 elite selections (coded A to T)	Macadamia breeding project
	A376, A403, A422, A447, A538	Hidden Valley Plantations
	344, 246, 741, 816 and A16	Industry standards

Table 3. RVT series 3 locations and varieties tested.

Four of the top-ranking RVT3 selections at year 8 were subsequently commercialised in 2017 and are now available as varieties MIV1 (Macadamia Industry Variety 1st Release) G, J, P and R. Since their release in mid-2018 the numbers of trees sold has roughly doubled with each reporting year. In 2020–21, firm forward orders suggest that sales will triple again, and it is expected that around 70,000 trees will have been planted by the end of this reporting year.

The varieties G and P have proved to be most popular so far, but more plantings are expected of variety J in Bundaberg and R on the Northern Rivers plateau as these are well suited to these environments. More detailed information about these new varieties is available at www.macadamiainnovation.com.au.

Uptake of new varieties has generally been aided by data from previous RVT trials. While factors influencing adoption of new varieties can be complex and varied, life cycle research has shown that uptake is generally slow initially (i.e. in the first 5 years). After this, uptake increases substantially in subsequent years as wider-scale confidence in the new variety increases. Limited budwood supply can also limit uptake of newly developed varieties and this has certainly been a factor for the new varieties G, J, P and R. Additional blocks of trees have now been planted in New South Wales and Queensland to improve the supply of budwood in the near future.

RVT Series 4: 2020 onwards

The latest elite crosses from the macadamia breeding program are now being propagated for planting in a new series of regional variety trial plantings. This will include comprehensive trial sites in Bundaberg and Wollongbar, an abnormal vertical growth (AVG) trial in Bundaberg and six grower supplementary sites in key regions in Queensland and New South Wales (Figure 1). RVT4 will

test genotypes from the second generation of the breeding program (MC14000) as well as varieties invited from local and international sources.

Elite selections that don't make it to commercialisation still have significant value as parents within the breeding program. All of the commercialised MIV1 varieties were derived from high performing parents identified in previous RVTs. These elite selections will continue to be crossed in subsequent generations to maximise genetic potential and performance of future varieties for industry.

Acknowledgements

The regional variety trial projects have been funded by Hort Innovation, using the macadamia research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

The Queensland Government has also co-funded the project through the Department of Agriculture and Fisheries.

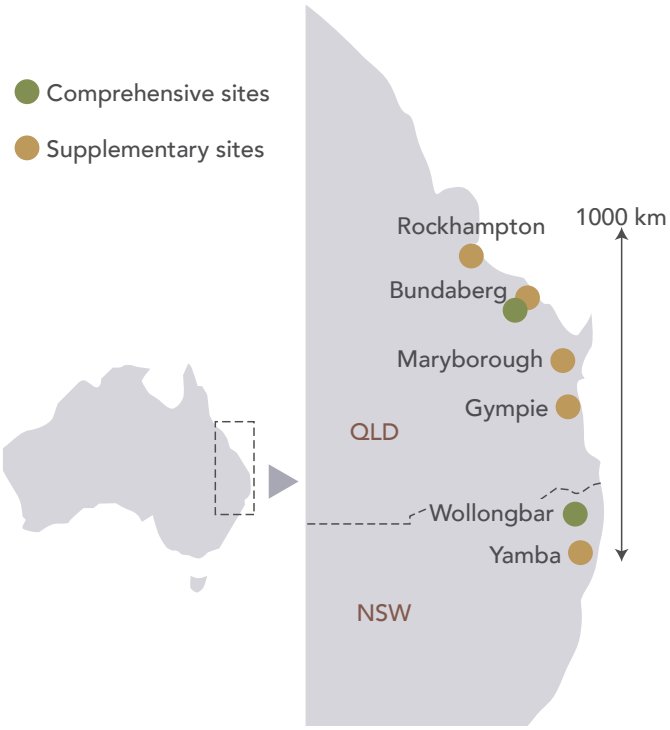
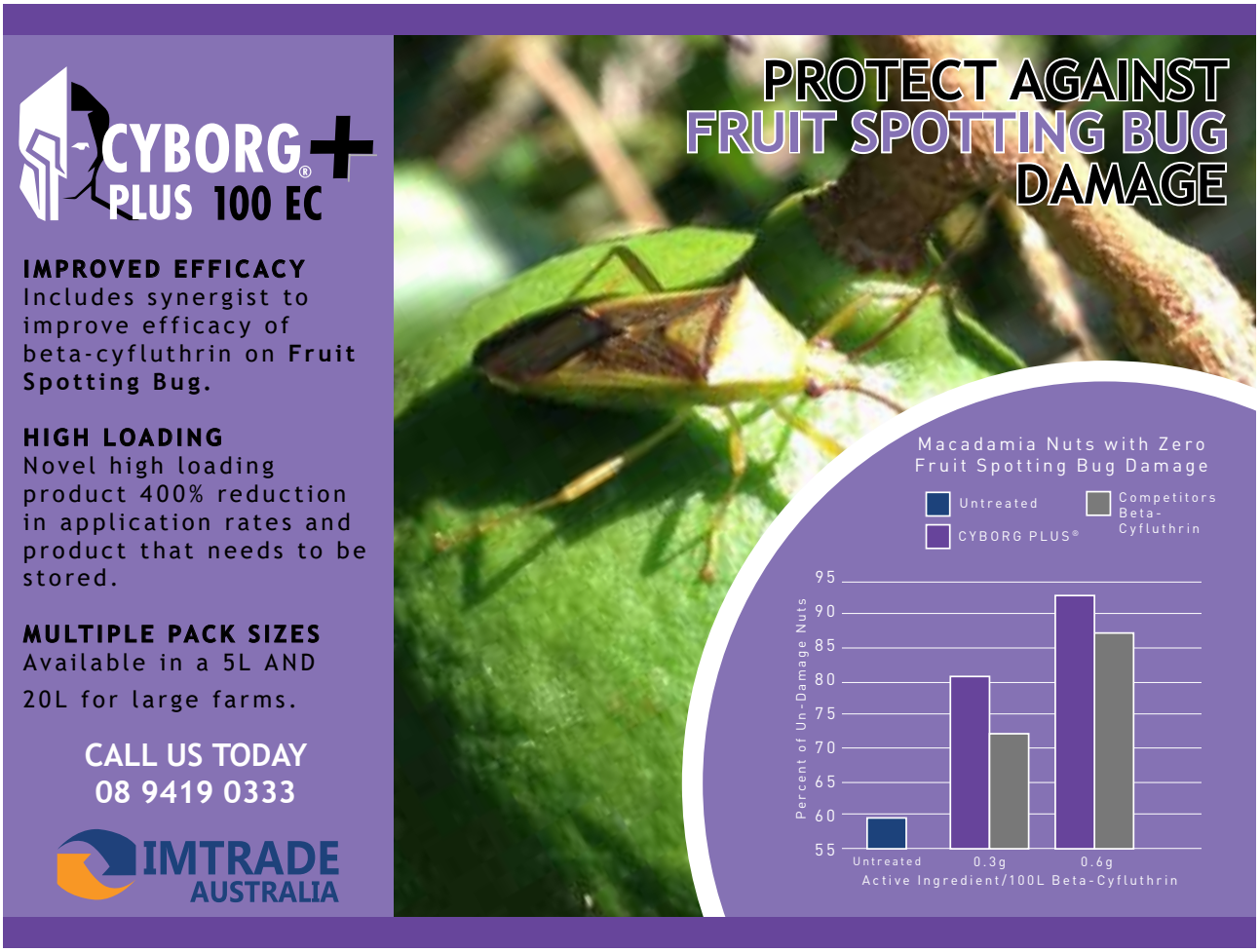


Figure 1. RVT4 proposed trial sites.



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Project snapshot

The macadamia research and development levy has invested in breeding research to increase grower profitability and sustainability of the Australian industry through the development of superior new varieties that are suitable to a range of regions and production systems.

The primary outcome of the *Macadamia second generation breeding and conservation project* (MC14000) was the development of more than 20 elite selections for field evaluation as potential new varieties for industry. This involved many processes and areas of research including:

- creating new seedling populations
- selection of second-generation progeny
- introducing genomics and DNA technology to reduce breeding cycle timeframes
- screening for disease resistance
- exploiting wild germplasm to increase genetic diversity.

Many of the field trials established during the project were planted on grower properties, which extends the range of tested environments and provides industry-based performance data.



Progeny trees planted at high density (4 m x 0.5 m) trial at the Maroochy Research Facility, Nambour.

New seedling populations created

Over 8,000 seedlings were generated and planted from cross pollinations and open pollinations between 2011 and 2018 (Table 1). Evaluation of these seedlings is continuing to identify elite selections that will be the basis for the next generation of varieties for industry.

Over 70 parents have been selected to create the second generation of progeny based on their genetic potential for yield, kernel recovery, tree size and other economically valued traits. These parents are combined using open pollination and also controlled cross pollination to produce seedling progeny.

The majority of these parents are elite first-generation selections that have no names, only breeding codes. Varieties that have been used in the ancestry of the breeding material include 741, 781, 842, 814, 791, 849, 816, 246 and 344 from Hawaii; A16, A4, A38 and A268 from Hidden Valley Plantations; and the Australian heritage varieties Daddow, Release, Renown, NG7, NG8 and NG18.

Location	Year of planting	No. of progeny planted	No. of parents
Bundaberg Research Facility[a]	2012	472	20
	2013	873	33
	2014	563	31
	2015	553	25
	2016	250	18
	Total	2711	
Maroochy Research Facility[b]	2011	704	39
	2018	1617	17
	Total	2321	
Alloway[b]	2017	1325	11
Pine Creek[b]	2017	620	9
Childers[b]	2017	572	6
Emerald[b]	2018	575	7
Grand total	**8124**		

Table 1. Details of progeny planted between 2011 and 2018.

Notes:
a: The parents are combined by controlled cross-pollination to produce the progeny.
b: Open-pollinated seeds are collected and germinated to produce the progeny.

Selection of second generation progeny



Growers and researchers with a 7-year-old dwarf selection at Bundaberg Research Facility.

A total of 23 elite selections were identified from the most mature seedling populations planted at the Bundaberg Research Facility. These were selected based on their improved kernel recovery, yield and precocity as well as reduced tree height and canopy size. Evaluation of these selections by the breeding team as well as the Macadamia Industry Variety Improvement Committee (MIVIC) has strengthened recommendations for further testing in regional variety trials (RVT). This testing will continue over the next 10 years to determine which of the selections will be released as the next generation of varieties for industry.

DNA technology to reduce breeding cycle time

Dr Katie O'Connor's PhD project introduced the use of DNA marker technology to reduce the duration of the breeding selection cycle. Molecular or genetic markers are fragments of DNA that are found at specific locations in the genome. These markers are used because they are either part of the gene controlling a trait of interest (e.g. yield), or more commonly because they are linked to that gene.

The study showed that seedling progeny were genetically diverse and that there is an opportunity to exploit marker technology to improve breeding efficiency. Research was undertaken to develop an understanding of the genes that specifically control yield-related traits. These include nut weight, kernel weight, kernel recovery, percentage of whole kernels, tree trunk circumference, total nuts per raceme and the percentage of racemes surviving from flowering through to nut set.

A genome-wide association study can be used to detect the presence or absence of markers that control traits of interest such as these. The benefit of this approach is that certain traits, such as yield, can be identified from a leaf sample at a very young age, rather than having to wait years to measure actual yield from a mature tree.

The study identified seven molecular markers significantly associated with nut weight, four associated with kernel weight, and 44 associated with trunk circumference. A genomic selection model was subsequently developed to predict the yield performance of breeding progeny.

Katie's study demonstrated that reducing the selection time for economically important nut characteristics resulted in increased genetic gain. The genomic selection processes developed through her research will rapidly predict complex traits like yield and tree size, which will ultimately allow new superior varieties to be identified and released to industry more rapidly, up to 4 years earlier than traditional techniques.

Screening for disease resistance

In 2017 a completed precocity trial planting was converted into a husk spot *(Pseudocercospora macadamiae)* disease-screening nursery with the aim of screening a large number of diverse genotypes. Bags of diseased husk were hung in trees as sources of inoculum. A moist environment was created using overhead sprinklers to ensure spreading and infection of the disease to developing husks. Nuts in infected trees were assessed for husk spot symptoms and premature nut drop.

