AUSTRALIAN MACADAMIA SOCIETY

SUMMER 2021 | VOLUME 49 | NUMBER 4

NEWS BULLETIN



2021 AMS Awards of Excellence winners

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AUSTRALIAN MACADAMIA SOCIETY

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Hort Innovation Strategic levy investment | MACADAMIA FUND

Front cover. *2021 AMS Awards of Excellence winners – clockwise from top left: Nicole and Daryl Wake, Andrew Robson, Fiona and Jason Klotz, Megan Boote, and Peter Fraser. Read their stories on pages 10-22.*

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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What's On

DATE	EVENT	LOCATION	CONTACT
Friday 24 December 2021 12:00 noon	AMS office Christmas closure	Lismore	AMS: 1800 262 426 office@macadamias.org
Tuesday 4 January 2022 8:30am	AMS office reopens	Lismore	AMS: 1800 262 426 office@macadamias.org
Monday 7 February - Wednesday 9 February 2022	AusMac 2022	Royal Pines Resort, Gold Coast	www.ivvy.com.au/event/AusMac2022 Phone: South East Events 0412 798 200 Email: info@southeastevents.com.au
Wednesday 23 March - Friday 25 March 2022	Australian Nut Industry Conference	Melbourne	http://nutindustry.org.au/shop/2022-conference/
Wednesday 11 May - Friday 13 May 2022	INC XXXIX World Nut and Dried Fruit Congress	Dubai	https://nutfruitcongress.org/dubai2022/



CEO's report



Among all the confusion and conflicting messages around COVID-19, it is reassuring to know that some things remain the same.

The Australian macadamia industry is still a great one to be part of and those who manage their orchards well are reaping the rewards. In this issue we cover the 2021 AMS Awards of Excellence, and the winners should be an inspiration to us all, regardless of our role in the industry.

In my close to 40 years in horticulture and association management, it is always the recognition of fellow growers and industry participants that counts most. These are people who understand what it takes to shine in the unpredictable and often unrewarding world of farming.

To Daryl and Nicole Wake, thank you. Your contribution to the outstanding growth of the industry in Bundaberg and to the Macadamia Conservation Trust make you worthy winners of the Norm Greber Award.

To Jason and Fiona Klotz and Peter Fraser, large and small growers of the year respectively, congratulations. To achieve the industry's highest average sound kernel recovery over five years is an outstanding achievement.

To Megan Boote, keep up the good work. Your growers and the AMS really appreciate the effort and care you put into supporting us. And to the team at the Applied Agricultural Remote Sensing Centre, let's realise the full potential of your work. You have opened possibilities to see the industry achieve amazing things.

If you want to learn from these award-winning people, and from the best in the business, the only place to be is AusMac, the biennial (usually) national conference of the Australian macadamia industry. Running from 7 to 9 February 2022 at Royal Pines Resort on the Gold Coast, it will be an event not to miss given the anticipation of the last two years. And with certainty around the Queensland-NSW border opening and early bird discounts closing 17 December, you have no reason not to book your place NOW. I look forward to seeing you there.

Recently we have been able to start reconnecting with each other and the AMS has hosted consultants' meetings in both NSW and Queensland, and MacGroups across all major growing regions. It was pleasing to see the interest in the Grower Toolkit presented to consultants by Leoni Kojetin and Dr Chris Searle. This has been a major undertaking by the AMS and has involved input from key industry participants and advisers. We are looking forward to its formal release at AusMac.

MacGroups were well attended and were a chance for me to continue to present some of the challenges your board see facing the industry and the society in coming years. The board have developed some exciting proposals to help meet these challenges and it was good to get feedback from members in person. The first of these ideas was initiated at the recent AGM with the motion to allow independent directors. More will be said on proposed membership changes at AusMac.

Another is the Women in Macadamias initiative aiming to get the amazing women who make up half of the industry more involved in leadership and decision making. A big thank you to those who filled out the survey. Based on your feedback Nyree, Leoni and the team will be developing a strategy to implement next year.

Finally, a huge thank you to all those growers who have contributed to the Voluntary Marketing Fund. Well over half the industry by volume have contributed to what, in my view, is one of the most important initiatives ever run by the AMS. The support and participation of all major processors has also been critical. To now have both an operational structure and a funding mechanism to raise marketing funds from most major procuring countries and to run marketing campaigns in key existing and new markets is an essential part of keeping your business profitable.

Jolyon Burnett, CEO

Play your part in securing our future

Contributing to a global campaign to ensure demand stays in front of supply is possibly the most important industry initiative since the AMS fought the anti-dumping case brought by the US in the 1980s, which, by the way, we won. That ensured there would be no additional duties on Australian exports to the US.

The Voluntary Marketing Fund (VMF) and the activities the World Macadamia Organisation (WMO) undertakes with funding from Australia and other participating origins will be critical to keeping global demand strong enough to ensure a market for all the global supply and to maintain the value of macadamias.

The VMF is being collected by all major processors and a number of individual businesses. Participating processors have worked hard with their suppliers to explain the need for the fund and the benefits global generic promotion will bring.

Strong industry support

Pleasingly, in its first year of operation and despite a drop in farm-gate prices for the first time in a decade, growers producing around 52% of the crop have contributed. At just 3 cents a kilogram in-shell, why wouldn't you invest in your own future?

The AMS would like to thank all those growers and processors for their support and preparedness to invest in the future of the industry. This initiative will benefit everyone by supporting stable prices and future market development. Even those planning to exit the industry will see this effort reflected in industry confidence and resultant asset values.

Broaden the base

With the fund now successfully established, we are seeking your help in broadening the contribution base in 2022. Many growers held off in 2021 to see if the fund would work and if other origins would contribute. The answer to both of these questions has been a clear YES. Speak to your neighbours and fellow growers and encourage them to pay their share of this important program. The continuing uncertainty of COVID and international trade and markets makes it even more important than in 2021.

To allay any concerns individuals might have, all funds collected are paid into a separate AMS account and used only for supporting the WMO or other marketing activities recommended by the Marketing Committee and approved by the AMS board. Not one dollar of the fund goes to the AMS, which is taking on responsibility for the administrative costs of the fund and the account. Participating processors are also assuming responsibility for the significant cost of establishing and administering the collection system for their suppliers. I encourage you to support processors who are supporting the VMF.

The table below is provided to show the AMS is committed to transparency around the fund and its contributions to the WMO.

2021 season to date – October 2021 - invoiced and reported	2021 $
Total receipts	811,770
Handlers	766,270
Growers	45,500
Total payments	215,456
WMO establishment costs	174,093
Marketing project expenses	41,363
BALANCE	**596,314**

Anticipated collection of over $800,000 in 2021 is a fantastic start. The proportion of the costs to date relate to the establishment of a well-governed international body and these are one-offs. The WMO will have a 100% focus on developing and expanding macadamia markets and ensuring strong demand supports the potential tripling of global supply over the next 10 years.

All contributions to the WMO are leveraged with contributions from five other macadamia origins, hopefully soon to be seven. Australia's share is around 35%; a great improvement on the 100% our marketing levy has represented in the past.

Jillian Laing the CEO of the WMO will be presenting at the AMS conference AusMac 2022 (7-9 February 2022) on the Gold Coast. I encourage you come along and meet her, listen to the exciting work she has planned and, if you do not already, contribute to the VMF in 2022.

ACT NOW TO PROTECT YOUR LONG-TERM INTEREST The AMS is asking you to play your part in securing our future. All growers are being asked to contribute just 3 cents per kg or less than 1% of your gross return to the Voluntary Marketing Fund. This will supplement the existing marketing levy and be matched equitably by other participating countries. Please contact your processor and opt in to contributions for the 2022 season.

GOT QUESTIONS? NEED HELP? If you have any questions about the program or need assistance or more information, please contact AMS CEO Jolyon Burnett on 0416 224 935 or jolyon.burnett@macadamias.org.



Here for the love of macadamias

At the WMO, we're passionate about growing global demand for one of the world's most untapped and undiscovered wholefoods.

As the worldwide industry champion, our key focus is to drive a greater understanding and appreciation of macadamias. Ultimately, we're here to stimulate growth and provide the long-term foundations for a strong, sustainable market.

The WMO is positioned right where it needs to be – at the intersection of the global industry and the consumer. We incorporated in Singapore in September 2021 and had Australia, South Africa, Kenya, Guatemala, Hawaii and Vietnam join as inaugural members. By coming together as an industry, we can leverage the resources of everyone.

Our focus is on building demand in three key areas; seeding the emerging Indian market, growing frequency of consumption in China, and strengthening demand in the rapidly increasing plant-based diet sector. The WMO will also facilitate health and science-backed research to build our credentials, collect insightful industry data, and create alignment in global product standards.

By supporting the World Macadamia Organisation you're supporting the future of your industry.

The WMO.
Here for the love of macadamias.

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www.worldmacadamia.com

Strong Australian sales and production as demand recovery continues



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

Supply

The latest published forecast for the 2021 Australian macadamia crop is 48,500 t in-shell at 3.5% moisture (52,000 t at 10% moisture), and the industry is optimistic that when the intake is reviewed in December, the 2021 season will deliver closer to 50,770 t at 3.5% (54,000 t @ 10%). This is due to favourable growing conditions in most regions despite the ongoing legacy of previous years' sustained drought. Queensland's growing regions performed strongly, and production from the new plantings in Bundaberg continues to increase as they reach five to ten years of age.

The global forecast for the 2021 season as reported by the INC is 240,424 t in-shell @ 3.5% moisture, an increase of just over 5%. Macadamias South Africa's (SAMAC) published crop estimate for 2021 is 54,174 t in-shell @ 3.5% moisture, 11% higher than the 2020 season. Figures from Kenya indicate a 2021 crop of 37,000 t in-shell @ 3.5% moisture. China and Malawi are expected to return solid crops.

As we look towards 2022, Australian weather conditions have been excellent for flowering. Young trees are in good health, and it is expected new plantings will increasingly bear more commercial quantities.

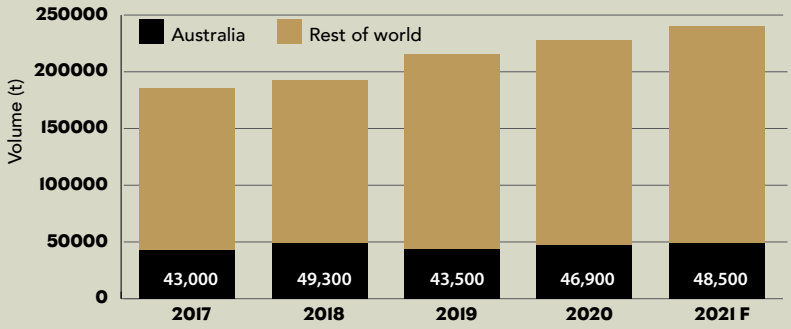

Figure 1. Global macadamia crop volumes 2017-2021 (tonnes)
Source: INC. All volumes are at 3.5% MC.

Demand

As reported by National Australia Bank in October, the economic recovery from COVID-19 is unfolding at varying rates across the globe, resulting in a significant disparity in growth trends between markets. One common issue that remains across all regions is supply chain bottlenecks causing disruptions across the global network and challenging the industry.

Global demand for total macadamia kernel imports reflects this unevenness with Asian markets growing (Japan and China/ Hong Kong up 19% and 15% respectively), Europe stable, and the USA well off the pace at -21% compared with the year before (MAT September – August). With international travel restrictions continuing throughout 2021, the Hawaiian crop was consumed domestically reducing demand for kernel imports into the USA.