Jasmine Nunn commenced a new PhD research project in January 2019 to investigate husk spot genomics. A husk spot screening experiment at the Tiaro ex situ germplasm block was established in spring 2019 to evaluate 212 wild macadamias and 14 cultivars. This screening was repeated in 2020 to identify trees with resistance to husk spot, which will be used in future breeding.



Husk spot screening trials showing a susceptible seedling.

Wild germplasm trials and development

The breeding program has access to a large collection of wild macadamias that aren't available anywhere else in the world. This gives the Australian breeding program a competitive edge over others through the availability of genetically diverse material that can be incorporated into future varieties through cross pollination. This collection of diverse genetics may hold a range of desirable traits for future varieties.

Over 300 wild accessions of all four macadamia species were genotyped using molecular markers. Accessions are genetically unique individuals (trees) collected from a specific location. Analysis of genetic diversity and population structure confirmed the species status of the wild accessions and revealed that there was a relationship between genetic distance and geographic distance for *M. integrifolia*. This means that the further apart trees were located the less they were related.

Over 200 accessions were also evaluated from 2017 to 2019 for key nut traits including nut weight, length and width, shell thickness and weight and kernel recovery and weight. Other traits evaluated included tree height, trunk circumference, canopy width and length, flower colour, new flush leaf colour and leaf serration.

A genome-wide association study is being performed to identify molecular markers associated with economically important traits. This work is occurring at two ex situ wild germplasm field trials at Alstonville and Tiaro. This study will identify desirable traits from wild germplasm that can be utilised in the development of new varieties.



PhD student Mai Thi Phuong Thuy at the wild germplasm trial in Tiaro.

New macadamia breeding project

The *National macadamia breeding and evaluation* program (MC19000) commenced in December 2019 and will run until 2024. The project will continue to produce new cultivars that increase the profitability and sustainability of the Australian macadamia industry. While aiming to increase yield, the project will also conduct research that enables breeding cultivars for the future through smaller trees, compact nut drop, self-fertility, precocious cropping and adaptation to warmer climates. See the full news article on the AMS website.

Acknowledgements

The M*acadamia second generation breeding and conservation* project (MC14000) project has been funded by Hort Innovation, using the macadamia research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

The Queensland Government and the University of Queensland have also co-funded the project through the Queensland Alliance for Agriculture and Food Innovation (QAAFI). We thank the growers and managers of our field trials and the project steering committee. These include Lindsay Bryen, Clayton Mattiazzi, David Bell, Adrian Walsh, Scott Alcott, Kevin Quinlan, Les Gain, Gary Kelly, Sue Kelly, Johan Oosthuizen, Ray Norris, Chris Searle and Ian McConachie.



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New Hidden Valley A-series variety release

The Bell family are well known for the A-series breeding program under the name Hidden Valley Plantations (HVP) that has produced many commercial macadamia varieties, including A4, A16, A29, A38, A203 and A268. The latest A-Series selections A376, A447 and A538 have performed very well in industry trials and warrant consideration when planting new orchards or replanting.

Henry Bell started the HVP breeding program in 1975. Not satisfied with Hawaiian varieties, bred to suit Hawaiian conditions, Henry set out to breed varieties that suited the birthplace of macadamias. His son David Bell continues the family's legacy and is in the process of commercialising the three new varieties. Some of the main criteria in Australian breeding programs are early bearing, high kernel yield and quality kernel.

High kernel recovery is also very desirable, increasing overall profitability. Many other agronomic factors, including insect and disease resistance, are part of 28 characters being assessed in HVP's breeding program. Assessments of more than 8,000 seedlings have taken place over 45 years.

Selections in the latest release were trialled as part of the industry's varietal improvement program, Regional Variety Trial Series 3 (RVT3). The trials tested 30 genotypes, consisting of five industry standard varieties; 20 elite selections from the Australian Industry breeding program; and five selections from the Hidden Valley breeding program. Below are summarised trial results of the new A-Series performance in comparison to standard varieties. Photographs and data courtesy of DAFQ RVT3 project, trees photographed at year 7.

Hidden Valley A376	Hidden Valley A447	Hidden Valley A538
		
A376 has a high kernel recovery and performed consistently well in trials. It was ahead of the standards at all sites except Wirra Willa and on average it was $1,040/ha/yr ahead of the standards.	A447 is a small tree, the smallest in the RVT3 trials and around 30% smaller than a HAES 246. Canopy is slightly dense. A447 outperformed standards at Alstonville, DeCortez and Childers; and on average it was $430/ha/yr ahead.	A538 is precocious, quite similar to A4 with a smaller kernel and tree size. This selection was ahead of the standards at Alstonville, DeCortez and Childers. It was not planted at B3. On average it was $850/ha/yr ahead.
Tree size: Medium	Tree size: Small	Tree size: Small
Precocity: Medium	Precocity: Medium	Precocity: High
Harvest period: Mid-season	Harvest period: Late, clean drop	Harvest period: Mid-season
Responds to Ethrel	Moderate response to Ethrel	Responds to Ethrel
Kernel recovery: ~46%	Kernel recovery: ~42%	Kernel recovery: ~45%
Kernel size: ~2.8g	Kernel size: ~3.3g	Kernel size: ~2.5g

Quantitative measures

Yield (in-shell, IS). The RVT3 kg/tree values are converted to tonne/ha. The average of years 4 through 9 is used and is multiplied by six for cumulative yield up to year 9. See Table 1.

Kernel recovery (KR). Figures as per the RVT3 project results with no modifications. See Table 2.

Gross revenue per hectare. Calculated from yield and KR with base price of $5/kg @ 33%KR, adjusted linearly for KR. See Table 3.

Regional sites and A-Series gross revenue compared to standards

Alstonville (AL). $1,570/ha/yr more than standards.

'DeCortez' & 'Booyan' (B1 & B2). $550/ha/yr and $290/ha/yr more than standards respectively.

Bundaberg Sugar (B3). $900/ha/yr more than standards

Childers (CH7). Best performing site, even with 2 years' less data due to cyclone destruction in year 7. $870/ha/yr more than standards.

Wirra Willa (WW). Also storm damaged, this was the only site the new A-Series did not outperform the standards.

Key to tables:

Top 5 | Top 10 | Bottom 10 | Mid 15

Figures in italics are calculated estimates.

New A-Series	Alstonville	BI DeCortez	B2 Booyan	B3 Bundy Sug	Childers (to yr 7)	W.Willa (AVG)	Average
A376	1.48	1.24	1.88	1.24	2.37	1.35	1.59
A447	1.93	1.32	1.71	1.21	2.35	1.39	1.65
A538	1.88	1.23	1.46	1.15	2.35	1.22	1.55
A403*	1.86	1.64	1.74	1.29	2.40	1.57	1.75
A422*	1.53	1.13	1.66	1.00	2.40	1.31	1.50
Average All	1.74	1.31	1.69	1.18	2.37	1.37	1.61

Standards	AL	BI	B2	B3	CH (to yr 7)	WW	Average
246	1.83	1.53	1.92	1.31	2.36	*1.63*	1.76
344	1.69	1.45	1.84	1.23	2.36	1.42	1.67
741	1.37	1.14	1.97	1.11	2.34	*1.63*	1.59
A16	1.45	1.40	1.68	1.16	2.37	2.04	1.68
816*	1.96	1.06	1.73	1.09	2.51	1.73	1.68
Average	1.58	1.38	1.85	1.21	2.36	1.68	1.68

Table 1: Yield in-shell tonne/ha, average of years 4 to 9.

New A-Series	Alstonville	BI DeCortez	B2 Booyan	B3 Bundy Sug	Childers (to yr 7)	W.Willa (AVG)	Average
A376	44.8%	46.1%	46.1%	50.0%	45.4%	45.4%	46.3%
A447	41.8%	41.1%	41.1%	41.1%	43.2%	43.4%	41.9%
A538	42.8%	45.8%	45.8%	44.6%	43.8%	44.6%	44.6%
A403*	43.2%	42.9%	42.9%	41.7%	37.7%	41.5%	41.6%
A422*	39.5%	40.7%	40.7%	42.8%	38.8%	42.6%	40.9%
Average All	42.4%	43.3%	43.3%	44.0%	41.8%	43.5%	43.1%

Standards	AL	BI	B2	B3	CH(7)	WW	Average
246	39.0%	39.2%	39.2%	40.6%	38.9%	*39.4%*	39.4%
344	34.0%	35.1%	35.1%	38.9%	*35.4%*	34.2%	35.4%
741	36.4%	38.3%	38.3%	44.0%	36.8%	*38.8%*	38.8%
A16	40.1%	42.0%	42.0%	41.5%	41.8%	45.0%	42.1%
816*	46.1%	44.8%	44.8%	46.9%	46.1%	45.7%	45.7%
Average	37.4%	38.7%	38.7%	41.2%	38.2%	39.3%	38.9%

Table 2: Kernel recovery (%)

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New A-Series	Alstonville	BI DeCortez	B2 Booyan	B3 Bundy Sug	Childers (to yr 7)	W.Willa (AVC)	Average
A376	$10,030	$8,654	$13,123	$9,383	$16,323	$9,309	$11,137
A447	$12,207	$8,214	$10,660	$7,554	$15,362	$9,163	$10,527
A538	$12,231	$8,500	$10,144	$7,784	$15,586	$8,271	$10,419
A403*	$12,159	$10,664	$11,333	$8,154	$13,679	$9,896	$10,981
A422*	$9,177	$6,953	$10,258	$6,476	$14,070	$8,439	$9,310
Average*	$11,489	$8,456	$11,309	$8,240	$15,757	$8,914	$10,694

Standards	AL	BI	B2	B3	CH (to yr 7)	WW	Average
246	$10,816	$9,107	$11,426	$8,082	$13,885	*$9,749*	$10,511
344	$8,710	$7,735	$9,793	$7,257	*$12,653*	$7,331	$8,913
741	$7,560	$6,588	$11,438	$7,431	$13,074	*$9,590*	$9,280
A16	$8,806	$8,937	$10,685	$7,289	$15,034	$13,886	$10,773
816*	$13,716	$7,174	$11,746	$7,755	$17,560	$12,009	$11,660
Average*	$8,973	$8,092	$10,836	$7,515	$13,662	$10,139	$9,869

Table 3: *Gross income $/h, average of years 4 to 9 ($5 kg base price).*

* A403, A422 not included in average, not released
* 816 not included in average, no longer planted due to disease issues

Averaged across all sites from years 4 to 9, the gross revenue of the new A-series group was approximately $770/ha/year ahead of the standards group in RVT3.

This represents a total gain for the new A-series, compared to the standards, of $4,620/ha by year 9.

For completeness, the other selections in RVT3 that are not currently in the latest release but have future potential are A403 and A422.

A403 is a slightly larger tree selection outperformed the standards at all sites except Childers and Wirra Willa, on average $880/ha/yr ahead. Kernel size is ~3.0 g. It has a late season drop pattern and low response to Ethrel.

A422 is a high yielding selection at Hidden Valley in the Glasshouse Mountains has not performed as well in the trials. Kernel size is ~3.1 g. It is a medium size tree with a late season drop and low response to Ethrel.

Availability and royalties

The new varieties will become available in 2020 only through licensed nurseries and royalties are payable as they are protected under Plant Breeders Rights. Royalties are the only source of funding for the breeding program and HVP do not receive any industry levy funds. More details of the HVP varieties, a list of licensed nurseries and options to submit an enquiry are available on the HVP web site: www.hvp-macadamias.com.

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MCT1 – Against all odds

Denise Bond and **Ian McConachie** both Macadamia Conservation Trust

MCT1 is one of the promising new varietal releases. Its precocity, yield, kernel recovery, moderate tree size and adaptability have resulted in strong demand, and royalties from its sale are contributing to the conservation of our wild trees.

Discovery and development of MCT1 is as unique as the variety itself. Over four decades the perseverance of Ian McConachie, aided and abetted by a handful of skilled people who shared his vision and commitment, ensured that this promising variety was noticed, protected and made available to the industry. In gifting Plant Breeder Rights to the Macadamia Conservation Trust, Ian and Jan McConachie have invested in securing the industry's gene bank, as well as conserving the rich biodiversity of Australia's subtropical coastal rainforests.