Total macadamia in-shell imports to China and Hong Kong were down by 16% following record import sales in the period before. However, Australia, Kenya and Guatemala experienced strong growth in this market at the expense of other origins. South Africa and Australia remain the major suppliers of NIS to this market.

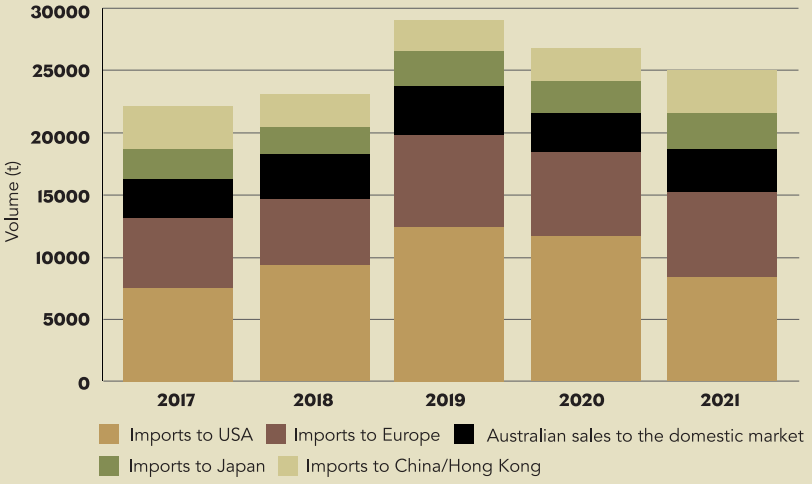

Figure 2. Macadamia kernel imports to top 5 markets (tonnes) MAT September - August
Sources: USDA, Eurostat, Japan Customs, China Customs, Hong Kong Census & Statistics Department via IHS Markit Inc, AMHA

Australian sales

The Australian macadamia industry has proven it is resilient following the global challenges of the COVID-19 pandemic in 2020. The quality standing of Australian macadamias in the global market and the strong commercial relationships in place have resulted in an upswing in Australian kernel sales in 2021.

Australian macadamia kernel sales performed very strongly, with all regions experiencing growth on prior MAT period. South Korea continues to be one of the fastest recovering markets for Australian sales, up 65%. Sales to USA improved with Australia's market share lifting from 5 to 7%. Sales to the domestic market were positive at +14% on the year before.

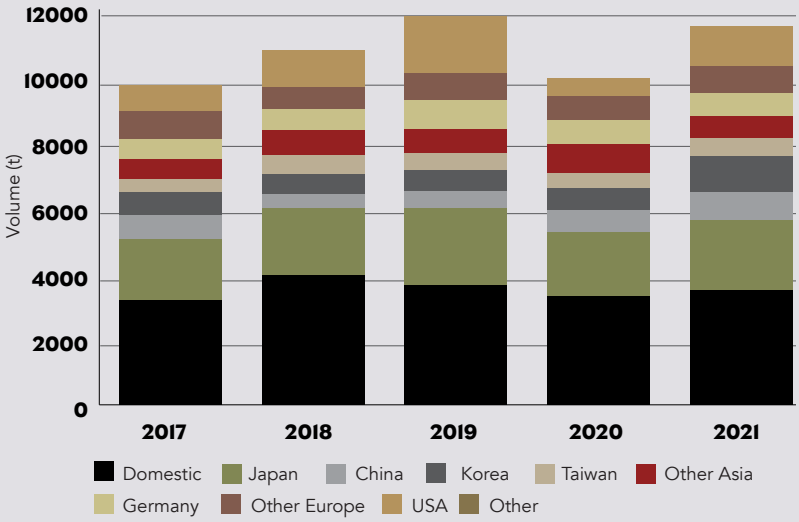

Figure 3. Australian macadamia kernel sales (tonnes) MAT (October - September) Source: AMHA. In-shell sales quoted at 3.5% MC. AMHA represents 90% production, sales are adjusted to represent non-AMHA members

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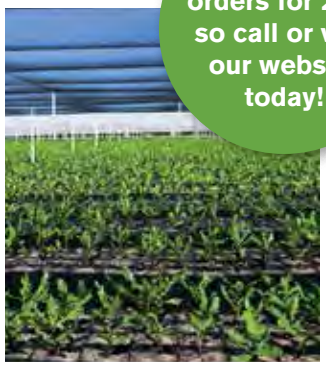





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Leoni's orchard rounds



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With no official crop forecast change released, the industry looks on track to achieve a crop of close to 54,000 t (@10% MC). Final figures will be released by the Australian Macadamia Handlers Association in December, but there are some clear trends with yield and total kernel recovery.

Industry yield is up on the last two seasons, but this does include some new plantings that have come into bearing. While yield has increased, the total kernel recovery (TKR) is expected to be lower than the 2020 record high of 37.85% average for all regions. In the 2021 season Queensland, which is still dealing with extended dry conditions, will achieve a similar result to 2020, likely above 38% TKR. The impact of rain and floods in New South Wales mean it will achieve a lower result, likely under 36% TKR.

Storm season - are you prepared?

One of the current challenges for growers is storm season. Longer, sunnier days, coupled with humid conditions and the recent BOM La Niña alert, increase the likelihood of more storms of greater intensity. While we can't control the weather, we can prepare for severe events, although most are long-term management strategies aimed at building orchard resilience.

Some of the obvious strategies are improving tree health and orchard floor preparedness. Healthy trees with a large and actively growing root system recover better from physical damage and stress events. Similarly, an orchard with good drainage, stable watercourses and protective ground cover will cope far better with any severe event.

With any damage, trees are likely to be stressed and applying kelp is a common strategy. Although the mechanism for stress amelioration with some kelp products is not well understood, growers have found it reliable in helping trees recover.

The other response common to any damage is to promote regrowth, particularly of root systems. While many growers think first about getting leaves back on trees (having more solar panels), roots are really the engine of the tree. Without actively growing roots, many plant processes are crippled and disease immunity is dramatically reduced. Root growth generally follows above-ground vegetative flushes, but because this growth is unseen, we often are not aware of it.

Working towards the goal of orchard resilience provides a buffer or insurance policy against extreme and unforeseen events. Actively promoting an environment for roots to thrive is fundamental to this goal.



A resilient orchard with good drainage, stable watercourses and protective ground cover will recover more quickly from storm damage. Photo: Megan Boote

Help and information

If you are affected by storm damage and need help or information, contact the AMS office. When there are severe weather events in any region, we work to help growers with information and advocate for disaster relief. This is only possible when we can quantify and report damage to the relevant authorities, so please keep us updated so we can help you.

Recovering from storm damage

Listed below are some general, short-term recovery strategies and considerations. Your orchard may have unique constraints, so it is important that you discuss any plans with a professional consultation before implementing them.

Key susceptibility	Likely damage	Recovery strategies/considerations
Hail		
• Flowers • Maturing nuts • Sunburn (with defoliation)	• Flowers and maturing nuts knocked off trees • Tree hail wounds leading to increased disease risk • Nut hail wounds leading to increased pest damage risk • Defoliation	• Physical wound protection such as paint • Fungicide spray for wounds (if ongoing weather is conducive to disease infection) • Sun protection such as kaolin clay • Stress amelioration products (like kelp) • Nutrition to stimulate root growth and leaf flush
Wind		
• Maturing nuts • Exposed sites • Young orchards • Known susceptible cultivars: A4, A38, A203, A268, 842 and Daddow • Cultivars known to be susceptible to being blown over: 344, 741, A268 • Fine clay soils • Sunburn (with defoliation)	• Trees blown over (in clay soils trees often have shallower root systems and some clays lose structure when wet) • Broken branches • Defoliation	• Pruning young trees to allow wind through canopies reduces risk of damage • Standing trees back up and staking if blown over. These trees will likely always struggle • Prune broken branches to neat wounds, not jagged, as these hold water and increase disease risk • Pruning back too much can deplete carbohydrates stored in tree structures • Sun protection such as kaolin clay • Stress amelioration products (like kelp) • Nutrition to stimulate root regrowth and leaf flush
Heavy rain		
• Poorly drained orchards • Over-canopied orchards • Low groundcover sites • Steep orchards • Flowers at pollination stage	• Erosive soil loss • Erosive organic matter loss • Exposed roots • Waterlogging and increased disease risk • Flower drenching, reducing pollination	• Excavators to reclaim displaced soil • Reapply organic matter, possibly material that breaks down more rapidly (depending on how close to harvest) • Orchard profiling in following dry season • Monitor for signs of *Phytophthora* and apply phosphorus acid if required • Stress amelioration products (like kelp) • Nutrition to stimulate root regrowth
Flooding/inundation		
• Low-lying areas • Poorly drained orchards • Unmounded sites	• Erosion • Prolonged waterlogging and increased disease risk • Lack of oxygen to roots if water is stagnant • Potential salinity	• Excavators to reclaim displaced soil • Orchard profiling in following dry season • Deep irrigation can reduce salinity, or apply gypsum • Monitor for signs of *Phytophthora* as with heavy rain • Stress amelioration products • Nutrition to stimulate root regrowth

MacGroups back on the calendar

As restrictions are lifting, the AMS is completing another round of MacGroups at the end of November in Queensland and beginning of December in New South Wales. It has been great to see you all after what felt like a long absence from face-to-face gatherings.

Our industry conference is scheduled for 7-9 February 2022 and it really is a must-attend attend for all growers.

I guarantee you will come away with loads of new ideas about how to improve your productivity and profitability. View the program at www.ivvy.com.au/event/AUSMAC2022 and take advantage of the early bird prices which are available until 17 December.

We look forward to seeing you there!

Leoni

Norm Greber Award winners help ensure future of macadamias – on farm and in the wild

Anne Currey, AMS Communications

Bundaberg-based growers Daryl and Nicole Wake, who are the 2021 Norm Greber Award winners, exemplify the commitment to the industry and generosity macadamia growers have long had a reputation for. The award recognises the important role Daryl and Nicole have played in helping to ensure the availability of MCT1 scion wood to growers and, along the way, contribute to efforts to conserve wild populations of macadamias for future generations.



Daryl and Nicole Wake

The story of MCT1 is well known to many in the industry. The cultivar, which was selected by Ian McConachie, was one of two survivors from a group of 80 experimental cultivars planted on "Warrawee" at Wolvi, in the late 1990s.

What is probably less well known is the role Daryl and Nicole have played in ensuring that growers who decided to plant MCT1 were able to source DNA-certified grafted trees from nurseries in Queensland and NSW. This, in turn, has ensured a reliable income source for the trust from the royalties paid, to fund its important conservation program.

After buying the family dairy farm from Daryl's parents in the early 2000s, he and Nicole set about converting it to a 26,000-tree macadamia enterprise, DarNic Park. One of the cultivars they planted was named M416. Daryl and Nicole documented its high-yielding potential by observing nuts and trees across the road from their home. When M416 was gifted to the Macadamia Conservation Trust (MCT) by Ian and Jan McConachie and Plant Breeders Rights (PBR) taken out, the name was changed to MCT1.

Daryl and Nicole recognised that because it was likely to become sought after by an expanding industry, supply could be an issue, so they proposed a joint venture with MCT to supply scion wood to nurseries. They were motivated to give back to the industry which had given so much to them.