And yet this might easily never have happened. The recognition and development of MCT1 is quite a story, as Ian relates …

In 1981 Calvin Winks, Senior QDPI Plant Breeder offered batches of 220 small seedlings in Jiffy pots to growers interested in planting and assessing them. Five or six growers accepted the offer. Calvin Winks, Tim Trochoulias from the NSW Department of Agriculture and Henry Bell from Hidden Valley, selected nuts from open pollinated seedlings from trees that they considered likely to be 'good parents'. Many were seedlings of H2, there were crosses and seedlings from the Bell family breeding program, and the remaining were selected by Calvin from a variety of sources.

One batch was planted at Wolvi, Gympie in a 5 x 2 metre spacing and at year 5 all trees not cropping or having low kernel recovery were removed. By 1990, after annual assessment and culling, 23 trees remained. These were grafted and four trees of each planted.



*MCT1's thin shell leads to high kernel recovery. P*hoto: Ian McConachie

Over the next two decades, we assessed the crop from these selections, recording volume, sticktights, quality and kernel recovery. Three selections: M407, M416 and M428 consistently stood out but were among hundreds of other promising trees from the official breeding program and from other growers.

Picking an elite tree from many other good performers is most difficult and often relies on eliminating promising trees because of any significant defect. M428 was a hybrid and prolific bearer but had quality defects and was deleted. M407 and M416 were offered to the Industry Breeding Program but were rejected because at the time of assessment, which was early in the season, they still had high levels of immaturity. My yearly assessments at Wolvi rated them at the top of about 80 varieties with no immaturity problems, they just matured slightly later in the season. A few trees were given to growers to assess and at Bundaberg they quickly stood out with large crops of high kernel recovery from a modest sized tree. Any concerns about immaturity were allayed by the confirmation that the variety simply matures later than most commercial varieties.

A rigorous process to establish ownership was undertaken and in 2017 the cultivar was gifted to the Macadamia Conservation Trust and protection obtained under the Plant Breeder's Rights Act. Advanced DNA testing techniques revealed that M407 and M416 were in fact genetically identical and they were treated as one cultivar and renamed MCT1 after the Macadamia Conservation Trust.

DNA analysis shows MCT1 to have a solid Australian selection pedigree, with some DNA from the Bell family selections A4 or A63, which in turn are related to some of Norm Greber's original selections: Renown or Own Choice or in the case of A4, both. Through Own Choice, MCT1 also shares DNA with Hawaiian varieties 246 or 828. Its wild origins are from the northern distribution of *M. integrifolia* with an *M. tetraphylla* of unknown provenance as one of its great-grandparents.

Much was learnt during the process of applying for Plant Breeder Rights (PBR) and making MCT1 available to growers, which might be of assistance to future breeders:

- Prior to PBR registration several growers had observed its potential, taken cuttings and grafted it. If permission to graft and sell had been granted at that time, it would not have been possible to apply for PBR.
- Tree morphology may not be sufficient to identify cultivars. Once the PBR application had started, reports were received of much lower kernel recovery from some trees. Through DNA analysis it was established that M500, a cultivar with an almost identical tree morphology, had been confused with and in some cases grown as MCT1. To make sure



MCT1 to the right of 741. Photo: Ian McConachie

that this confusion would not result in the lower performing M500 trees being sold as MCT1, the Trust took the unprecedented step of confirming all MCT1 parent trees by DNA testing at Southern Cross University. Even with some assistance from a Tech Voucher Grant from the NSW State Government, the cost of DNA authentication for MCT1 has been close to $80,000.

- Sourcing and bulking up propagating material has been a challenging process, badly impacted by the dry conditions of 2019.

The path has been slow and uncertain but enough people believed in its potential to advance industry productivity: Lindsay Bryen, Jolyon Burnett, Brice Kaddatz, Jan and Ian McConachie, Gavin Porter from ANFIC, Chris Searle and Bruce Topp. These people freely gave of their skills and time to overcome the hurdles and bring MCT1 to the industry and the Trust.

You don't have to climb trees to be a Wild Macadamia Champion



Paul O'Hare, MCT Chairperson, collecting a leaf sample. Photo: Ian McConachie

One of MCT's important conservation activities is to work with owners of wild macadamias to protect significant trees and habitat. Here MCT Chairperson, Paul O'Hare collects a leaf sample from one of the trees thought to be the source of most Hawaiian macadamia varieties. On a subsequent visit, Paul O'Hare and Andy Burnside cleared woody vines from around these venerable old trees.

You can show *your* support for protecting wild macadamias simply by becoming a Wild Macadamia Champion:

- Sign up
- Get your friends and family to join.

Becoming a Wild Macadamia Champion is the easiest way for people outside the industry to find out about wild macadamias and support their protection.

All you need to do is provide your name, email address and postcode and MCT will send you two newsletters a year, keeping you up-to-date on wild macadamia discoveries and conservation activities.

The more we spread the word, the more opportunities we have to influence decisions that impact on wild macadamias. Join today, or invite someone else to join, at www.wildmacadamia.org.au, or email Denise at wild@macadamias.org.au.

Vale Richard

Richard Doggett was one of the original champions of Macadamia conservation, serving on the MCT Public Fund Management Committee and providing wisdom and support. He will be sorely missed.

New Sprinkler Stake provides a simple and effective solution

John Vaughan Macadamias Australia

Macadamias Australia has teamed up with Garden City Plastics to develop and produce the Sprinkler Stake. The clever stake provides an alternative solution to support polypipe and sprinklers in the orchard. The AMS caught up with John Vaughan to learn more.



How did the need for the irrigation stake come about? What problem or issue were you trying to solve?

We were looking for an alternative to the current methods used to support polypipe and sprinklers within the orchard. We had tried several methods over many years but without the success we wanted.

Macadamias Australia came up with the idea when looking for an alternative solution to support polypipe and sprinklers in the orchard, and had been working on a design concept. Macadamias Australia submitted its design concept to Garden City Plastics and both businesses worked together to refine the design and its manufacture. The end result is a solution for tree crop industries produced by two like-minded Australian family owned businesses working together to produce a 100% Australian made product.

What does it do and how does it improve your orchard operations?

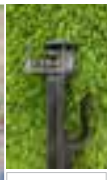
The Sprinkler Stake offers many benefits within the orchard. Firstly, the Sprinkler Stake provides a way to support the polypipe between the trees within the orchard, irrespective of the age of the tree, and provides a placement for the sprinkler. The support of the polypipe provided by the Sprinkler Stake is very useful in areas where trees are not located in rows, which may be due to a number of reasons, and allows for a clean and efficient harvest of nuts and other orchard practices.

As the polypipe is not attached to the trees, it also allows for the polypipe to be kept off the ground and out of the way, particularly useful if a tree is removed from a row, if the polypipe is crossing a waterway or if sprinklers are installed at a younger age of the surrounding trees. During preparation for harvest season, the polypipe does not interfere when blowing or sweeping beds to remove leaf, sticks and old nut and it also allows for a clean, efficient harvest without nuts being left behind or trapped by polypipe laying on the ground. There is also an added benefit of less interference from tree shakers as the polypipe will just move away from the tree trunk as the shaker grasps it.

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In the transition from dripper to sprinkler the Sprinkler Stake can be installed first with the drippers in place and it helps direct the water to the lowest loop point which is the tree, whereas the current method of attaching to the tree runs the water away as the lowest loop point is in the middle between the trees. This type of transition can then be staged by an orchard to suit the available time, labour or budget restrictions.

The sprinkler is then mounted on the top of the Sprinkler Stake via the mounting pin which will accept either the sprinkler or spaghetti hose mounting points. This provides a well-positioned sprinkler with consistent height throughout the orchard, which is crucial for placement consistency and fertigation applications.

What are some of the technical details of the Sprinkler Stake?
The Sprinkler Stake is made from UV stabilised plastic for longevity in the orchard environment, and comes with depth indicators on the pointy end to provide consistency of height. The sprinkler attaches via a mounting pin which makes for easy, quick changing when necessary, unlike the cable tie and other methods currently used. The polypipe is supported by the flexible hook attached to the main shaft of the sprinkler stand, primarily made for 25 mm polypipe but will accept from 19 mm (a little loosely) up to 32 mm. The hook for the polypipe has a notch to assist in securing the polypipe because in the early prototypes the polypipe was easily bumped out of the hook and this improvement has proved to be successful.

Why is it so cost effective?
The Sprinkler Stake is one item that provides more than one solution for orchard practices, namely the securing and supporting of polypipe and the sprinkler. It removes some of the more time consuming alternatives that we have tried in the past for attaching sprinklers and the need to reattach polypipes to trees if they have been replaced or outgrown their current supporting methods.

Where can growers order them?
Garden City Plastics are manufacturing, supplying and distributing the Sprinkler Stakes throughout Australia and the world.



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Customised combination utility harvester solution for Gympie grower

Megan Boote Suncoast Gold Macadamias **M:** 0484 099 462 **E:** Megan.Boote@suncoastgold.com.au

Previously a pineapple and passionfruit grower, Ken Ward has always been an inventive and thrifty farmer. Switching to macadamias from these more intensive crops has allowed him time to develop a customised harvest solution for his macadamia farm.

Ken and wife Helen run a 15 hectare (5,000 tree) macadamia orchard on the family farm at Kandanga in the Mary Valley area of the Gympie Region.

Ken has built the fingerwheel harvester with on-board dehusker as an out-front implement for a secondhand Bobcat Toolcat utility vehicle. The harvester includes a set of Robmac wheels with a custom-built frame and an old Ad-mac dehusker and auger built with parts from a number of old harvesters and bits and pieces that Ken had on hand.

The Toolcat utility is a versatile machine – it has four-wheel drive, all-wheel steer, hyrdrostatic transmission, and an air-conditioned enclosed cab with two seats. There are a number of things that led Ken to his design combination for application as a macadamia harvester.

Hydraulic ability – the out-front hydraulics have high flow capacity of over 95 L/min at 3,000 psi. This is adequate to run both the harvester and dehusker on the steep hills on the farm.

Versatility – The machine is used for a number of orchard applications including sweeping, spraying under trees, road brooming as well as harvesting and dehusking. The unit can operate any Bobcat implement, including trench diggers, post-hole drivers and buckets, so it is perfect for a small farm. The change-out from sweeper to harvester only takes around 5 minutes. With the hydraulics and the out-front gear, visibility and workability are excellent for most applications.

Ease of access – A relatively low profile, with small wheels, 4WD and offset gear means the machine can fit just about anywhere and deal with the steep terrain, sharp turns and drains in the orchard. The unit will rarely lose traction even on steep rows and its shorter wheelbase means the fingerwheel head keeps contact with the ground for better harvest efficiency.

"To me it was just the ideal mid step between the small fingerwheel harvester and a tractor-driven harvester, plus it has the versatility of using other implements and the ability to drive the dehusker," said Ken.

The nut goes through the dehusker and up a long auger which removes most of the husk and leaf. The bin in the back holds about 500 kg of in-shell, has a chute in the back and can hydraulically tip for easy off-loading.

The dehusker part of the unit is a work in progress. "We currently get at least 95% of the husk off before the nut gets to the shed, but we do get a bit of cracked nut," said Ken. Ideally a more gentle drag tyre dehusker on board would be the solution Ken is after but it will take a bit more work to get it right. Running and maintenance costs are relatively low. The machine doesn't use a lot of fuel, although the fuel tank is relatively small. The unit will get a new set of fingerwheels prior to the start of next season which will be its third harvest.

You can look at the unit in action on the Suncoast Gold Macadamias Grower Services You Tube page: youtu.be/nQfyR8eCiAU.

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From the soil to the sky: Queensland trial integrating new technologies

Paul Hibbert Suncoast Gold Macadamias **M:** 0419 209 466, **Megan Woodward** Journalist **M:** 0487 352 859

Jason Klotz from Red Rock Macadamias, Bundaberg, and Suncoast Gold Macadamias Grower Services Manager Paul Hibbert are undertaking a trial project to test products and the integration of various new technologies.

Jason Klotz is an AMS award winning macadamia grower and fifth-generation farmer from Bundaberg. Jason made the switch from sugar cane and small crops to macadamias about 14 years ago and hasn't looked back.

"Recently we established a new block at Childers and between both farms we've got more than 200 hectares under macadamias. Obviously with growth comes more elements to manage," he said.

Technology to maintain efficiencies and productivity

"Essentially we're trying to figure out what every farmer wants to work out – how to be at two places at once and still maintain efficiency, productivity and profitability," Jason said.

Jason and Paul Hibbert have been running a small trial project to test the use and integration of various new technologies to help monitor and manage the crop.

While new technologies can save time and increase efficiencies and productivity, with every new piece of technology comes a different platform. These platforms often do not 'talk to' each other.

As Paul explains, "Trying to get the weather data platform to talk to the irrigator controller and then record what's going on in the trees and having all that information in the one spot is not as easy as it should be. I was also really keen to build in drone data."

Paul saw the value of helping to connect growers with different service providers to help them streamline their 'ag tech'. "There is so much technology out there, but everyone is doing it on their own," he said.

"There's also countless companies competing in the same space, but with really specific offerings. It made sense to help bring as much of that technology together to see how we could make some better industry options."

Small trial to measure and treat tree stress

The main focus of the trial that Paul and Jason have established at Red Rock Macadamias is measuring and treating stress in trees.

"The aim of the trial was to use the available ag tech to understand how trees fare in times of stress, like heat events. We are keen to get a better grasp on how many nuts trees might drop when stressed, or how the development of the tree is affected," Paul said.

"The trial is pretty simple and small at the moment, but we are going to expand it and create another replicate in the future," Paul said. Currently there are four 'treatments' (three treatments plus a control) each with six trees. The three treatments are designed to test three different stress-mitigating products:

1. Endofight (Novum Lifesciences), a calcium silicate product containing beneficial microbes
2. Kelpak (Agrichem), an extract from fast growing South African Kelp
3. Enhance KCS and BioElite (Agrichem), potassium calcium silcate with biostimulants.

"Two treatments were applied in August and September this year and another will be undertaken in

November. Oztech Drones are running the application sprays," explains Jason.

"Last season we sprayed manually, but this was very labour-intensive and time-consuming," Paul said. "Using a spray drone was a great solution because it was ideal for spot sprays in the trial."

Paul explained that the drones are programmed specifically to spray six trees in a treatment with one of the products; then change products and spray the next six trees in the next treatment.

"The single spray drones can hold 16 litres and have what's called a 'controlled droplet applicator' or CDA," he said.

"It drops the liquid onto a spinning disc that then shatters the droplet. This can be controlled while the drone is in the air and it also has a pre-set so if you see unnecessary drift you can make the droplet coarser, literally on the fly.

"In real terms, while 16 litres is great for our trial work, it's a small amount of solution for an orchard. However, you can fly these drones as a swarm from one controller so there's potential to run five drones at once to cover a larger area. At the moment the potential is mainly for spot spraying to target areas of the orchard and take high resolution images and multi-spectral imaging."

Once treatments have been undertaken, the trial involves integrating the following technologies and information:

- sap flow meters (see below)
- red edge mapping (see below)
- soil probes measuring moisture, temperature and electrical conductivity
- weather data from the existing farm weather station
- yield and quality data.

Four **sap flow meters** (one for each of the three treatments plus the control) were purchased by Suncoast Gold, and installed and supplied by Rimik (including communication capabilities). The sap flow meters measure water use and stress in the trees, in particular, they measure the amount of water that trees use and exactly when they are using that water. Paul said, "We're really fortunate that Dan Manson will be helping us interpret the data."

Normalised difference **red edge** (NDRE) imagery is a method of determining crop health by using the red edge part of the spectrum to detect changes in chlorophyll content within the leaf and through the plant canopy. It is a useful tool to use in orchards as it can show differences over time or between parts of the orchard.

A drone was used to capture the data in September 2020, and there will be another flyover in December and then February, so data captured at different stages of the phenological cycle will provide an indication of changes in tree health. The imagery is captured by Bellamish Drones and interpreted by Aerobotics software (see images below).

For the sake of the trial, we are following a spray application program and will use the data at the end to determine if any of our data observations support the yield results achieved.

As an ongoing farm management tool, we hope to be able to utilise this data to show areas that need special attention, enabling the possibility of variable rate applications of fertiliser or other amendments.

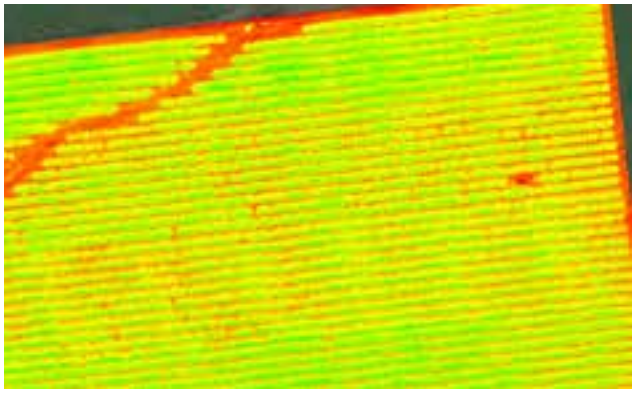
Bringing the data together

At the core of the multi-faceted trial is data collection.

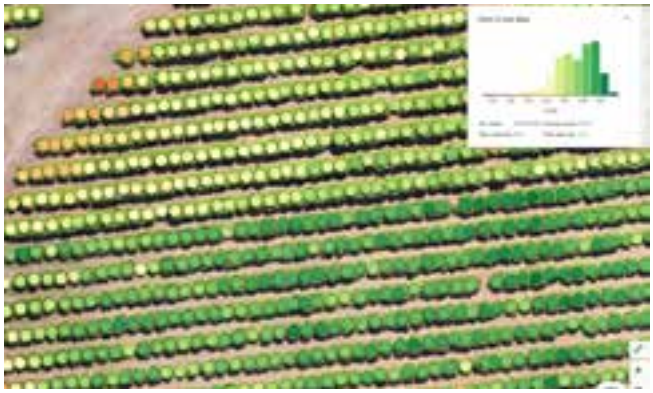
"The data points are only useful if we can use them as a whole. We've been using a farm management software platform called Farm In One to put all the data together," Paul said.

The Farm in One software app brings together the various information collected. As Paul explains, "The drone operator can access his spray task from the app, telling him what products need to be sprayed where and at what rate and total volume. When this task is accepted, the app then follows the GPS and records exactly where the spray was applied. Along with this, the app can record weather data information during the spraying operation and subsequently create an audit trail for health and safety purposes as well as tracking trial progress."

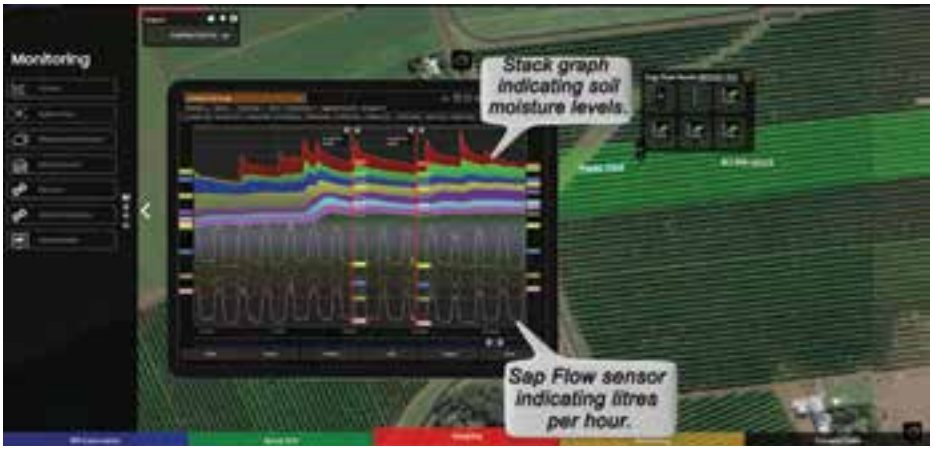
At the same time, the data from the sap flow and soil moisture meters can be displayed and analysed, this can then be cross-referenced with the layers of aerial maps



Normalised difference red edge (NDRE) imagery captured by Bellamish Drones.



Red edge data interpreted by Aerobotics provides a health index for every tree in the orchard. Data is from September 2020.





Jamin from Oztech Drones and Craig from Bellamish drones looking at flight data.

Screenshot of Farm in One app showing integration of sap flow and soil moisture level data.

and other data sources including irrigation and fertiliser information.

"When we have more data we will be able to graph the vapour pressure deficit against the soil moisture and sap flow data. We'll be able to overlay maps of where we sprayed with the tree health mapping from the red edge work captured by drones. We can then test all of this against tree health and yield.

"Our preliminary trial in 2019 gave us some good indications that the products, particularly Kelpak, may assist the trees with nut retention and quality. At 46% SKR, 1.1% RKR without sorting, at an extrapolated yield of approximately 3 t of sound kernel per hectare (approx. 6.5 t/ha in-shell), the trees were performing well," Paul said.

While positive results are always the end game, for Jason Klotz it has reinforced the value of industry collaboration.

"Getting multiple sectors and service providers and tech platforms to all work together is hard work, but seeing the rewards for our efforts makes it worthwhile," Jason said.

"I'm really pleased that we're involved in the trial. If it delivers some good results it's not just my operation that benefits – it can provide options and solutions for the rest of the industry too, and that's always the end goal," says Jason.

Keep an eye out for part 2 of this story in next Bulletin – Meet the service providers working behind the scenes on this Queensland trial work.



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Trial of harvesting over on-ground driplines shows promise

Jamie Zapp Netafim Agronomist **M:** 0418 311 157 **E:** Jamie.Zapp@netafim.com

During the 2019 and 2020 harvests, Netafim set out to investigate the use of current harvesting machinery in orchards with multiple on-ground driplines. As Jamie Zapp Netafim Agronomist explains, the results are promising and indicate that machinery and driplines may be compatible after all.

It is generally accepted that dripline irrigation has some attractive attributes compared to sprinkler irrigation. These include less evaporative losses which leads to greater water savings, less ongoing maintenance, and lower system flows which mean lower power costs.

Sprinklers do have some attributes that many growers desire. Sprinklers can wet-up a greater soil area compared to a single dripline and sprinklers are better at wetting surface organic matter.

South African macadamia growers have been evolving dripline irrigation on mature macadamia trees for a number of years (see winter 2019 *News Bulletin* story). They have developed a system that uses two driplines per tree row. This wets-up a wider strip than a single dripline system, and it gets close to the wetted area provided by sprinklers. This is a highly productive system that has many of the benefits of both drip and sprinkler irrigation. A key difference in South Africa is that they harvest their macadamia nuts by hand; they do not use machine harvesters.

Here in Australia the macadamia industry has always believed that machine harvesting of macadamia inhibited the use of multiple on-ground driplines. It was thought that the fingerwheels and blowers or sweepers used on the harvesters would foul and damage the dripline. This had always been assumed, and had never been tested.

Trial harvest over driplines

During the 2019 and 2020 harvests, we investigated if multiple on-ground driplines were compatible with current harvesting machinery. We ran trials at three Bundaberg farms that had two surface driplines located 60–80 cm either side of the tree trunks. The common heavy-wall dripline sizes of 16 mm and 20 mm were used. All farms were harvested using standard fingerwheels and blowers. The harvester operators ran the harvesters as they normally did, that is, full blower and at typical harvester speed and positioning.

What the trial showed

The trial results were promising.

- The blowers did not move the dripline significantly. This was likely due to the combination of using widely spaced pegs and having moderate tension on the driplines.
- The fingerwheels did not pull, lift or damage the driplines.
- Nuts were removed and collected from around the driplines.

We would recommend using plastic pegs rather than metal pegs to hold down the dripline as plastic pegs pose less risk to tyres and other farm machinery if they are lifted.

The trials demonstrate that machine harvesters may be able to be used with multiple on-ground driplines in macadamia orchards. Australian macadamia farmers can now also explore the benefits of having multiple driplines that wet-up a wide strip.



Driplines were unmoved during blowing and pickup. All nuts were collected.

New Gen Z research reveals macadamias' relevance to the demands of younger consumers

Jacqui Price Market Development Manager, AMS **P:** 02 6622 4933 **E:** jacqui.price@macadamias.org

Findings from the Australian macadamia industry's most recent consumer insights study have been released, providing a glimpse into the future of food. While previous research was focused on opportunities for macadamias in particular food categories, this time the subject was an entire generation of consumers – Generation Z. As the current group of up and coming shoppers, it is their needs, attitudes and behaviours that will shape the future food landscape as their purchasing power grows.



Who is Gen Z, what are their food narratives and can macadamias fit into that?