To get this proposal off the ground was not a simple matter. Of particular concern to MCT was ensuring that the scion wood was genetically pure and from Ian's original selection, M416. To confirm this Daryl and Nicole, with the help of MCT1 scion distribution coordinator, Brice Kaddatz, and Southern Cross University, had 1,000 of their trees DNA tested.

After genetic confirmation, the next step was to produce scions to supply to nurseries. This was no small task. Daryl and Nicole employed extra staff to assist with cincturing, stripping, sizing and packaging orders. In the past 14 months, more than 160,000 scions from DNA-tested wood have been delivered to nurseries from those trees, ensuring that growers have access to this promising new cultivar.

Daryl and Nicole will continue their partnership with MCT until the end of June 2022.

Other than the direct costs of their involvement in being one of the main suppliers of DNA-tested wood for MCT, Daryl and Nicole have also foregone the early income potential from the MCT1 trees that they planted.

Jolyon Burnett, AMS CEO, congratulated Daryl and Nicole on winning the award saying that they have shown great generosity in directing their orchard's resources away from personal gain and to supporting the industry and ensuring other growers have access to MCT1.

"At the same time, their actions are contributing to the conservation of macadamias in the wild, which will be so important down the track for development of new cultivars as well as for the enjoyment of future generations," he said.

Daryl and Nicole said they were both honoured to accept the Norm Greber Award.

"It's exciting for us to be a part of a young, growing, and 'like-a-family' industry. We feel privileged to support our fellow growers to build a stronger industry while also assisting the MCT as they strive to ensure the conservation of wild macadamias into the future," they said.



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Max Millar from Yolmax Macadamia Farm

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The winners of the 2021 AMS Awards of Excellence have been announced

The AMS extends congratulations to all national and regional winners.

The major award winners for 2021 are:
Norm Greber Award: Daryl and Nicole Wake
Large Grower of the Year: Jason and Fiona Klotz
Small Grower of the Year: Peter Fraser
Young Achiever of the Year: Megan Boote
Innovation of the Year: University of New England Applied Agricultural Remote Sensing Centre

We've caught up with all our winners in this edition and found out some of the secrets behind their success.

LARGE GROWER OF THE YEAR: Jason and Fiona Klotz

Karina Griffin Project Support Officer, AMS



Fiona, Sam and Jason Klotz

Grower: Jason and Fiona Klotz, Red Rock Macadamias

Location: Bundaberg and Childers Queensland

Home farm: 80 ha (mature 13 - 14-year-old trees). A203, 741, 816, Daddow and A4

Red Ridge farm: 120 ha (young 4 - 5-year-old trees, now bearing), A203 and 741

Spacing: 8 x 4 m, 312 trees/ha

Soil type: Home farm - red volcanic and black clay; Red Ridge farm - mostly grey loam

Jason and Fiona Klotz have taken out the 2021 award for large farm of the year best productivity, which recognises consistent, high production over the last five years. In an impressive result, they achieved an average of 5.8 t/ha (NIS) and 2.2 t/ha kernel. Jason and Fiona featured in the Spring 2018 edition of the *News Bulletin* when they took out the top spot for saleable kernel. Since then, they have undertaken a major expansion with an additional 120 ha of macadamias now in the ground and starting to produce a crop.

Karina spoke with Jason and Fiona to get an update on their expansion and what it takes to maintain consistent, high-quality production.

Expansion of Red Rock Macadamias

Since 2018, Red Rock Macadamias has significantly increased the area planted to macadamias with the establishment of 120 ha of trees on their Red Ridge property near Childers. Jason and Fiona decided to plant A203 and 741 cultivars and the trees are now four to five years old.

"Kernel recovery, quality and taste were key factors in the decision to have A203 as the main variety on Red Ridge," said Jason. "We then went with 741, which are a known variety with history of good performance and yield, with similar kernel properties to the A203, so if we ever blend them in the future it should work from a marketing point of view."

Jason explained that efficient management practices were a major consideration in the Red Ridge site development, beginning with rows "as long as possible". This is no exaggeration, with rows having an average length of 1 km. Another element of ensuring management efficiency was planting cultivars separately in large single cultivar blocks.

"We like to harvest by variety so only one variety is running through the shed at a time," said Jason.



Red Ridge farm is the newest Red Rock planting with 120 ha of A203 and 741. Photo: Jason Klotz

The advantage in this is that it allows them to run on pre-set equipment specifications which have been optimised for each cultivar to preserve quality.

Focus on machinery and system efficiency

Finding efficiencies in their production systems is a core component of Jason and Fiona's business. By adopting new and existing technology both in the orchard and in the shed, they have been able to implement continuous improvements over time in anticipation of handling an additional 120 ha of nut.

Jason works closely with all his staff including his shed manager Mark and engineer Darren to improve harvesting and sorting equipment so it is as efficient as possible. Cameron and Paul from Agri-Con Equipment in Bundaberg have also been heavily involved in the new harvester designs for the orchard. Other recent projects undertaken include a custom-designed dehusker, a custom tree sprayer from Interlink Sprayers and now a mobile dehusking plant.

The modifications to their sprayer and harvester mean they can now operate them at almost twice the speed they used to and cover double the amount of ground in the same time.

Walking through the dehusking and sorting shed with Jason and Fiona you can see that they are passionate about making the process as efficient and quick as possible without compromising the quality of the nut.

"The quicker we can get it through the shed and out the door to our processor, the better the nut quality will be," said Jason.

The dehusker, which runs on their harvesters and in the shed, has been designed to cleanly remove husk with minimal damage to nut in shell (NIS) and kernel, with the aim of preserving quality. As well as being functional, the high-quality components are beautiful with shiny, smooth, clean lines.

In the shed, Jason could see that dehusking the entire harvester load was slowing them down, particularly when their onboard dehusking unit was taking off between 70 to 90% of the husk in the field. The solution was to use a colour sorter to separate the nut in husk (NIH) from the NIS, so only NIH was sent through the dehusker.

"This means that all NIS and NIH goes straight across the colour sorter. We can feed up to 6 t/hr of NIS and NIH. With 30% NIH we dehusk about 2 t/hr, so it is much more efficient and extends equipment life. Also, we now only require two people on the sort table to maintain 4 t/hr of finished NIS."

As further proof of his success in developing innovative equipment, the fingerwheels designed by Jason and the team (featured in Autumn 2021 *News Bulletin*) have been commercially available for two harvest seasons, with great feedback from growers who are using them.

Despite being an innovation trail blazer in the industry, Jason is modest about what he's doing saying "it's just been a bit of fun, really".



Jason has been working closely with Agri-Con to custom design a new harvester.



Fabrication of the frames and scrolls that form the basis of the custom designed dehusker used on Red Rock harvesters and in the dehusking shed.



A unique feature of the dehusking shed that increases throughput is that only nut in husk is sent through the shed dehusker. This is achieved by harnessing colour sorter technology to separate nut in husk from nut in shell.

Refining orchard management practices and adapting to seasonal conditions

Even with thousands more trees to look after since the article in 2018 there is still a focus on 'getting the little things right'.

In the orchard, Jason and agronomist Tate collect and keep detailed records on irrigation, tree phenological stages and their water use patterns, using soil moisture probes, sap flow meters and fruit dendrometers.

"It has obviously been a bit drier over the past few years, and this means that we are monitoring water use by the trees very closely, so we can see when they are really needing it," said Jason.

All the soil moisture and sap flow monitoring tools are checked regularly and can be accessed remotely. When developing the Red Ridge farm, irrigation infrastructure was carefully planned so that the pumps and lines can be run and monitored remotely from the office.

On all the Red Rock farms a combination drip and sprinkler irrigation line is used: "The drip is there for applying that concentrated water volume where the tree really wants it in those high water use periods. The sprinklers are there to keep all the feeder roots moist and give them a little bit of moisture so they can uptake nutrients efficiently." said Jason.

Pest, soil and tree health monitoring is also done regularly to inform any chemical spraying, nutrient requirements and water inputs.

Soil and leaf tests are conducted regularly, and nutrient programs are adapted over the year based on results. This combined with managing different soil types is key to getting the best out of the trees.

Tate also runs trials on new products to evaluate their value and efficacy, to determine whether to integrate them into Red Rock's orchard management program.

'We are nothing without our team'

Jason and Fiona both agree having dedicated staff gives them the best return on investment for the farms: "We can invest in top class equipment but unless you have the right people to operate and maintain it we never get the best out of it."

They now have five permanent full-time staff and three casuals, some of whom were with them when the first trees were planted on the Home farm in 2006. Their son Sam is also involved on the farm while finishing school and is keen to learn more about the drone work. On the day I was with Jason and Fiona I shared in the excitement of the much anticipated arrival of 'Wall-E', their new multifunctional robot that is being trialled in their orchard by Oztech Drones and the Central Queensland University.

"It's a lovely industry to be in and it's nice to be able to do it together as a team and a family. We thoroughly enjoy that and, as Jason pointed out before is, we need our team as we can't do it by ourselves," said Fiona.

Hard work brings consistent results

Taking out the Grower of the Year award this year is a testament to the hard work of Jason, Fiona and their Red Rock Macadamias team.

"Having the highest saleable kernel in a given season is great but to receive an award for five years of consistent high-quality kernel is really something," said Fiona.

Jason agreed, adding that he is committed to everything he does. "I look at it as being just like a big hobby.

"What else would you want to be doing?" he asked.

Congratulations to Jason and Fiona for this fantastic achievement.





Pest, soil and tree health monitoring is done regularly to inform any chemical spraying, nutrient requirements and water inputs.

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SMALL GROWER OF THE YEAR: Peter Fraser

Anne Currey, AMS Communications



Location: Rosebank, Northern Rivers NSW

Grower: Peter and Mary-Louise Fraser

Orchard: 8 ha

Cultivars: Nutty Glen, A16, 344, 246, A38 A4, 849 and 741, 36 years old

Spacing: 7.5 x 3.5 m

Soil type: Shallow ferrosols on clay

Long-term focus on nutrition and the orchard floor proves a winner

Winner in the 2021 small farm category for best production is Peter Fraser whose 7.9 ha orchard, located in the Northern Rivers near Lismore, recorded an exceptional 6.3 t/ha (NIS) average and 2.4 t/ha (kernel) over the last five years.

For the 40 years that Peter and his family have been growing macadamias, their philosophy has remained consistent – to invest in the key priorities to develop a healthy soil and a highly productive orchard.

Conventional wisdom in the industry is that yield will decline as trees age, however, this certainly is not the case with the Fraser orchard whose mature trees continue to be highly productive.

Nutrition the key

An important contributor to this is Peter's long-term nutrition regime, which is based on applying significant amounts of organic material and no synthetic fertilisers. This nutrition regime has been shaped by the orchard's soil, which is a shallow ferrosol underlain by clay, meaning that it is important to ensure moisture and nutrients are in good supply and to control erosion and runoff.

"My philosophy is to continually build the soil resource to sustain higher yields," Peter said. "The focus is to increase soil carbon and soil life, especially fungi and earthworms, so nutrients are in abundance, balanced and available at all times."

Peter's plan for building organic matter has extended from pre-planting to mature orchard, as he explained:

- Pre-planting. Cover crops such as lablab and lupins to build nitrogen and organic matter.
- During establishment. Grasses and legumes established in the interrow and side-cast under trees. Fertiliser applied to the interrow.
- Mature trees. Leaf drop and chipped prunings are the main source of organic matter.