The definition of Gen Z in this research is people born between 1995 and 2005, currently aged 15 to 25. What they expect from food is markedly different to the expectations of the generations before them. With a heightened sense of health and environmental awareness, Gen Z's expectations around food are high but they also demand 'different'.

While they view the world very differently to older generations, their thinking and behaviours present spaces in which macadamias can comfortably and naturally fit. The research revealed some key narratives that dominate Gen Z's expectations around food.

The 'Dalgona' effect: For Gen Z, food is a form of social currency and they expect the food they purchase to look as good as it tastes. Discovering a unique flavour combination, limited edition or exclusive food brand partnership has the ability to elevate their social status and create excitement amongst their tribe.
Macadamias are relevant here because: they can add that unique edge to products visually (crumbs, textures, garnishes) and texturally (creaminess, crunch). In Asia particularly there's intrigue in new flavours and formats and cross-category fusion.

Pimp my snack: The lines of traditional meal times and sizes are blurring for Gen Z. They're rejecting traditional breakfast, lunch and dinner in favour of many mini meals in a day, and anything goes, any time. Salad for breakfast, eggs for dinner, a 10 pm and midnight snack? This is normal behavior for Gen Z.
Macadamias are relevant here because: they're the ultimate versatile ingredient and can talk to different occasions and benefits. There's an opportunity to push the boundaries of the ingredients they're combined with to dial up their power to pimp snacks.



Cultural rediscovery: Gen Z like to borrow each other's cuisines while creating a re-appreciation of their own. Family heritage, friends and colleagues provide them with new perspectives on food, ingredients and what a 'classic' dish is; while smartphones and TV present unparalleled access to global food trends.
Macadamias are relevant here because: they hold potential to act as direct replacements for traditional ingredients in Asian food, speaking to global fusion while recognising heritage.

Feel-good food: Gen Z want to make positive food choices and feel good about what they eat. In Western markets, a move away from meat and dairy is motivated by the 'greater good', while in Asia, the desire to make good choices is borne out of a focus on personal benefit and food safety and quality needs.

Macadamias are relevant here because: as a natural, plant-based ingredient, there's ample opportunity to use macadamias to increase the feel-good factor across a range of product innovations targeting younger consumers in the West. In Asian markets, Australian grown macadamias can be an appealing and differentiated ingredient for Gen Z due to positive provenance associations and nutritional benefits.



Healthy delicious: The traditional view that 'healthy' food must be bland and boring is being rejected by Gen Z, and they are prepared to pay a premium for healthy products that are all natural, GMO-free and sustainable. Western Gen Zs are highly aware of maintaining good mental wellbeing too.
Macadamias are relevant here because: they have powerful health credentials to leverage, whilst leaning on both taste and texture. They add a no-compromise, nutritious boost to food, that can supercharge a 'goodness' proposition, whilst tasting great.

The macadamia innovation hotspots for food brands targeting Gen Z

The research confirmed macadamias are an appealing and resonating ingredient for Gen Z, with a host of benefits that make them exciting and relevant for new product development. Five key innovation opportunities to engage and excite Gen Z with macadamias emerged from the study.

1. Experimentation stations: Macadamias lend themselves to a range of bold and brilliant food innovations. Think unique flavours, cross-cultural fusion, contrasting textures and complementary tastes. *No combination is off limits.*
2. Feel good factor: Macadamias naturally play in the plant-based space, with the ability to enhance existing alternative products, or add a layer of goodness to a broad range of foods. *Macadamias are a foundational part of the plant-based movement.*
3. Complexity currency: Treating macadamias in a way that is complex adds a layer of uniqueness to the consumption experience. This drives social currency and encourages Gen Z to share their macadamia experiences with the world. *Macadamias can make it complex but fun.*
4. Supercharged: Macadamias benefit from high functional nutrition, with protein and healthy fats that can power up food and tap into a desire for wholesome, supercharged products. *Macadamias can help create strong and powerful food that packs a punch.*
5. Aesthetic amplification: Macadamias can transform products visually, adding multi-faceted layers that create intrigue and appeal to a generation seeking food that has the ability to impress. *Macadamias can help create products that look as good as they taste.*



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Controlling fruitspotting bug damage in macadamia: Timing is everything

Craig Maddox NSW DPI, **Chris Cook** Dymocks farm manager and **Bob Maier** MNC Macadamia pest consultant

Protecting the macadamia crop from insect pests is a complex, ongoing challenge for industry. It requires a deep understanding of the biology/ecology of the various pests that can impact negatively on yield through damage to the nut and/or plant.

Developing this understanding alone is difficult, but when coupled with the responsibility of minimising the impact protection strategies have on the environment and attaining a degree of social licence, the challenge becomes considerably greater. Irrespective of the chemistry that is available for crop protection in macadamia, one thing is for sure: the chances of achieving a satisfactory result are increased considerably when the timing of spray application is optimised.

A lot of our knowledge on fruitspotting bug (FSB) damage and tools to optimise management have been developed through trials set up at the Centre for Tropical Horticulture (CTH) at Alstonville. One of the most effective tools developed in the past is the use of *Murraya paniculata* monitoring hedges to identify the flight times of FSB. This simple but effective tool has enabled targeted, rather than calendar, spray regimes for FSB control.

Using this approach has significantly reduced the number of sprays for FSB, from five to six down to two to three per season (see Figure 1). For the CTH site, depending on the timing of the second FSB flight, spray programs to protect the nut until it reaches the shell-hardening phase aren't typically necessary after early February.

Some of our more important observations over the past three seasons when conducting this spray regime are:

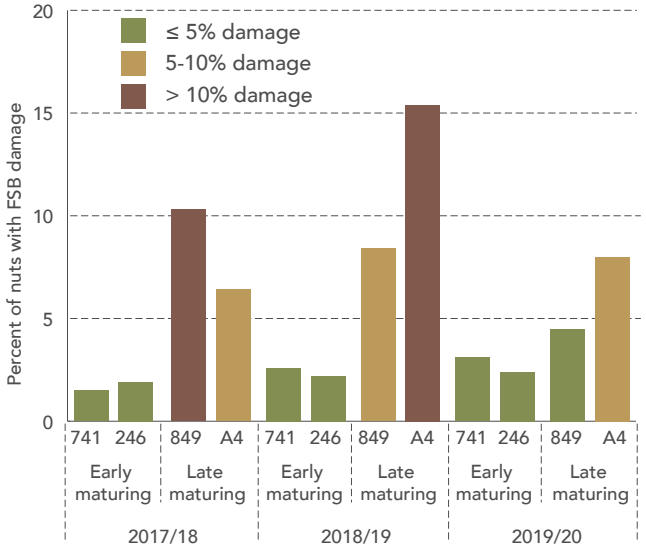
- the spray program (depending on chemistry used), when aligned with flight times, is effective at keeping damage levels generally below 5% (see green bars in Figure 1)
- we see higher damage on the later maturing varieties with higher kernel recoveries (Figure 1)
- rainfall events impact on FSB activity and damage risk (i.e. lower risk in drier seasons)
- our worst damage is usually in the first harvest samples of March, and then samples get progressively cleaner until the end of harvest in September.



FSB feeding on Macadamia ternifolia *indicates 1st and 2nd flights.*



Fruitspotting bug (FSB) feeding on Murraya paniculata *monitoring hedge indicates 3rd and 4th flights.* **Photos:** Craig Maddox



FSB flight	Date & action		
1	4/12/17 sprayed	21/12/18 sprayed	23/12/19 sprayed
2	8/1/18 sprayed	4/2/19 sprayed	27/1/20 sprayed
3	12/3/18 no spray	25/3/19 no spray	23/3/20 no spray
4	30/4/18 no spray	6/5/19 no spray	11/5/20 no spray

Figure 1. *The effect of season, variety and FSB spray treatment timing on the proportion of nuts with fruitspotting bug damage from the Centre for Tropical Horticulture Alstonville site. Data shown in the table under the chart are the predicted flight dates of FSB based on monitoring of* Murraya paniculata *hedges and* Macadamia ternifolia *trees at CTH and the action taken (sprayed or no spray) with regards to FSB control.*

Optimising FSB control strategies – what does the data tell us?

Despite weekly data being available to pest consultants since 2014 from the FSB monitoring hedges, the Macadamia Benchmarking Team (MC18002) continues to identify producers on the NSW Mid North Coast as susceptible to suffering higher levels of insect damage compared to other regions (see MNNSW in Figure 2). The main culprit suspected of causing the damage is fruitspotting bug. There are several possible reasons for the higher levels of FSB damage in the Mid North Coast region, including greater levels of bush surrounding farms, smaller farms and therefore greater fragmentation, poor spray coverage on late season varieties, and not as much control being attempted generally.

However, data from the *IPM program for the Australian macadamia industry* (MC16004) project for the past two seasons has shown that the Mid North Coast trial sites have experienced an increase in FSB damage levels during the harvest season. This pattern of damage is most unusual. The increase in damage from the start of harvest to the end of harvest in some instances is more than triple (see IPM trial site 2018/19 in Figure 3). This has led us to ask the question, "Does FSB continue to invade that late in the season and cause more than triple the damage?".

Our monitoring of trees at CTH has shown that FSB are active between February and May. We checked the caged nut on tree trials where we released FSB and *Leptocoris* sp. to compare and distinguish the visual characteristics of their feeding. Assessments were made on the CTH varieties between February and May 2020 and found evidence of FSB feeding activity during this period.

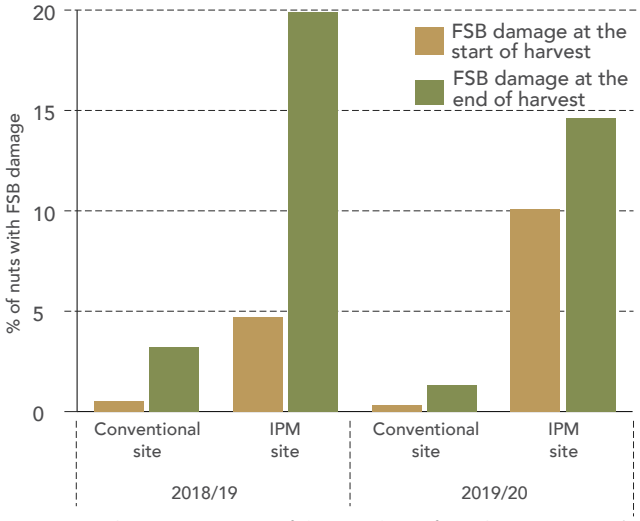


Figure 3. The proportion (%) of damaged nuts from the conventional and IPM trial sites on the NSW Mid North Coast when sampled at the start and end of harvest for seasons 2018/19 and 2019/20.

FSB damage – don't put the sprayer away too soon

To test if FSB damage was occurring later than we thought, and look at whether it can be prevented, Craig Maddox (DPI), Bob Maier (pest consultant Mid North Coast) and Chris Cook (manager of the Dymocks farm group) set up a trial on several of Chris's farms. Through canopy sampling before and well after the last flight, the trial aimed to determine if we could detect any increase in damage to the crop. Chris and Bob provided samples from eight different blocks on Arapala and Jindilli farms with suspected late bug damage in early May 2020. After the May 2020 flight was detected at CTH Alstonville, Chris sprayed an eight-tree section of each plot with Lepidex @2 ml/L to see if treatment would be effective. Samples were then supplied back to NSW DPI to check the damage levels taken from the canopy in late June 2020.