His nutrition program is similarly matched to orchard stage with pelletised composted chicken manure applied regularly in small quantities with rain to establishing trees. As trees mature, features of his nutrition program include:

- Applications of crushed rock products such as lime, gypsum, calcium borate and calcium silicate every two to five years.
- In a normal year during spring or summer, if it is dry, foliar fertilisers are applied in chelated organic form with extra boron and calcium. Peter said that the reason for the foliar application is that trees cannot source these nutrients from dry soil, and it is important to ensure an adequate supply during the critical development stages of flowering and nut development.
- Applications of foliar kelp when it is extremely hot and dry.

He also checks soil nutrient status with a soil test after wet season to ensure pH levels are within range and that nutrients are in abundance and in balance. Since he has been fertilising with manures and compost, tests



Peter checks a native bee hive in the orchard.

have always confirmed an abundance of nutrients other than sulfur, boron and silicon, which he corrects by applying the crushed rock products.

An issue in the orchard, which is on hilly country, has been sheet erosion. To combat this, he has brought in organic matter from off-farm.

"I apply partially composted wood and animal manures as soon after harvest as possible, and I follow this up with an application in December of true compost made from nut husk, chicken litter and any organic material available," he said.

Using this approach, Peter explained that he does not have to apply synthetic fertilisers, as shown by his soil and leaf tests. The advantages of this are that organic inputs are cheaper than synthetic fertilisers and they act to improve soil structure, cover roots and increase soil mass. As well, they only need to be applied once or twice a year and not at all during harvest.

He added that if synthetic fertilisers are used, much more organic matter will be needed. Mulch will disappear quickly exposing soil to sun, soil carbon will be burnt from the soil (excess free nitrogen) and soil life will be affected (superphosphate kills earthworms and fungi) halting soil development and nutrient recycling.

He does not use copper fungicides either.

"Using them in mature orchards severely limits nutrient recycling by fungi. Copper is expensive and not needed as shown by the fact that we have had no economic loss from husk spot since we stopped using it 15 years ago," said Peter.

Infrastructure upgrades

With harvest efficiency in mind, he also has recently upgraded his infrastructure to enable more efficient handling, including a new pinwheel/ejector system and a new inspection conveyor to remove all leaf, rocks and sticks.

Along with continuous harvesting and mowing, his new machine means that each round takes about two days to pick up 90%+ of nuts compared to previously, when it took between five and seven days.

"And the new conveyor means that dehusking now proceeds without jams and down-time and less maintenance is needed," said Peter.

These improvements in the shed allow him control over quality and he delivers the nut to the factory as soon as he can. The result is a robust, resilient orchard system that is consistently highly productive.

Eye to the future

Peter has his eye on more improvements with two high on the list: automation of dehusking and a road broom to keep drains clean, dig nut out of long grass and put soil and organic matter under the canopy.

"Most of all I want to improve soil life at depth by using a machine that drills holes so I can place lime and compost into the subsoil," he said.

Peter's top tips for new growers (learned the hard way)

- Buy the best soil and the least sloping land possible
- Know your soil and its problems
- Fix drainage issues before planting
- Avoid east/west row alignment (decreases potential for light to get into the canopy)
- Don't grow trees too quickly and don't plant them too close together
- Don't use windbreaks
- Don't stake trees
- As a risk management measure and to improve pollination, plant many cultivars
- Expect the price of NIS will drop below costs periodically
- Don't let trees grow tall, rather follow the *Integrated Orchard Management Guide*. "It's spot on and I wish I had it when starting out."

And most important, good luck – you'll need that too!



Peter has had to combat sheet erosion on his hilly orchard

YOUNG ACHIEVER OF THE YEAR: Megan Boote

Anne Currey, AMS Communications



AMS Young Achiever of the Year Megan Boote says she loves being a part of the macadamia industry and has paid tribute to the many growers and consultants who have helped and supported her since she joined Suncoast Gold in 2016.

The Young Achiever Award recognises her contribution and the passion she brings to the industry.

Grower perspective a priority

Megan is no stranger to agriculture, having been raised on a farm and then completing a Bachelor of Agricultural Science, she has worked across industries ranging from intensive livestock production, rural lands management, and managing farms alongside her husband. An advantage this background gives her is an ability to see issues "from both sides of the fence" and to understand the challenges that growers face every day on the farm.

One of the things she particularly enjoys about the macadamia industry and her job as grower liaison officer is the variety of tasks and the people she deals with.

"When I started at Suncoast Gold, my role was mainly on farm focusing on integrated pest and disease management (IPDM), but since then it has evolved considerably. I still have a strong focus on IPDM, but I also do a lot behind the scenes to ensure growers have access to the latest information for continual improvement, and the process of delivering their crop is as smooth as possible."

"I enjoy the diversity of the role and find it rewarding to be able to spend time in the factory as well as visit growers and interact with the broader industry," she said.

In a short time, Megan has firmly established a reputation among growers and the industry in general, including other consultants and grower liaison officers, for her enthusiasm and willingness to freely share information and her knowledge.

The growers she services in the Gympie area comment on the lengths to which she will go to help them and tailor her recommendations to each situation, so they are practical and achievable.

"Communication is so important and is key to improving yield and quality outcomes. Delivering information and research outcomes to growers in a timely and relevant way is what I have strived to achieve," she said.

She also explained that as part of her role it is important to understand that growers have different expectations of their businesses, and that this will affect how they manage their orchards and the assistance they need.

"For instance, growers embarking on new projects or renovating older orchards are more likely to need more support along the way," she said.

Megan's commitment to the industry doesn't begin and end with growers. According to Jolyon Burnett, she has been a great supporter of the AMS and its activities and is always willing to give a helping hand to the Macadamia Conservation Trust.

Eye to the future

Looking to the future, Megan believes that a challenge will be operating within a much larger industry, with production and numbers of growers increasing.

"While this is a positive, it does mean that we will need to focus on ensuring growers have the same level of service and can access help and advice when they need it," she said.

Megan has worked hard to establish herself as a valuable member of the industry and is keen to be part of its next generation of leaders, an ambition that recently motivated her to complete the ANIC Leadership Program.

"There are lots of opportunities in the industry, as well as a few challenges, and I am keen to be a part of its future," she said.

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INNOVATION OF THE YEAR: University of New England Applied Agricultural Remote Sensing Centre

Anne Currey, AMS Communications

Innovation of the Year uses emerging technologies to give industry management edge

The winner of the 2021 Innovation Award is the University of New England's Applied Agricultural Remote Sensing Centre (AARSC), the research team behind the Multi-scale Monitoring Tools for Managing Australian Tree Crops: Phase 2, funded by Horticulture Innovation and the Federal governments 'RR&D4Profit scheme'.

Under this project and its predecessor (Phase 1), all macadamia orchards in Australia have been mapped, with the results now being used to support the industry-wide development and adoption of remote sensing tools that will help the industry better manage all orchards.



The Australian Tree Crop Map Dashboard shows where Australia's tree crops are grown.

Tools developed and in use

When it was first approved, the potential applications of the project results were not fully appreciated across the industry. Through efforts of the team, whose skills include data management and analysis, AI and remote sensing, new tools are being developed that offer significant benefit to individual growers, regional groups, policy and biosecurity managers.

The first stage of the mapping identified areas planted to macadamias in NSW and Queensland down to orchards as small as 2 ha, some of which had not previously been known to exist.

With the tools from this project, the industry now knows where orchards are located and will have the ability to better quantify annual change in production area and orchard distribution, yield, disease and biosecurity risks, the impact of natural events such as bushfires and storms, as well as assess the age of trees and plant health. This ability will provide the macadamia industry with a powerful resource that will allow a faster and more comprehensive response to natural disasters and to biosecurity threats as well as providing a more accurate basis for forecasting the national crop and planning for orchards in the future.

Development continues

Now the mapping is being complemented by historical data to identify orchard age as well as being integrated with innovative remote sensing algorithms to develop a range of applications including yield mapping and forecasting at the block, farm and regional level. This is currently being evaluated by many of Australia's largest macadamia producers and being integrated into existing climate forecasting methods developed by QDAF.

Much of the management and practices of future orchards will be based on this mapping and the remote sensing tools that are built around it.

Leading-edge technology freely available

This project undertaken by the AARSC has established the Australian macadamia industry as a global leader in the adoption of emerging technologies (remote sensing technologies and industry wide spatial data



Craig Shephard, senior researcher from AARSC, validating a new macadamia plantation to inform the map.



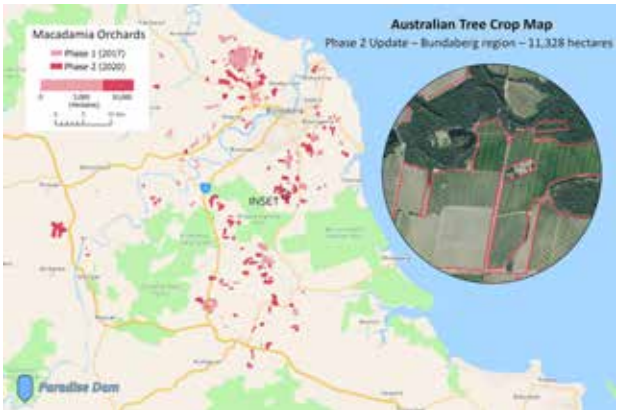
Prof Andrew Robson, Director of AARSC and project lead of the Multi-scale Monitoring Tools for Managing Australian Tree Crops: Phase 2.



Joel McKechnie, researcher from UNE, validating macadamia trees for the map.

infrastructure) that will substantially benefit the entire Australian industry for years to come.

The mapping work can be freely accessed on a world-leading Australian Tree Crop Map Dashboard, which was awarded best international dashboard application at the global Esri User Conference earlier this year, attended by over 70,000 delegates. This award is complemented by the Maxar Technologies Award to the AASRC for 'Best Organization in Imagery Application, for the team's work in applying high resolution satellite images to solve real world problems' for the Oceanic and Australian region. The mapping dashboard is now hosted on the AMS website, allowing direct access to all Australian growers.



The Australian tree crop map reveals the rapid expansion of macadamia orchards in Bundaberg since 2017.



Land use survey of a new macadamia orchard. Without this survey, this orchard would not yet be in the map.



Dr James Brinkhoff, Senior Research Fellow at AARSC, whose recent work with macadamia yield forecasting has attracted significant interest and engagement by industry.

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2021 REGIONAL AWARD WINNERS

Finalists in the regional awards were shortlisted by the QDAF benchmarking team using yield and quality data collected from the 2020 season. The awards are separated into small and large farms. Regional winners are listed below. Congratulations to all.

Selection criteria
Best productivity (saleable kernel t/ha) and best quality (lowest RKR and achieving or exceeding 2020 industry average productivity of 0.95 t/ha saleable kernel).

Gympie, Glass House Mountains, Northern Rivers NSW and Mid North Coast NSW
Small farms = <30 ha
Large farms = >30 ha

Bundaberg and Central Queensland
Small farms = <50 ha
Large farms = >50 ha







Some of the regional award winners, from top: Scott Allcott, Macadamia Farm Management (Central QLD and Gympie winner), Craig Van Rooyen (Central QLD winner), Victoria Thynne and Robert ('Tod') Todhunter (NSW mid north coast winner).

Region and category	Winners, orchard	Details
Central Queensland		
Best productivity		
Large farms	Jason and Fiona Klotz (Red Rock Macadamias)	2.20 t/ha SKR
Small farms	Macadamia Farm Management (Quamby)	2.08 t/ha SKR
Best quality		
Large farms	Macadamias Australia	0.46% RKR
Small farms	Craig Van Rooyen (Nunkeri)	1.17% RKR
Gympie Queensland		
Best productivity		
Large farms	Macadamia Farm Management (Como Park)	1.49 t/ha SKR
Small farms	Bruce Maguire (Twisted M)	1.79 t/ha SKR
Best quality		
Large farms	Macadamia Farm Management (Como Park)	1.97% RKR
Small farms	Bruce Maguire (Twisted M)	2.13% RKR
Glass House Mountains Queensland		
Best productivity		
Large farms	Chaney Walter (Walts Nuts)	1.04 t/ha SKR
Small farms	Henry and Jarod Agostinelli (Coastal Produce Queensland)	1.95 t/ha SKR
Best quality		
Large farms	Chaney Walter (Walts Nuts)	1.32% RKR
Small farms	Henry and Jarod Agostinelli (Coastal Produce Queensland)	0.53% RKR
Northern Rivers NSW		
Best productivity		
Large farms	David and Sharon Wardrop (Poligolo)	1.69 t/ha SKR
Small farms	Peter Fraser (Macadamia)	2.37 t/ha SKR
Best quality		
Large farms	James Auld (Noorook)	1.8% RKR
Small farms	Richard Paine (Merraldan)	1.2% RKR
Mid North Coast NSW		
Best productivity		
Large farms	Victoria Thynne (Elanora)	1.26 t/ha SKR
Small farms	Fern Hinchcliffe (Barrington Grove Macadamia Farm)	2.28 t/ha SKR
Best quality		
Large farms	Victoria Thynne (Elanora)	2.01% RKR
Small farms	Tim Zeck and Dru Marshall (Wirrimbi)	1.3% RKR

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Macadamia harvester modifications improve safety and performance

Willy and **Rita Camilleri,** Northern Rivers NSW growers

Before they moved to the Northern Rivers in 2017 to grow macadamias, Willy and Rita Camilleri spent most of their working life on an irrigated broadacre and vegetable farm near Gunnedah in NSW.



Farm: Caprice Downs

Growers: Willy and Rita Camilleri

Location: Rous Mill, Northern Rivers NSW

Size: 7.4 ha

Spacing: 7 x 5 m (285 trees/ha)

Cultivars: 344, 741 and 246

Soil type: Red loam

Willy has always looked for ways to improve and customise his machinery for the farm, so it was no surprise when he and Rita agreed early this year that their harvester should be modified to improve its efficiency.

Willy planned out most of the modifications and improvements in consultation with Tony (Rita's brother), who also helped with fabrication. They also manufactured some parts with a local engineering shop in Lismore.

We asked Willy to share what modifications they made and why.

The machine

We bought our Kubota F3690 without the front mower deck and modified it to make our macadamia harvester. Originally, Rita and I inherited a secondhand harvester with the farm (Kubota F3560), similar to models available from Lismore Engineering and other machinery suppliers.

The key reasons for modifying the harvester were for safety, efficiency and reliability. The old harvester wasn't in great condition when we got it, but we persevered with it for a few years while we got started.

Modifications

Hydraulics and bearings. We added a self-contained hydraulic system to operate the harvester head, bin, and auger. We have a dual hydraulic pump direct-coupled to the PTO drive. There are two circuits, one pump that drives the front and one that drives the rear.

The entire harvester is set up as a modular unit. The three advantages of this are:

- Repairs are easier. I can unbolt things to remanufacture or repair them, rather than having to cut them off.
- I can remove the front and trailer for out-of-season storage.
- I can run the front and trailer independently. For example, if I need to do some sweeping for clean-up, I remove the weight of the trailer and augers. I can remove the trailer in about 10 minutes with two jockey-wheel jack stands, one on each side of the trailer chassis, and then removing two pins.



The entire harvester is set up modularly so the front and trailer can run independently and can be removed easily.

The old header castor wheels would constantly jam when turning at headlands because dust kept getting into the greased pins and bushes. So I swapped to hub and axles with tapered roller bearings on new header castor wheels (similar to Toro 7210 Zero turn mower, front castor wheels).

Harvester head and finger-wheels. We had to do an extra pass during harvest because the old head wasn't quite wide enough to harvest in two passes. This was frustrating as a small strip of nuts was left behind.

We replaced the original 5 x 21 small, white finger-wheel packs with 15 packs of eight medium black finger-wheels. We also widened the frame by extra 60 mm, which allowed us to give the outside wheel packs a 30 mm clearance. In the old setup there was only a few millimetres clearance and small twigs would jam in the end wheel packs regularly. Having to stop and start to fix this was annoying and an inefficient use of time. I also chose to go with centre-aligned finger-wheels in all positions to minimise jamming by debris.



A small lug (arrow) was welded on to stop the flaps going back too far and getting stuck.

With the new header we also used rear push-type wheel packs. We found that the flap covers over the cross auger hinged back too far and wouldn't drop back down or they would get caught behind the top toolbar frame. To overcome this, I welded a small lug and cut a gap in the hinge so that the flap could only go up part of the way, as shown in the photo. This flap now drops back down by itself.

The front of the machine, including the sweeper, is now 3.7 m wide, giving me perfect coverage for 7 m row spacing in the orchard, but I now need a wider door on the shed. Rita won't let me put it in the garage, telling me that I need a bigger shed!

Bin trailer and augers. Even though our farm is relatively flat, there were times when we would have wheels off the ground when turning or going through ditches, even when driving carefully. To improve safety, the machine chassis was modified so the bin was set up more like a trailer rather than sitting on top of the engine. This also makes it much easier to access the engine for maintenance.

The connection point between the machine and the bin trailer is high and there is a pivoting axle on the bin trailer so it travels smoothly through ditches. When turning, all the wheels stay on the ground. The high connection point also gives the bin auger less forward and back movement when harvesting through a gully.

On our original harvester, the auger fed the bin from the side. This put most of the weight on one side of the harvester when it was full and, because the bin was also up high, it was dangerous and unstable. I would end up having to manually push nut into the centre which took time away from picking up nut, and it was hard work.



For the new design I added a second auger to feed into the centre of the bin which evened out the weight distribution making operation much safer. We also increased bin capacity from 0.4 m^3 to 0.6 m^3.

By timing the hydraulics of the augers and bin so the auger goes out before the bin starts tipping, only one lever is required to empty the bin. The tip of the bin was designed for a Nally Bin (1.12 m) but could be easily adjusted if you needed to get a bit higher for a skip. The castor wheels on the back are also set so they are flush with the bin frame and Nally Bins when you reverse to unload.

Improved performance

We have had one season with the new harvester, which performed very well, and I've now had time to give it a paint job.

We decided to call the harvester ZMAC as a play on words. Z is for Zahra (Rita's maiden name) and 'mac' is the 'cam' of Camilleri backwards, and it is appropriate for macadamias.

We now don't have to do that extra pass so harvesting is much quicker and the reduced potential for blockages with stick in the pinwheels significantly increases our efficiency. With the improved weight distribution, we feel much safer when we are operating the harvester and all wheels stay on the ground. It is also much more comfortable to drive.

The machine is perfect for our small farm and nut set is looking good, so we are hoping for a profitable season ahead.

More modifications ahead

Next year I want to add a Kubota cruise control system for comfort, as constantly depressing the hydrostatic foot pedal was causing my leg some grief by the end of the season. I'll also add front and rear work lights.

Finally, thanks to Tony and the local engineers for helping us finish the ZMAC just in the nick of time for our 2021 harvest.

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Making the most of intercropping in the orchard

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As the macadamia industry continues to expand, some growers are intercropping in their macadamia orchards. Intercropping, planting specific plant species or encouraging natural regrowth of species in the interrow space, is not a new concept in agriculture and there are many examples from across the world. The reasons for growing different plants in the interrow space vary, and the practice is being used in both young, non-bearing macadamia orchards and in mature ones. In this article we describe three case studies on different intercropping planting systems in young orchards in Queensland.

CASE STUDY 1: Intercropping for soil health and a cash crop



Grower: Joe, Christine, Stephen and Samantha Muscat

Location: Oakenden, Mackay Region Queensland

Business name: JCS Enterprises

Size: 11 ha non-bearing trees (1 year old)

Cultivars: Mainly P, A16 and MCT1, with H2 and Beaumont rootstock

Spacing: 10 x 3 m (330 trees/ha)

Soil type: Sandy loam

The Muscat family farm near Mackay is a traditional mix of sugarcane with broadacre crop rotations such as soybeans, mung beans, maize and hemp. The Muscats are now diversifying into macadamias and have started a macadamia nursery business.

Harnessing the interrow space of their non-bearing orchard for growing cash crops was a no-brainer given their existing machinery and knowledge.

"While our trees are non-bearing, we wanted to generate an income from that land. We are also utilising the residue from the crops to put under the trees as mulch," said Joe. "It's about keeping carbon there, retaining moisture and supressing weeds."

Species planted

Soybeans were the first crop to go in: "They didn't produce as much plant residue for the trees as we hoped, but we did yield about 3.8 t/ha which we were happy with," Joe explained.

Maize went in next and was growing well when we visited the farm. Joe was pleased with the number of cobs and said that after the crop is harvested, the residue will make "great mulch".

Peanuts, which they have not grown for about 12 years, will be the third crop.

The plan is to grow both maize and peanuts every year until the trees start bearing. Peanuts rather than soybeans have been chosen because soybean harvest was difficult with tree mounds and the profile of the interrow.

"We couldn't get the harvester head down low enough to get the centre bed," said Joe.

Soil preparation and planting

Joe and Stephen already use permanent beds for their cropping with controlled traffic lanes set using GPS to minimise soil compaction. The spacing of these beds determined the row spacing for their trees so they could use existing equipment and traffic lanes.



A good looking cob of maize, almost ready to cut for silage or if left for longer to dry out for grain.





Soybeans were the first crop to go in (left) and then maize (right).

Before planting the interrow is pre-watered or timed after rain. The ground was laser levelled in the past so the interrow crops are furrow irrigated and sprinklers set up for the tree rows: "We are irrigating like we would if the macadamias weren't here, because we want to produce a good saleable commodity," said Joe.

They sow crops with a vacuum plate planter and use a Case grain header for harvest. Two haul-outs have been converted for field bins so they can cart grain as well as cane.



Harvesting the first interrow crop of soybeans.

Challenges

Joe and Stephen already have experience in growing interrow crops so they have all of this in hand. It is the macadamias that are new so their biggest challenges are learning about how to grow macadamias and choosing cultivars to suit the region.

Joe has been consulting with growers and consultants in different regions to learn more about growing macadamias and has found everyone is very willing to share information. When talking about selecting his cultivars, a big consideration is late summer rainfall.

"In February you really don't want to be in the orchard here, so we have selected later dropping varieties," said Joe.

He also wanted a smaller tree size and high kernel recovery. This led him to select A16, MCT1 and MIVI-P.

With trees having been hardened off in the on-farm nursery, a 9 ha block is about to be planted and they are starting to think about their pruning regime for the young trees.



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CASE STUDY 2: Intercropping for soil health and generating mulch



Grower: Theunis Smit, grower/agronomy manager at Macadamia Farm Management (MFM)

Location: Avondale Queensland

Size: 28 ha non-bearing trees (6 months in ground)

Cultivars: Beaumont

Spacing: 8 x 4 m (312 trees/ha)

Soil type: Sandy grey loam with some clay and silt on flat land

Theunis Smit, a grower and agronomy manager for Macadamia Farm Management, has been trialling different approaches to intercropping on some of the MFM orchard development sites. We visited two of these sites with different approaches but similar overall goals in improving soil health.