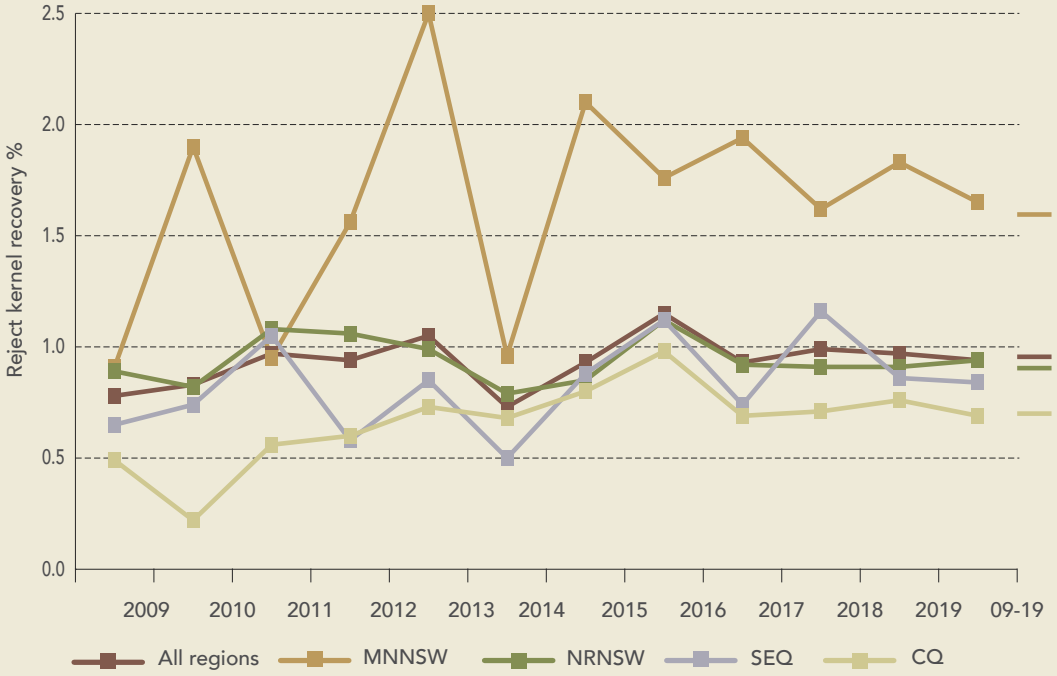


Figure 2. Regional insect damage, percent reject kernel (2009–2019) showing consistently high levels of damage in NSW Mid North Coast (MNNSW) orchards. Source: Macadamia industry benchmark report – 2009 to 2019 seasons

The results at the Dymocks farms show that even the best-managed properties are being invaded in late autumn, and that damage can be significant with all eight blocks showing increased damage between early May and late June (see Figure 4). In this case there appears to be general late season activity, and highest where damage was already present (Jindilli B). Chris said, "I will definitely be spraying later in the future and we will use our hedges and talk to other growers with a hedge to time our late sprays". The Lepidex treatment is only effective for 2–5 days and this has not been successful across all sites. NSW DPI are currently well into investigations on the residual activity of new and registered pesticides for FSB and *Leptocoris* sp. and better options are likely soon.

Take home message

The take home message is clear: timing is everything when it comes to effective FSB damage control. One of the keys to getting the timing right is to know the phenology of your macadamias and how it aligns with FSB flights. While some growers may need to only monitor for the first two flights of FSB due to their varietal mix (i.e. early maturing plants) and/or location, others need to be aware of later flights and the need to potentially be spraying for FSB control in late autumn (Figure 5).

Another key point to be aware of is that FSB commonly return to trees where there is damage after rain in macadamia, *Murraya paniculata*, avocado, custard apple and a few other host crops. The term 'hotspot' is apt. Knowing that you are carrying these sites and where they are located on your farm is key to limiting the impact the bug can have. Canopy sampling in those areas will help you decide if you should be managing the pest later in the season or not. It is also why the *Murraya* hedges work, because they become hotspots as the season unfolds, being more attractive than the macadamia crop at CTH from March onwards each year.

Bob Maier, NSW Mid North Coast pest consultant says …

This is a good news IPM story for growers who now have a tool to detect late FSB activity levels and decide whether a control spray may be warranted.

If growers wanted to do their own checking next season it would be important to contact the lab and ask if they can give the percentage breakdown of the different kinds of insect damage and in particular FSB, green vegetable bug and *Leptocoris* sp.

Regarding the existing *Murraya* hedges at Valla, Macksville (Macvest) and Yarrahapinni (Arapala), NSW DPI suggested boosting existing hedge planting density for reliability. This boosting in numbers has taken place. Weekly hedge data, ideally from local hedges, will inform growers in real-time of any local increases in activity and the timing of such sprays is well documented in the DPI *Plant Protection Guide.*

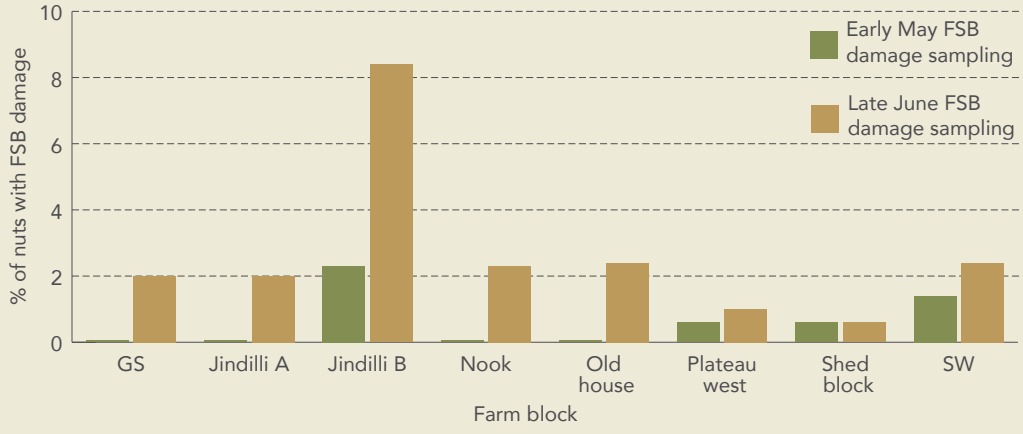


Figure 4. Changes in FSB damage levels from early May to late June for eight macadamia blocks at Arapala and Jindilli farms (Stuarts Point, NSW Mid North Coast region). Each column shows the proportion (%) of nuts from 100–200 nut samples collected in early May and late June for each block with FSB damage. Late June samples were pooled for Lepidex (treated 17 May) and non-Lepidex treated trees as there was no difference in damage levels.

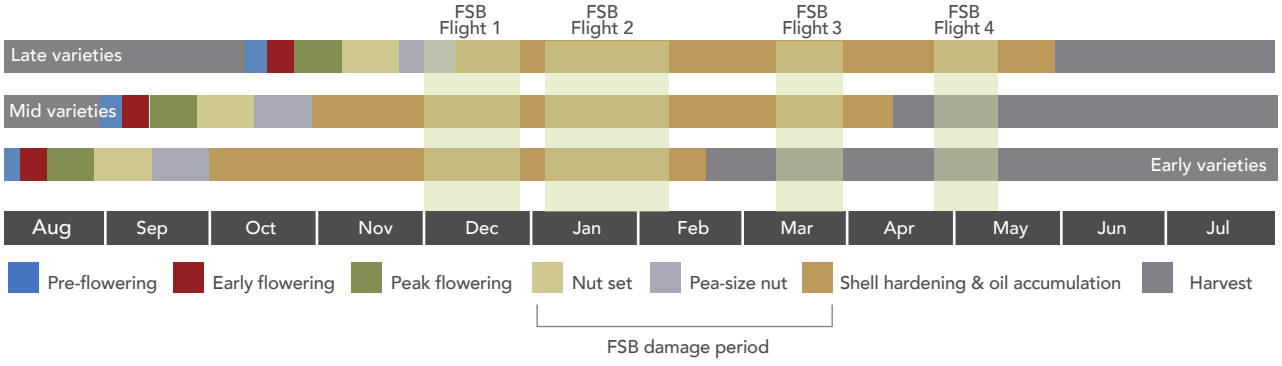


Figure 5. The relationship between susceptibility of macadamia varieties and late season FSB activity. Nut set, pea-size nut and shell hardening & oil accumulation stages are the key stages for FSB damage. Phenological stages for early, mid and late varieties are shown with flight times.

Estimating macadamia planting year and productive area in Australia

James Brinkhoff **E:** james.brinkhoff@une.edu.au and **Andrew J Robson**, both University of New England

Project snapshot

Predicting crop yield is important for macadamia growers and the industry because it guides marketing, finance and logistic decisions. Yield forecasts, such as those produced by D Mayer's team at Queensland Department of Agriculture and Fisheries, rely on accurate estimates of the productive area of macadamias and accurate estimates of tree age.

The aim of our project was to predict the planting year of macadamia trees at the pixel scale (i.e. 30 m resolution), then apply these predictions to calculate total productive area per year across the macadamia industry in Australia using a combination of satellite and farm data.

An algorithm was applied to all macadamia features in east Australia, as defined in the 2017 Australian Tree Crop Rapid Response Map (www.une.edu.au/webapps) and the planted area and total area per year was calculated. The area estimates were further refined by removing non-macadamia pixels (such as roads, dams, houses etc.).

Orchard information used to derive model

This study made use of grower-supplied information about 95 macadamia blocks, from nine orchards in three growing regions: Bundaberg, NSW Northern Rivers (Ballina) and NSW Mid North Coast (Macksville). Block boundaries and known planting year dates for each block were obtained from the growers.

Predicting planting year

We tested various modelling techniques based on previous similar studies. We found that due to variation in land characteristics before planting across Australia, previous planting year prediction methods relying on finding the year land was cleared were not accurate. Instead, we determined the year when trees reached 3 years old, indicated by a vegetation index (information from satellite images) crossing a threshold. The best plant year prediction algorithm was identical between macadamia growing regions, indicating the technique should be robust enough to be applied to other areas.

A plot of actual vs predicted planting year for the 95 blocks is shown in Figure 1. More than 75% of the planting year prediction errors are 2 years or less, and only 7.5% of the errors are 4 years or more.

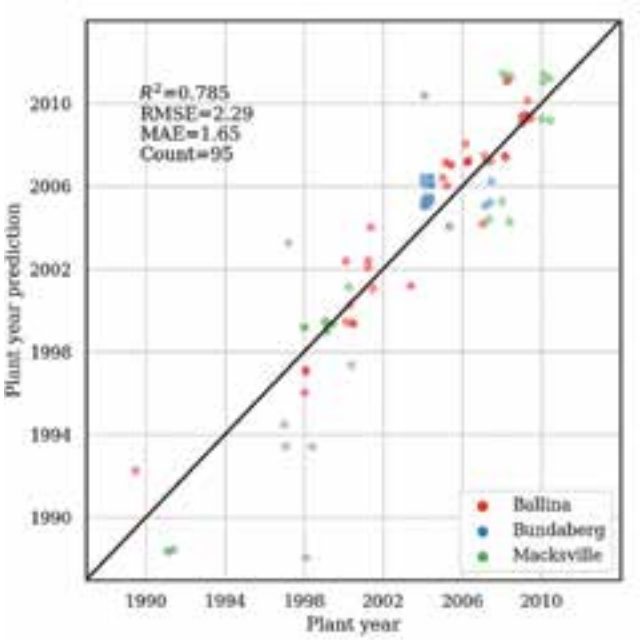


Figure 1. Predicted vs actual planting year, using the model based on satellite images.

Creating a productive macadamia area mask

The 2017 Tree Crop Map macadamia areas are at a coarse scale because areas smaller than 2 hectares are aggregated. This means that many macadamia areas include non-productive areas like roads, houses, dams and very recently planted blocks. An example macadamia feature is shown in Figure 2a (boundary is green).

To determine the actual productive macadamia area, we used finer scale, 10-metre resolution images (from 2019 satellite images) to create the productive area mask.

The results of applying this mask to the example area is shown in Figure 2b. The mask successfully removes roads, boundaries and houses. The mask does omit some pixels from macadamia blocks. However, these areas are likely to correspond to trees that are less productive and contribute less to the overall yield; and so would not have a significant impact on yield predictions.

The planting year predictions (with mask applied) are shown for the same feature in Figure 2c. There are usually multiple planting dates within a single macadamia area in the Tree Crop Map. So using a 'per-pixel' calculation of area planted per year like we have is more accurate than simply taking the median planting year per map feature.

Computing the historical area of macadamia orchards planted per year

Having developed an algorithm to predict macadamia planting year, and a mask to remove unproductive areas from each macadamia feature of the Tree Crop Map,



Figure 2. (a) Example Alstonville macadamia orchard, with the Australian Tree Crop Rapid Response Map feature shown in green. (b) The productive area mask for the Alstonville example, and (c) the per-pixel planting year predictions.

we then estimated the total area of macadamia trees planted each year across the east of Australia.

The total area was calculated both with and without the productive area mask. Previous versions of regional yield estimation have not used this mask, but it is expected that using the mask will enhance prediction accuracy.

The total macadamia area planted in Australia each year was estimated, and a similar calculation was undertaken for each of the major growing regions. The planted area (within the productive area mask) per year and the total cumulative area are shown in Figure 3 for each of the regions. Of particular note is the growth in plantings in Bundaberg after 2000.