"The soil on this farm is pretty depleted and in areas it is rock hard," said Theunis. "And the site is really messy so we decided on a low budget trial to see what we could get growing instead of just weeds."

Building organic matter to hold the soil in the tree rows together during rain and breaking down compacted soil in the interrow were also key factors in the trial.

Species planted

Theunis is impressed with tillage radish: "They're pretty cool in that they actually store nitrogen. When they break down in the soil, they will slowly release this nitrogen, along with carbon and other nutrients".

They are long like a carrot and can be as thick as a fist, so they also aerate the ground as they grow and later break down, making channels for water penetration.

Turnips, vetch and a bird seed mix are other species being trialled. Like the radish, turnips grow to a large size and aerate the soil. They also release nutrients as they break down, feeding the soil.

Vetch, which is a small flowering groundcover, was included as a trial pollinator mix. It has lots of different coloured flowers that attract beneficial insects.

The bird seed mix contained a little bit of everything, including sunflowers, oats, millet, barley and some vegetables. According to Theunis, "at about $2/kg, the mix was very cheap, so it was an easy choice for this trial to see how it went".

"After planting, the soil structure is completely destroyed, so we were also aiming to hold onto the soil on the mounds, so it doesn't wash away," he said.

Soil preparation and planting

The main soil preparation was for tree mounding. No herbicides were used to prepare the site and the aim is to avoid their use if possible.

A broadcast fertiliser spreader was used for seeding onto the ground before planting the trees: "Just after planting we had between 25 and 30 mm of rain. We didn't water the interrow just the trees, so it was all rain fed".

The unirrigated plants were dying off when we visited the site. However, they will provide good mulch and continue to suppress weeds.

Challenges and next steps

"Our biggest challenge is getting management paired with the interrow and tree-row planting," said Theunis. "On this site the sunflowers, oats, millet and barley grew quite tall, making the trees and sprinklers more difficult to access, and the workers were hesitant to go in there because of snakes and other critters."

While he is happy with the results of the trial in supressing weed growth and generating bulk organic material for the trees, Theunis has now moved towards using low-growing plants like clovers and slow growing perennials rather than quick growing annuals.



Turnips are a brassica and like the radish they break up the soil around them as they grow and then when they die and break down nutrients are released slowly back into the soil.



"It's a bit messy but doing the job, we wanted to grow something other than weeds along the tree row."

CASE STUDY 3: Intercropping for soil health and generating mulch



Grower: Theunis Smit, grower/agronomy manager at Macadamia Farm Management (MFM)

Name: Vella Farm

Location: Booyal Queensland

Area: 165 ha non-bearing trees (1 week in ground)

Cultivars: A16, A203, MCT1 and Daddow

Spacing: 9 x 3.5 m (317 trees/ha)

Soil type: Sandy loam and brown loam on undulating terrain.

According to Theunis, this farm is very different to the Avondale site in that they had a plan of what they wanted to do.

"Our biggest reason for the interrow planting here was for the soils. There is a fair bit of clay and it varies across the site, so the aim is to use plants with taproots to break up the clay and improve soil health," he said.

Intercropping on this site started before macadamia trees were planted, and when we visited the trees had only been in the ground for a week.

Species planted

A range of legume species are being used - cowpea and calluna pea, lucerne and medic.

Legumes are nitrogen-fixing plants that convert atmospheric nitrogen into a plant-available form and this helps build nitrogen in the soil.

Theunis explained that the reason for planting lucerne was to take advantage of its long taproots, which can grow up to 2 m deep.

"The aim is to get down through the clay layer and improve soil structure."

"Because lucerne is a perennial we don't have to keep reseeding and we are hoping to generate a large amount of bulk material to mulch under the trees. It should generate between ten and fifteen tonnes of material each cut depending on weather conditions," he said.

The flowers are also attractive to pollinators and other insects.

Like lucerne, medic has long taproots and produces insect-attracting flowers. It is low growing and will complement the lucerne to create a good ground cover and suppress weeds. It had already started to produce seed heads when we were on site and Theunis hopes these will establish so that re-seeding will not be required.

Annual ryegrass is included in the lucerne and medic mixture as additional bulk organic material. It establishes quickly and increases diversity of plant species.

The undulating terrain of the site means that there is potential for soil erosion, so mounding, profiling and planting waterways was important. The waterways have been sown with a custom blend of grass species to stabilise the soil, including unhulled couch, Katambora Rhodes grass, Haifa white clover and Pensacola Bahia grass.

Soil preparation and planting

Before site preparation and mounding for the macadamias, the cowpea and calluna pea mixture was sown into what would become the interrow. This crop was in for between three and four months, and when it went to seed and died off it was incorporated into the soil with a box seeder and harrows.

The lucerne and medic (70:30 blend) and annual ryegrass were then direct drilled by a contractor about two months ago, after it had rained. This mix was





Mixture of rye grass, lucerne and medic are planted in the interrow of the entire 165 ha farm at Booyal. Left-Theunis showing the rye growing within the lucerne. Right- Seed pods of the medic.

planted at a rate of 5 kg/ha, and with the cost of seed this came to $100/ha plus the contractor sowing fees.

"The direct drill seeder wasn't quite wide enough for the interrow and the shape of the profile means that is the lowest point, so there is a little section in the middle that was missed. I'm wondering if there will be a bit of wash here but so far a few storms haven't caused too much damage," Theunis noted.

Challenges and results

"Moisture is one of the biggest challenges for the farm and I'm a little bit nervous at this stage because we need follow-up moisture to get it established," said Theunis.

However, once they are established lucerne and medic are very robust and can survive dry periods even if they die off a bit they will reshoot.

It's a bit early to evaluate the results of the plantings but at this point everything they have planted has come up, and there is probably an 80 to 85% germination rate. Theunis will continue to monitor the intercropping on this farm and quantify the organic matter produced.

"The plan is to cut the interrow every three or four months and continue to promote a diverse range of plant species and flowers on the farm to attract beneficial insects," he said.

He thinks that the cost of sowing the interrow is nothing compared to the value of the organic matter produced. He gave an example of the cost of seed plus the contract sowing being $200/ha.

"If you bought $200 worth of compost that might get you three cubes, which is not going to go very far on a hectare of trees," he said.

Counting the benefits of intercropping

The intercropping being done by the Muscats and Macadamia Farm Management are just a few examples of people harnessing the interrow space to grow different plant species. Along with the soil health benefits and growing a useable resource, having different plant species in the orchard increases plant diversity and can attract more beneficial insects and spiders into the orchard.

Both Joe and Theunis said that the management of the interrow will change over time. Once there is increased machinery traffic, trees are bearing and shading occurs as they get bigger, the types of plant species in the interrow will need to change.

Growers in NSW with young orchards and older bearing orchards are also trialling intercropping for soil health, stability and biodiversity. In the Spring 2021 edition of the *News Bulletin* (pages 58 and 59), we described how grower Ross Arnett's 10 m wide row spacing allows him to maintain ground cover and keep interrows of both sown and self-seeded species most of the year round.

A true pioneer in the industry in relation to intercropping is Rex Harris who has regenerated his mature orchard with row removal and diverse interrow plantings to improve soil health, attract beneficials and stabilise the soil to reduce erosion. Read his story on page 37.

You can choose to go all in straight away or you can start slowly by identifying a limiting factor that intercropping could address. The idea is to start simply with reduced mowing strategies and work up to growing your own organic matter inputs for the orchard.

For more information, see the cover cropping fact sheet on the AMS website www.australianmacadamias.org/industry.



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Why sunlight and regenerative agricultural practices are the key to this macadamia orchard

Rex Harris Northern Rivers NSW grower **E:** drexharris@gmail.com **Instagram:** @drexharris

Since 1998 Piccadilly Park Macadamia Orchard near Bangalow in the Northern Rivers has been the home farm of Rex and Lynette Harris. With sons Carl and Daniel, farm manager Mark Jones, and agronomist Ray O'Grady, they collaborate in a stewardship with nature to care for this 90 ha orchard, which features a diversity of macadamia, rainforest trees and interrow cover crops.

The farm story

Following purchase in 1998, months were spent clearing the rampant exotic weeds - camphor laurel, privet, and lantana - before establishing 16,500 macadamia trees in the orchard and about 60,000 rainforest and sedge species along riparian zones and gullies.

The orchard was managed using conventional practices until 2011 when it became obvious something was wrong. It was showing signs of tree dieback and production was well below that of similar farms.

At about that same time, it was discovered that corn and potatoes had been grown on the property for many years during the early 1980s. Standard practices for growing those crops included heavy tillage on undulating land, so the topsoil lost during the normal rain events, let alone east coast lows, would have been substantial.

It was obvious that soil health needed to become the number one focus.

Change in nutrition strategy

In November 2011, Ray O'Grady became consultant agronomist and under his guidance a natural approach to nutrition began, particularly moving away from chemical fertilisers and to the use of animal manures and compost. Aluminium toxicity was a major problem and a program to balance all soil elements began. Sourcing animal manure became difficult over time so we decided to make our own compost.

Three full-length rows of macadamia trees were removed to make way for a compost making pad. New compost making equipment was purchased and compost applications instead of applications of chemical fertiliser became a core practice for tree health. Following harvest each year 100 kg of compost is







Rex decided to make his own compost on farm. Left - New compost making equipment to water and turn piles. Middle - Three full length tree rows were removed to make way for the compost pad. Right -Fungal life within the compost that trees were fertilised with.

applied per tree. Sweet smother-grass was established throughout the orchard as a ground cover to help protect the precious topsoil that was being re-formed.

Gradually tree health and production improved but the 7 m wide rows of macadamia trees began to canopy over the interrow space thus blocking sunlight to the orchard floor. This caused smother grass to rapidly disappear and provide little protection for the precious topsoil that we had spent vast expense and time rebuilding.

In August 2017, we started an eight-year program to remove 1,000 trees a year. Every tree was removed from each second row and all the removed tree biomass was double ground and used as a component of our compost. Nothing was wasted.

Fulll-row tree removal left 14 m between tree rows and large areas of uncovered and unprotected soil. Daniel had recently completed a regenerative agriculture course and started hand sowing sunflowers, millet, sorghum, clovers and other species to help stop erosion. Hand seeding worked well but soon became impracticable. We purchased a small spreader to broadcast seed and later, as we learnt about and observed the benefits of the cover crops, a no-till seed drill and roller crimper were purchased to better plant and manage those crops.

Transitioning from bare unprotected soil took about two months for the cover crops to provide soil protection and nine months for grass and clovers to protect the area from the interrow cover crops to the trunk line of the trees.

This also started our journey into researching, learning and implementing regenerative agricultural practices. Plenty of mistakes were made, but from those mistakes, other ideas and methods evolved.



Diverse species planted in the interrow with vetch and rye planted under the dripline.

Learning by observation is important as is getting out with a spade. We discovered between 20 to 25 worms per sunflower seeds/ha = 2.5 million worms/ha working 24/7, and that's just on sunflower, let alone the other 8 to 10 species in the planting mix. Deposits of worm castings were abundant providing the perfect natural package of highly active biological mixture of bacteria, enzymes, rich in water-soluble plant nutrients, and 50% more humus than topsoil - all provided freely by nature.

A lot of regenerative ag. information is freely available on-line in audio, video, journals, papers and podcasts plus learning by doing.

Once the tree removal program is complete, half the orchard area will be macadamia trees and the other half will grow diverse species of seasonal cover crops.

This will convert the orchard from a monoculture to a polyculture plus the natural rainforest plantings.

The benefits of full row tree removal, cover crops and regenerative practices

SUNLIGHT is the key.

Full-row tree removal provides the space to allow sunlight to fully penetrate the remaining trees as they relax branch structure from growing forever upwards like tall poplar trees. As branch structure relaxes downwards, holes appear in the side architecture of the tree rows and this openness to sunlight energises the trees to produce new fruiting wood in the previous dead zone. It has taken about four years for this process to near peak at Piccadilly Park, and those trees remaining from the first thinning in 2017 now are showing productive fruiting wood through the whole of the tree, not just the top canopy.

Sunlight also provides the driving force to introduce diverse and seasonal interrow cover crops. These crops become an ecosystem engine using their elevated solar array to collect sunlight and through photosynthetic capacity these plants exudate carbohydrates to vastly increase and feed soil biology. This ecosystem service builds soil organic matter and soil carbon.

Now nature has started showing cumulative benefits which gradually change one's mindset to think differently, to join with mimicking nature and to transition away from chemical dependence.

Farming has become enjoyable and rewarding, and regenerative practices enhance an appetite and hunger for learning which is diverse and freely available.

Sunlight and regenerative agricultural practices provided the following benefits in the macadamia orchard.

Diverse cover crops:

- Exude a cocktail of carbohydrates feeding soil biology and sequestering carbon.
- Have roots that have a symbiotic relationship with mycorrhizal fungi to extend, connect and share nutrients and water.

- Have root hairs that farm endophilic bacteria via an incredible process named "the rhizophagy cycle".
- Have roots that exude glomalin to assist with the formation and gluing of aggregates to allow space for water and air.
- Result in increased organic matter and soil carbon = increased water holding capacity. As the carbon builds, interrow cover crops become water reservoirs. Every 1% increase in carbon is like a sponge that will hold an additional 120,000 L/ha.
- Have roots that gradually break through compaction and increase water penetration, reduce run off and soil erosion
- Mixes of cover crops with inoculated legumes fix plant available nitrogen freely into the soil with tiny cost of seed.
- Become a bountiful home for beneficial insects, pollinators, birds, and other animals. The farm has become alive with nature. Bird song in the orchard is a pleasure, Brahminy Kites are regular visitors and recently a White-bellied Sea-Eagle has been seen surveying the cover crop areas.

Sunlight allows vetch and rye to be grown under the dripline of the trees in a window of time between the end of harvest in August and January. The vetch fixes nitrogen in the root zone of the trees and the rye roots gradually penetrating deeper each year to reduce compaction.

These are just some of natural system services provided by nature to build healthy soil to produce healthy, nutrient-dense food for human health.



Sunlight has been essential to allowing the plant species to grow.



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Weather data essential for orchard management

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Accessing and using weather data is something that most if not all growers are doing to manage their orchards and schedule activities such as spray applications. The AMS recently began a weather station project using funding from the Queensland Government's Digital Transformation Grant (Digisolutions). One of the things we have done as part of this project is to learn more about weather stations and weather data, as well as what is available publicly and what you need to measure on farm. This article summarises information sources and how to effectively use weather data in managing your orchard and provides an update on the project.

Online weather resources

The BOM: publicly available forecasts and historical data. The Australian Bureau of Meteorology (BOM) is the main source of publicly available weather data. While this data is integrated into most weather forecast apps and websites (e.g. WillyWeather, LongPaddock, Elders), you can access forecasts straight from the BOM through MetEye.

Using MetEye, you can select different layers to show on the map and search for your location. For example, one of these additional layers is adverse weather 'Storm, Snow, Fog, Frost'.

The YouTube video "MetEye - your eye on the environment" by Bureau of Meteorology runs through how to interact with MetEye: https://www.youtube.com/watch?v=1VMxdVVR9NQ

From the BOM homepage http://www.bom.gov.au/ you can also navigate to the 'Agriculture' tab which takes you to resources that include both historical and forecast data.



For further reading: For more information on interpreting climate information see the Autumn 2021 *News Bulletin* article by Dr Chelsea Jarvis page 44 to 46.

How does this information relate to conditions on farm? In my experience with spraying field trials in Bundaberg, wind direction and wind speed forecasts three days out were normally accurate enough to be able to schedule spraying times although, as can be expected, it was not 100% accurate all the time.

With BOM you can access weather data that is updated regularly during the day for the general region. How relevant this is to your farm depends on its location relative to the BOM station, both in distance and direction. To check this, find out where your local BOM weather station is (often they are at airports) and ask yourself if weather conditions there are representative of conditions on your farm.

This is important for your spray records, especially now with increased scrutiny from the public and environmental protection agencies about chemical applications. Doing the 'right thing' by keeping spray records with documented local weather parameters, products and application rates, specific times and when you stopped spraying if weather conditions such as wind direction or speed changed, will ensure you meet your legal requirement. Further information can be found in the NSWDPI *Macadamia Plant Protection Guide*.

Further reading: *Macadamia Plant Protection Guide 2021-22,* 'Your responsibilities when applying pesticides' Pg 119-122. https://www.dpi.nsw.gov.au/agriculture/horticulture/nuts/growing-guides/macadamia-protection-guide

What localised on-farm weather data should I collect? Although some publicly available weather data can be used for on farm decisions and spray records, the most reliable and least risky approach is to collect key information through on-farm monitoring tools. There are a range of technologies available ranging from handheld devices to fixed weather stations.



Ben Stephenson installing a Sensor Node linking to a soil moisture probe in the orchard.

Further reading: The AMS fact sheet (2019), *Anemometers, wind meters and weather stations* gives examples of devices that can be used on farm, from simple and cheap to sophisticated and expensive. Some growers use anemometers or connect via Bluetooth to their smartphone. There are also various apps available to record spray weather data on the run that can then be downloaded for your spray records.

While on-farm weather data is mainly used in macadamias for spraying and spray records, this information has many more potential uses, including integrating it with sensor arrays for farm management e.g. soil moisture sensors for irrigation scheduling.

Many agricultural industries also use predictive models linked into to weather station data and sensors for integrated pest and disease management such as understanding the risk of disease infection or pest life cycles according to degree days. The Digisolutions project is the start of identifying the potential of similar tools for macadamia.



Weather station units containing rain gauges, temperature and humidity sensors should be about 1.5 m from the ground in an open location.



Anemometers should be located up high in an exposed location, this one is about 7m high.



On-farm weather stations are good for measuring local weather conditions, most now come with phone app and/or web-based platforms to access real-time data.

On-farm weather stations

On-farm weather stations are one of the best permanent ways of monitoring local weather conditions and are the best records to have if you are investigated by a regulatory agency such as the EPA.

A range of units are available at multiple price points and functionality. When choosing a weather station, at the very least they should measure:

- temperature
- humidity
- rainfall
- wind speed and direction.

Delta T, an Australian guide for determining if conditions are appropriate for spraying, is another useful reading to look for on weather data viewing platforms.

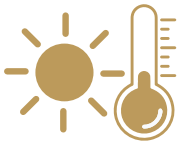
If you decide to buy units online, it is important to check compatibility and user support, e.g., units calibrated in the northern hemisphere may need to be recalibrated in Australia. This is one reason that buying from a local supplier or Australian-based company is recommended.

The 2019 fact sheet *Anemometers, wind meters and weather stations* has examples of entry, mid- and top-level weather stations. Keep in mind that some weather station units require extra sensors which can change costs, so make sure you ask the supplier about these. There can also be subscription costs for accessing data, especially if the weather station feeds into a website or phone application for you to view data. For general data access, these fees are generally less than $1/day, which is a small cost compared to the value of that weather data in terms of having it for legally required spray records (i.e. avoiding a fine) and other crop monitoring applications.

If you have neighbouring areas that are sensitive to spray drift you can install windsocks to provide a visual reference and then pair them with a fixed weather station or handheld device data to determine if conditions are appropriate for spraying.

Positioning weather station sensors and equipment

The position of any weather data collection device will determine its accuracy and usefulness for decision making. Some important factors to consider are:

Wind	Temperature, humidity, barometric pressure and solar radiation	Rain
		
Measurement influences		
Wind speed is lowest at ground level and increases with height. Wind direction and wind speed can vary across an area, particularly if you have undulating terrain, wind breaks etc.	Many factors and objects in the environment significantly affect temperature, humidity, barometric pressure and solar radiation measurements. Clearance from certain objects/areas such as reflective sheds is required.	The volume of rainfall measured in a gauge changes with the height of the collector. The higher it is, the more it is influenced by wind, which can make data inaccurate.
Position considerations		
BOM stations at airports place wind sensors at a height of 10 m for meteorological purposes. In an orchard this may not be practical, and the height can be reduced to suit your site and your tree size, for example 5 to 7 m. Wind speed measurements from lower than this are unlikely to be accurate for spraying purposes in mature orchards.** Only if an anemometer is within 20 m proximity of mature macadamia trees, should it be placed 2 m higher than the treetops. Young small trees can potentially use wind readings from <5 m but this would need to be increased later to match spraying height.	Sensors should be in an open and exposed location that receives a lot of sun during the day. Sensors should be at least 30 m away from large asphalt and concrete areas, which radiate heat. Irrigation sprinklers, pools, dams and rivers can affect localised temperature and humidity so keep clear of these. A flat or gently sloping area on grass is preferable to rock or gravel. The sensors are ideally located about 1.5 m above the ground. Temperature, humidity and barometric pressure sensors should be protected by a radiation shield.	The lower the better. BOM standard is for the top of the collector to be at 0.3 m. On farm it can be impractical to have a rain gauge sitting on the ground. Weather station units with a rain gauge plus additional sensors are normally placed at about 1.5 m. If you have multiple gauges e.g. manual and automatic, make sure they are all at the same height. The collection area e.g. bucket size should be the same if you want to compare readings. Position away from tall trees, buildings or solid fences which can make rain shadows. If mounting on a pole it should only be as high as the gauge and not shadowing the collection vessel.
Handheld or mobile devices e.g. Kestrel©, phone compatible sensors		
Make sure to hold these away from your body into the wind in an open area. Consider taking a few readings from different locations e.g. standing on the ground and then extending higher out of the tractor window.	Hold away from your body at about chest height in an open area. Follow any device specific instructions.	

** An exception to the rule for wind anemometers mounted in a high position is the measurement of evapotranspiration. This combines factors of soil and plant surface evaporation, plant transpiration and wind speed for application in water management. Anemometers for this purpose should be placed about 2 m above ground. In this case you may need two anemometers.

Note: An anemometer measures wind speed and wind pressure, it does not measure wind direction.



Figure: Annual subscription cost for many weather station user platforms is around $1/day.

QDAF Digisolutions project update

Earlier in the year, the AMS was awarded a Digital Transformation Grant by the Queensland Government to set up a network of weather stations to improve microclimate monitoring and help growers make better decisions at key crop stages.

A big thank you to the growers who have agreed to host weather stations for this project in Queensland. Site selection was based on location relative to pre-existing stations on the 'weatherlink' network and some sites are assisting with disease prediction trial work with Prof. Femi Akinsanmi from UQ.

There are now seven stations live in Queensland on weatherlink.com, and over the next few months we will be working on the grower dashboard and data sharing part of this project, so watch this space.