Next steps

Given the rate of increase of macadamia planted area in Australia, to ensure ongoing currency of area estimates, such maps will need to be updated regularly. There is an effort at present to update the Tree Crop Map to 2020 (www.une.edu.au/webapps), and also to reduce the minimum mapped features from 2 ha to 1 ha. Other recent efforts have made use of machine learning and other analytical techniques to map specific tree crops.

Work has begun on using these satellite-derived area and tree age predictions in regional yield forecasts. The Applied Agriculture Remote Sensing Centre at University of New England are also working on block-



level yield predictions using localised satellite and climate data along with the tree age predictions. They are providing block-level yield forecasts in January through web apps to collaborating growers. They would be keen to hear from any growers with historical block-level yield data (that can be used to improve the predictions) and that would be interested in participating. Please get in contact with James Brinkhoff.

Acknowledgements
This work is funded by the Australian Government Department of Agriculture and Water Resources as part of its Rural Research and Development for Profit program, and Horticulture Innovation grant number ST19008 *(Multi-scale monitoring tools for managing Australian tree crops: Phase 2)*. The authors are grateful for input from AMS, Chris Searle, David Mayer, Janus Erasmus and collaborating growers including Macadamias Australia, Chris Cook of Dymocks Farm and Graham Wessling of LNL Australia Pty Ltd.

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Please see full article for all references: Brinkhoff J & Robson AJ 2020, 'Macadamia orchard planting year and area estimation at a national scale', *Remote Sensing*, 12, 2245, doi:10.3390/rs12142245, available at www.mdpi.com/2072-4292/12/14/2245.

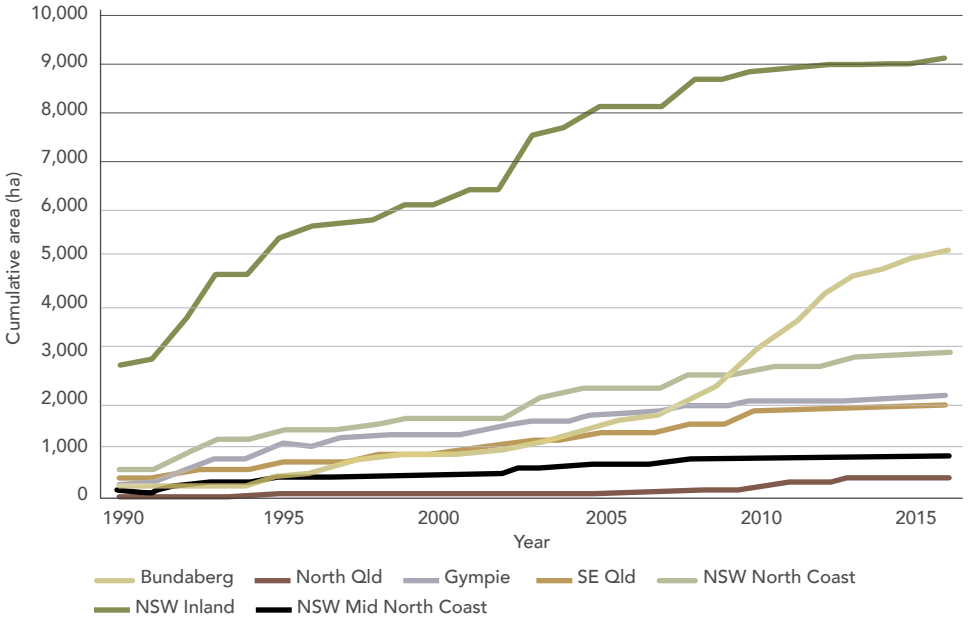


Figure 3. Estimates of cumulative macadamia area (ha) in each production region 1990–2016 2016 (within the productive area mask).

Note:
Region definitions:
North Qld is Atherton Tablelands, Rockhampton, Mackay and Emerald.
NSW North Coast is Byron Bay and Newrybar.
NSW Northern Upland is Lismore and surrounds.
NSW Mid North Coast is Maclean, Yamba, Macksville and Nambucca.





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Financial benefits of under-tree netting system are clear

Bill Johnston E: bill.johnston@daf.qld.gov.au and **Stuart Irvine-Brown E:** stuart.irvinebrown@daf.qld.gov.au

Under-tree netting at 'Falkirk Farm'

Recent information (*AMS News Bulletin,* spring 2020, pp. 71–73) described the clear agronomic and soil health benefits[1] provided by the under-tree netting system established by James and Aimee Thomas in their orchard in the Gympie area of the Mary River catchment. The nets increase soil stability and biological nutrient cycling, and improve water and nutrient retention and availability; all of which contribute to increased in-shell (IS) yields.

Coinciding with these orchard floor management results and yield increases, have been considerable reductions in the variable production costs specifically associated with management of netted rows. Queensland Department of Agriculture and Fisheries (QDAF) worked with James and Aimee to quantify the potential financial benefits and return on investment from the use of under-tree nets.

Key findings

Key economic findings from this investigation into the use of under-tree nets are:

- The under-tree netting system **costs $10,522 per hectare** to purchase and install ($9.57 per linear metre).
- The system **generates $2,481 per hectare** in benefits per year ($2.25 per linear metre).
- Over a 20-year period, under-tree nets generate an additional $28,453 per hectare.
- General efficiencies and cost savings occur from reduced area of orchard floor management combined with better use of inputs such as rainfall/irrigation, nutrients and agri-chemicals.
- An **average 20% increase in total production** of nuts was found from under-tree nets.
- Payback period of 4 years based on a conservative 7-year $4.50/kg average in-shell farm gate price[2].
- Breakeven in-shell farm gate price of $1.16 for under-tree nets compared to $1.56 normal practice.

Comparing netted and un-netted rows

Investigations around the economics of the macadamia netting system at 'Falkirk Farm' involved distilling the impact down to a per hectare basis. For the purposes of extrapolation to other planting densities, this was converted to an economic impact per linear metre (LM) of netted row.

The economic modelling is based on a planting density of 312 trees per hectare at 9 m x 3.5 m spacing (11 rows per hectare). However, this can be converted to any grower's orchard layout by applying the costs per LM. This economic study, a cost-benefit analysis, is based on the farm's gross margins (gross revenue less growing costs) while considering the upfront capital investment in the netted system.

James and Aimee have been collecting data on the effects of the netted system to compare the potential benefits. This regular recording of management costs, yields and IS quality specific to the netting system, allowed the construction of the economic model to assess the impact the nets had on their bottom line. Table 1 defines orchard floor management efficiencies from the use of nets compared to conventional, un-netted, 'base' orchard practice.

Production activities and inputs		Base ($/ha)	With netting system ($/ha)
Machinery costs (FORM)	Mowing & slashing	$135.00	$81.00
	Herbicide application	$90.00	$45.00
	Mechanical harvesting	$375.00	$250.20
Labour	Mowing & slashing	$162.00	$108.00
	Herbicide application	$108.00	$54.00
	Pre-harvest clean up	$36.00	$12.06
Fertiliser and chemicals	Fertiliser (Mac Mix)	$1,113.60	$890.88
	Glyphosate	$56.25	$18.68
Irrigation	Crop irrigation	$80.00	$33.40
Industry levies	Levies per kg	$255.84	$305.92
Freight	Freight per tonne	$159.90	$191.20
	Total costs per ha	**$2,571.59**	**$1,990.34**
		Cost savings per ha	**$581.25**
		Cost saving per LM	**$0.53**

Table 1. Comparison of variable costs per hectare of macadamia production (mature orchard).

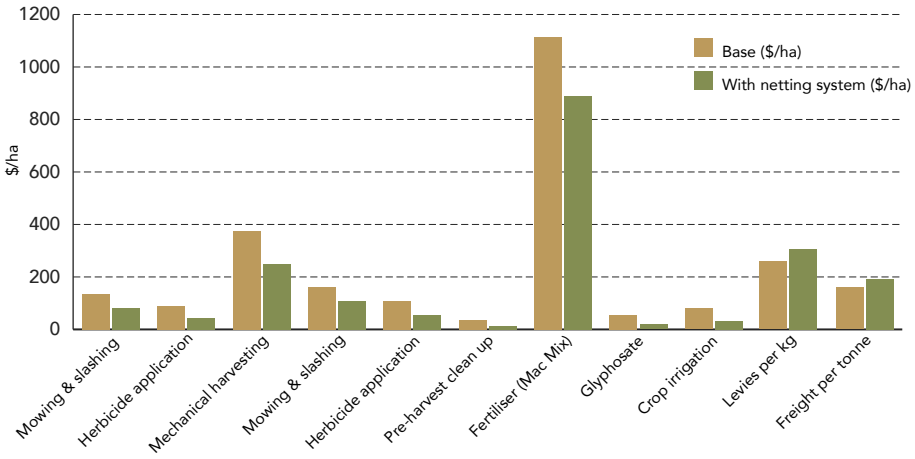


Figure 1. Comparison of variable costs per hectare of macadamia production (mature orchard).

Cost of installation: around $10,000/ha

Naturally, the main question asked by any grower would be 'What is the cost of setting this system up in terms of capital purchases and the labour required to install the netting?'. In the netted rows, two 1.5-metre wide nets run down the length of the rows on each side of the trunks, overlapping slightly across the middle of the tree row. The nets are tilted down towards the interrow alley at an angle of around 40° to divert falling nuts into the interrow preventing the need to harvest under the tree and disturb the 'magic metre' around the base of the tree where ground cover is often thinnest and where critically important fine feeder roots are most dense[3].

Initially it took around 8 hours to install the nets under a single 100-metre row. This required removal of any obstructing orchard limbs, placement of end-of-row strainer posts, and installation of tensioned wire and shade cloth, with clips, staples and supporting pickets. As they streamlined the process and became more experienced the input in terms of labour per row was reduced to 5 hours per single 100-metre row.

As shown in Table 2, it costs $10,522 per hectare ($9.57 per linear metre) of orchard to purchase the items required and install the netting. Installation labour accounts for $4,400 of that total investment (42%). The actual capital investment in equipment is $6,122 per hectare. Labour costs represented here involved the use of a fencing contractor to assist in the installation of the netting system.

Economic benefit: more than $2,400/ha/yr

Logically, the next predicted grower question would be 'What are the benefits in terms of production?'. Based on data collected by James and Aimee, the average total production of nuts increased from their base production of 4.1 t/ha to 4.9 t/ha (20% increase).

After losses are accounted for, such as missed nuts due to wet weather, shot nut, disease and other causes, the saleable yield of IS from the netting system trial is reduced to 3.82 t/ha. From on-farm IS quality assessments completed there was no noticeable difference in the quality of IS from netted rows.

Capital item	Total ($/ha)
Shade cloth (30%)	$1,584
Strainer posts (row ends)	$1,452
Installation (5 hours per row)	$4,400
Ratchets (wire tensioning)	$352
Wire	$880
Clips (shade cloth to wire)	$950
Staples (shade cloth to tree)	$1.76
Galvanised pickets (800mm)	$880
Picket clips	$22
Capital outlay for nets per ha	**$10,522**
Capital outlay for nets per LM	**$9.57**

Table 2. Capital investment in the netting system per hectare of macadamia orchard (mature).

Summary	Base	With netting system
Production of saleable nuts	3.20 tonnes	3.82 tonnes
Gross revenue	$14,391	$17,208
Annual production costs	$5,001	$4,420
Gross margin (revenue – production costs)	$9,390	$11,871
Annual benefit per ha: netting compared to traditional (base)		**$2,481**
Annual benefit per LM		**$2.26**

Table 3. Production summary and economic outputs.

Table 3 summarises the economics and production differences between the base case and the use of under-tree nets. The nets provide an annual benefit per hectare of $2,481.

Costs recovered in 4 years

The next obvious question for growers is 'How long does it take to recover the initial capital investment?'. Figure 2 shows the projected cumulative gross margins (per hectare) over a 20-year period. The 20-year period was selected based on an average orchard lifespan before potential for orchard re-planting may need to be evaluated.

This benefit, above and beyond the base scenario, delivers around $2,481 per hectare, recovering the initial investment in the orchard netting system in 4 years.

Over the 20-year life of the analysis the netting system generates $28,453 per hectare of additional benefit to the farm.

With a breakeven IS farm gate price of $1.16 for under-tree nets compared to $1.56 for a conventional orchard, James and Aimee have a greater capacity to withstand price fluctuations. Such positive findings indicate more in-depth investigations into under-tree nets at more farms across major production regions are certainly needed. This is particularly because increased yield and input use efficiency savings on water, nutrient, and agri-chemicals along with harvesting techniques and use of tree shaking will vary depending on orchard management techniques. Additionally, further research into under-tree netting and the potential benefits may help offset a future that looks to be dominated by increasing climatic and economic risks.

Acknowledgements

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QDAF would like to thank James and Aimee Thomas for their ongoing collaboration and willingness to share on-farm data collected as part of this economic investigation for the purposes of presenting the findings of this trial to the AMS and industry. For more information please contact Bill Johnston, email: bill.johnston@daf.qld.gov.au or Stuart Irvine-Brown, email: stuart.irvinebrown@daf.qld.gov.au

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2. Australian Macadamia Society Factsheet 2018, *Farm Gate Prices.*
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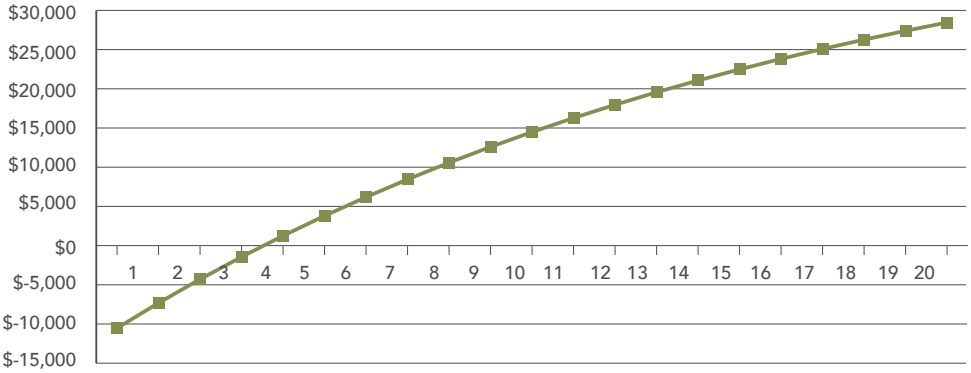
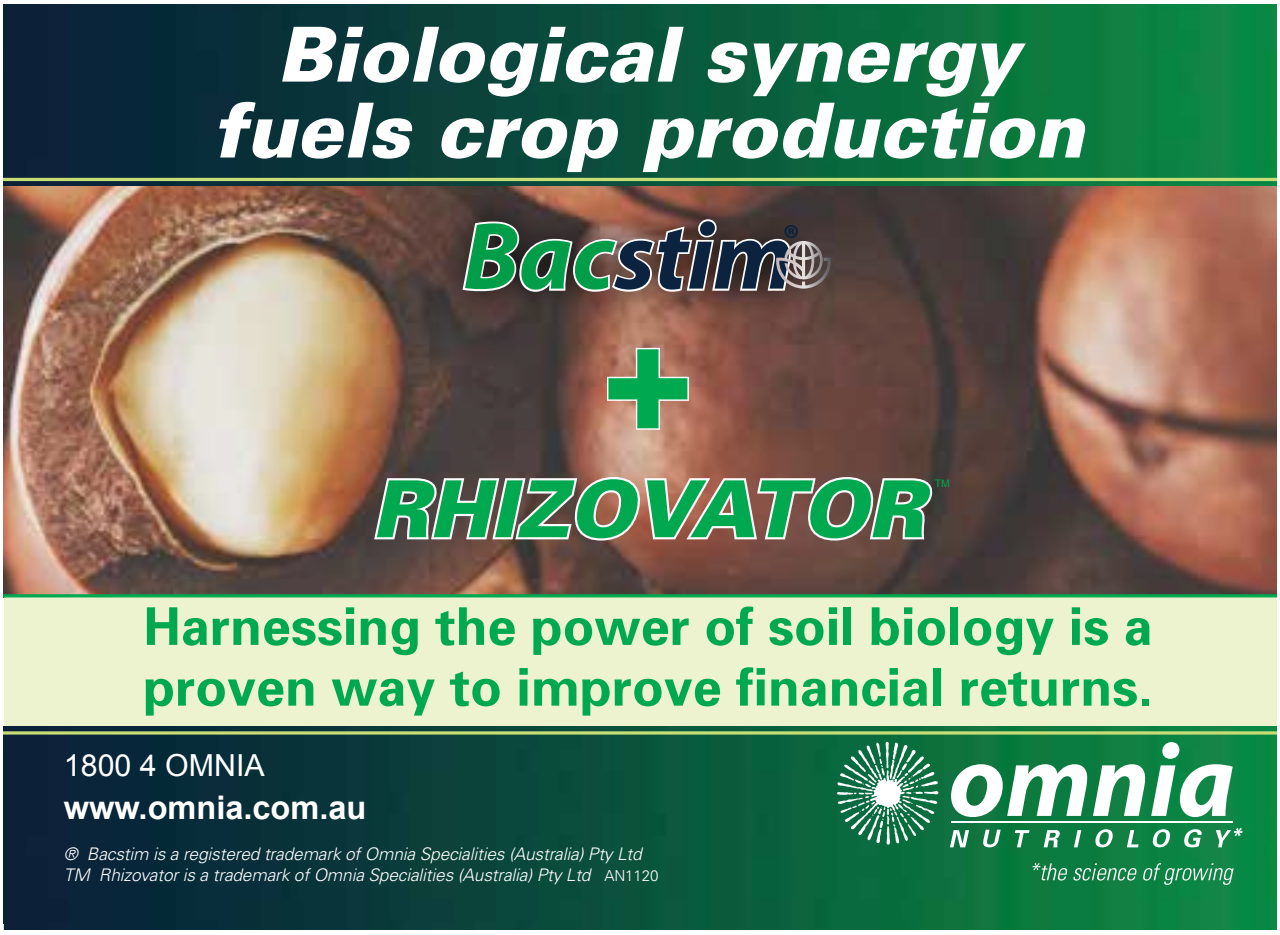


Figure 2. Cumulative benefit per hectare for the netting system above the traditional orchard practice (base).



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Summarised below are the research and development projects being funded by your research and development levy and voluntary contributions.

Project no.	Project name	Delivery partner	Expected end date (subject to change)
Macadamia Fund investments: levy projects			
MCI5004	Australian macadamia industry innovation and adoption program	Australian Macadamia Society	Feb 2021
MCI6000	Innovative rootstocks for the Australian macadamia industry	Qld Department of Agriculture and Fisheries	Dec 2021
MCI6002	Macadamia industry minor use program	Hort Innovation	Ongoing
MCI6004	IPM program for the Australian macadamia industry: NSW DPI	NSW Department of Primary Industries	Oct 2021
MCI6005	IPM program for the Australian macadamia industry: Qld DAF	Qld Department of Agriculture and Fisheries	Sep 2021
MCI6006	IPM program for the Australian macadamia industry: IPM Technologies	IPM Technologies	Oct 2021
MCI6018	Macadamia integrated disease management	The University of Queensland	May 2022
MCI7005	The effect of macadamia nuts on cardiometabolic risk factors and adiposity: a randomised intervention study	Loma Linda University	Jun 2020 (ongoing)
MCI7006	Macadamia regional variety trials series 4	Qld Department of Agriculture and Fisheries	Aug 2026
MCI8000	Australian macadamia communication program	Australian Macadamia Society	Feb 2022
MCI8002	Benchmarking the macadamia industry 2019–2021	Qld Department of Agriculture and Fisheries	Mar 2022
MCI8003	Macadamia crop forecasting 2020–2022	Qld Department of Agriculture and Fisheries	Apr 2022
MCI8004	Genetic diversity and population structure of wild and domesticated	Southern Cross University	July 2021
MCI9000	National macadamia breeding and evaluation program	University of Queensland	Dec 2024
MTI6005	Enhanced National Bee Pest Surveillance Program	Plant Health Australia	Dec 2021
MTI9008	Strategic agrichemical review process (SARP) – Updates	AGK Services	May 2020 (ongoing)
MTI7015	Consumer behavioural and retail data for fresh produce	Nielsen	Mar 2021
STI6006	Generation of residue, efficacy and crop safety data for pesticide applications in horticulture crops 2017	Eurofins Agrisearch	Feb 2020 (ongoing)

Note: In addition, most research and development projects also have significant in-kind support from the agencies who are managing them. Information about the research and development (including completed project reports) funded by the industry levy is available at www.australianmacadamias.org/industry and www.horticulture.com.au.

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Chemical	Permit no.	Pest/Disease use	Application rate	Withholding period (no. days)
Minor use permits				
Abamectin	PER87510	Thrips and flat or broad mites	• Product containing 18 g/L abamectin: 750 mL /ha plus 5 L summer spray oil/ha • Product containing 36 g/L abamectin: 375 mL /ha plus 5 L summer spray oil/ha	28
Chlorpyrifos & maldison	PER13642	Australian plague locust	• Product containing 500 g/L chlorpyrifos: 350 mL/ha • Product containing 440 g/L maldison: 1.4 or 1.9 L/ha • Product containing 500 g/L maldison: 1.2 or 1.7 L/ha • Product containing 1000 g/L maldison: 600 or 850 mL/ha • Product containing 1150 g/L maldison: 520 or 750 mL/ha • Ground application	Chlorpyrifos: 30 Maldison: Not required when used as directed
Diazinon	PER14276	Macadamia lace bug	• Product containing 800 g/L diazinon: 120 mL product/100 L	14
Ethephon	PER11462	Promote nut fall after maturity reached	• Product containing 480 g/L ethephon: 65–250 mL/100 L water • Product containing 720 g/L ethephon: 55–165 mL/100 L water • Product containing 900 g/L ethephon: 44–132 mL/100 L water • Do not spray stressed trees • Refer to critical comments for varietal rate adjustments	7
Indoxacarb	PER86827	Macadamia seed weevil	• Product containing 150 g/L indoxacarb: 50 mL product/100 L • Product containing 300 g/kg indoxacarb: 25 g product/100 L	42
Methomyl	PER12796	Banana caterpillar	• Product containing 225 g/L methomyl: 1.5–2 L/ha • Spraying ground mulch/soil surface up to treelines only	Not required when used as directed
Petroleum oil	PER11635	Macadamia felted coccid	• Product containing between 763 and 861 g/L petroleum oil: 1 L/100 L water	Not required when used as directed
Trichlorfon	PER13689	Macadamia lace bug, fruit spotting bug, banana spotting bug and green vegetable bug	• Product containing 500 g/L trichlorfon: 200 mL/100 L	2
Emergency permits				
Chlorantran-iliprole	PER89353	Fall armyworm	• Product containing 350 g/kg chlorantraniliprole: 18 g product/100 L + 15 g active/100 L non-ionic surfactant/ wetting agent • Product containing 200 g/L chlorantraniliprole: 30 ml product/100 L + 15 g active/100 L non-ionic surfactant/ wetting agent	10
Indoxacarb	PER89278	Fall armyworm	• Product containing 300 g/kg indoxacarb: 25 g/100L	42
Methomyl	PER89293	Fall armyworm	• Product containing 225 g/L methomyl: 1.5–2 L/ha • Product containing 400 g/kg methomyl: 0.84–1.13 kg/ha • Spray ground mulch/soil surface only	Not required when used as directed
Spinetoram	PER89241	Fall armyworm	• Product containing 120 g/L spinetoram: 40 mL product/100 L	Follow product label for each crop

All efforts have been made to provide the most current, complete and accurate information on these permits, however, AMS and NSW DPI recommend that you confirm the details at the APVMA website portal: https://portal.apvma.gov.au/permits.

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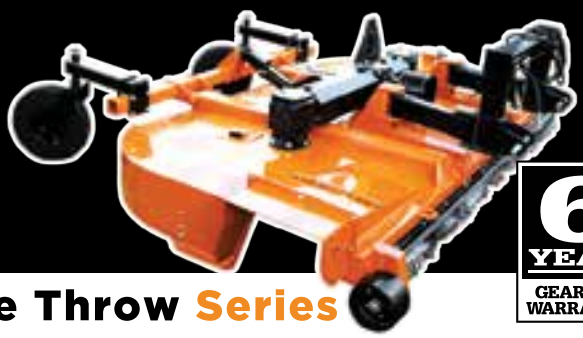
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