There is a free 'Basic plan' that anyone can sign up to on www.weatherlink.com, this will give you access to a real time (updated every 15 minutes) basic weather data map from any station on the public network. You will see this gives huge coverage globally. As a default it is set to American units; to change this click on the little person icon under your name and then unit measurements to select the units you want to use.

The design and format of the grower dashboard is still under development; however, the aim is that macadamia growers will get more data access than you can get from a free weatherlink account. For example, historical data from the day the AMS stations are activated. The stations upload data every 15 minutes, 24 hours a day.

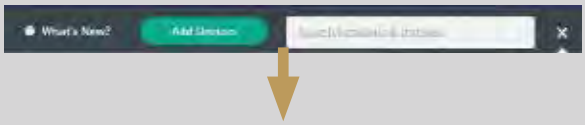
There are also many growers with pre-existing Davis weather stations who have agreed to contribute to the network, and we are currently working on how this information integrates with our station network.

There are also six weather stations yet to be deployed in NSW macadamia growing regions and there are growers who have agreed to share their data to the network. Once these are live, we will give you more details.



Figure. Screenshot of the 'Map' tab of the weatherlink web page. Map is interactive and you can zoom in to the region of interest. Make sure to select 'Temperature' from the drop down on the left-hand side of the page, sometimes it defaults to 'Air Quality'.

In the interim you can find the AMS stations using the search bar at the top right of the page.



AMS stations in Queensland
Cootharaba 00284
Farnsfield 00279
Crohamhurst 00288
Amamoor 00285
Oakenden 00285
Coonarr 00286
Wallaville 00287

Acknowledgments
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Mapping mistletoe aids management

Matt Weinert and **Simon Andreoli, Marquis Macadamias,** *and* **Matt Johnson,** Crop Scan Tech

Mistletoe is a major pest in macadamia orchards and can be crippling to trees if left unmanaged. Controlling mistletoe currently takes much effort and many in the industry are trialling ways to identify and better manage it.

About mistletoe

Mistletoes are native, obligate, hemiparasitic plants, the hypocotyl (stem of a germinating seedling) of which grows into the macadamia tree's vascular tissue and steals nutrients from this system to grow. Being obligate hemiparastic, they don't require all their sustenance from a host, but they do require some transfer of water and nutrients to reach maturity.

In 2018, a review of mistletoe in macadamia commissioned by Hort Innovation (Project MC18001) identified five mistletoe species infecting macadamias: *Amyema congener, Benthamina alyxifolia, Muellerina celastroides, Dendropthoe glabrescens* and *D. vitellina.* The *Dendrophthoe* species are the most problematic in terms of abundance and growth habit, with external runners and multiple attachment points allowing the mistletoe plant to move up the canopy, shading the tree and hampering mechanical removal.

Mistletoes are mainly spread by mistletoebirds, as well as brown honeyeaters and other fruit-eating songbirds. Once the fruit is digested, the sticky surface of defecated seeds sticks to the perch or lower branches. It takes between 4 and 14 minutes for the seed to transit the digestive tract of a mistletoebird.

Growers have observed that birds spreading mistletoe seeds prefer open and even sparse canopies rather than dense ones, something that has been confirmed by research. Macadamia varieties with more open canopies, including 816, A203, A16, A4, A38 and 344, are more susceptible to mistletoe infection, compared to varieties like 660, 849 and 741, that have a more contiguous canopy and more upright growth habit.



Mistletoe of the Dendrophthoe species are common in orchards in Queensland.

This means that canopy management where the crown is trimmed and inner branches removed to increase light penetration and greater nut set also increases the susceptibility of macadamia trees to mistletoe infection, with seeds being more likely to germinate and establish.

Mistletoe management in macadamia trees is labour intensive and involves regular monitoring and removal of infested branches twice a year. Some growers, particularly in Queensland, are reporting having to remove large volumes of tree just to remove the mistletoe and then going in again the following year to clear a new infestation. One grower estimated that up to 70% of trees can be affected by mistletoe each year. While this is manageable on a small scale, in larger operations it is costly and inefficient.

Farm staff in some orchards take flagging tape with them when they are working on trees so that when they spot mistletoe plants, they tag it with the tape. Some workers are also recording sightings on mobile platforms. This is a time-consuming process and mistletoe can easily be missed as it is notoriously difficult for the average person to identify in macadamia trees, particularly smaller plants or those that are not flowering or fruiting. If it is missed in one pruning round, a mistletoe plant can become large, requiring the removal of a large portion of a tree later.

New technology for detecting mistletoe

With advances in remote sensing technology, there is a potential to detect mistletoe more accurately. Using a scan of the orchard, it is possible to task staff to work on the most critical blocks or to better understand those that are more susceptible to infestation.

Crop Scan Tech (CST) is a new business that has been on providing data to tree crop growers in the Bundaberg region. The business uses technology developed by an Australian company called Green Atlas. The system can measure anything that is visually identifiable in trees, including mistletoe, which has a distinctive colour difference that is highly visible to trained sensing technology. In the last 12 months, CST have used this technology on macadamia farms around Bundaberg for yield mapping by counting nuts early and late season and for detecting mistletoe.



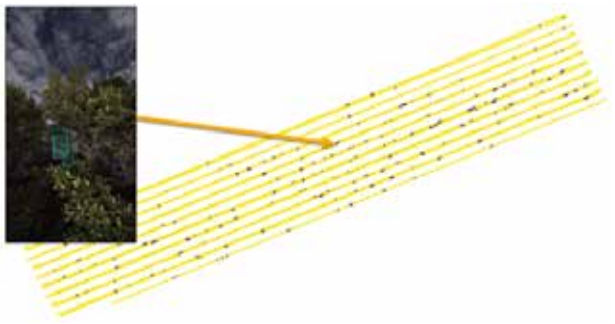
Crop Scan Tech's cartography system travels at 15 km/hr taking 3 photos every second. It can map about 50 ha/day.

The cartography system sits on the back of an ATV that is driven up and down tree rows. The mapping equipment on the back of the ATV is a combination of multi-directional high-definition cameras, light strobes, batteries and computers.

The cameras capture everything at 90 degrees to the lenses and four photos are taken of every tree. The detection algorithms are continuously being updated and trained for the different macadamia varieties.

After mistletoe has been mapped with this system, a geotagged PDF is provided that can be loaded into the free Avenza Maps app on a smartphone or tablet. Using location tracking, the position on the map is marked and the grower can walk to infected trees. This app also allows you to tag locations, upload photos and add notes as required.

The system can also measure tree height, canopy area and canopy density, which some growers are now using to manage block pruning schedules.



Geotagged map of mistletoe detections. Each line is a row of Macadamia trees, when zoomed in these are spots which represent a photo. Yellow= no mistletoe, dark areas (green to purple) = mistletoe detection. In the desktop mapping files a user can click on any spot and also access the tagged photos.

Potential time saver in the orchard

As well as being used on farms around Bundaberg, the imaging system has proven to be effective in detecting mistletoe in the A203 trees in a trial block in North Bundaberg and the algorithms are being continually updated for different varieties. In a walkthrough of a 400 m row of A203 using the geotagged map, mistletoe both small and large were identified at greater than 95% of the detection spots and less than five mistletoe were found that weren't mapped.

Technology like this has been very effective in identifying mistletoe at an early stage and improving the speed of detection of infestations. Although the current process of removal is still time consuming, this could streamline and target management of mistletoe in orchards.

Information

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See also fact sheet, Mistletoe and macadamias, on the AMS website.



Unravelling the mystery of the macadamia family tree

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The industry has long recognised that an important way of ensuring its sustainability is to find and preserve wild populations of trees to provide access to a reservoir of genetic diversity. This is one of the reasons for establishing the Macadamia Conservation Trust.

An exciting project the trust has recently developed in partnership with Brisbane City Council and the Queensland Government is the Wild Macadamia Hunt. With the results of the first round of the hunt now in, we have already made three important discoveries:

- at least four trees identified may be related to the "lost clade"
- many old backyard trees are from wild macadamias (as expected) rather than cultivars
- people carry macadamia nuts far and wide, and probably have done for many thousands of years.

From the perspective of the industry, the discovery of four trees possibly related to a lost clade is the most significant.

What is a clade?

A clade is a group of organisms that can be traced back to a single ancestor.

When Dr Cathy Nock, Prof Craig Hardner and their colleagues analysed DNA from wild *Macadamia integrifolia* growing from the Gold Coast to Mt Bauple, they found that the species clustered into four clades. That is, all the trees in each clade have *Macadamia integrifolia* as ancestor, but the ancestors of the different clades were genetically distinct from each other. It is likely that the most recent common ancestor of the different clades existed before the rainforest in south-east Queensland retreated into separate patches, that is, around seven million years ago.

Since then, *Macadamia integrifolia* habitat remained divided into areas that were too far apart for cross-pollination to occur across the physical boundaries. This explains why the clades identified by Cathy Nock and her team in 2019, which were separate populations of *Macadamia integrifolia,* became genetically distinct from each other. From north to south, the clades are centred around Mt Bauple, Kandanga, Pine River and Mt Tamborine.

The lost clade

Adding a bit of mystery to the story is the possibility of a lost clade. Using DNA analysis, it has been established that two trees known to pre-date cultivar development (the Walter Hill Tree planted in 1858 and a tree planted at the University of California Berkeley campus in 1879) and a third from a Brisbane backyard are much more closely related to each other than to any of the other wild trees sampled. They share some characteristics with the Gold Coast clade, and a current hypothesis is that they may have grown in rainforest habitat that has since been cleared to make way for the City of Brisbane.

This possibility of a lost clade was the inspiration for the Wild Macadamia Hunt.

The exciting news is that the hunt located four more trees that appear to be related to the lost clade. A current Hort Innovation project being delivered by Southern Cross University (project no. MC18004) and dubbed "Ancestry.com" will include these results and others from the Wild Macadamia Hunt in its work to build the macadamia family tree and form a better understanding of how genetic diversity is distributed across the genus. This is critical information for both conservation planning and breeding.

Travelling nuts

One of the requirements of the hunt is for people to look for trees that were older than the introduction of Hawaiian cultivars, so it is not surprising that nearly all the reported trees are related to wild trees or other backyard trees.

What is surprising is the distances that the nuts producing these trees appear to have travelled. Oral history bears this out, with nuts being widely shared among family and friends so that a tree planted on a property west of Gympie might be related to a tree from the lost clade, and a tree in Menangle, NSW is related to trees growing at Mt Cotton, south of Brisbane.

But macadamias have a much longer history of being transported than this. We believe that First Nations peoples have been sharing, gifting and trading nuts for more than 50,000 years, including across the physical boundaries between the clades. This must have had an impact on what now grows where, and it is a major piece of the puzzle that we hope will be investigated as time goes on.

Research into the dispersal of black bean and bunya pine is providing some insights into how the use and deliberate dispersal of seeds by First Nations people has impacted plant distribution and how this impact can be factored into the geological timescale of evolution.

Want to know more?

To find out more about the results of the Wild Macadamia Hunt and locations for wild populations, go to website hlw.org.au/project/the-wild-macadamia-hunt.

Long-term viability of macadamia seeds

The Macadamia Conservation Trust is continuing its collaboration with the Royal Sydney Botanic Gardens over the long-term storage of macadamia seed.

So far, the results confirm a poor response to storage. Fresh nuts germinate best, and despite a variety of drying and cooling treatments, a much smaller percentage of nuts germinate after even a month's storage.

Because it is proving difficult to preserve the large fatty seed (macadamia nut), the next stage is to concentrate on preserving the tiny embryonic axis (the growing tip of the seed).

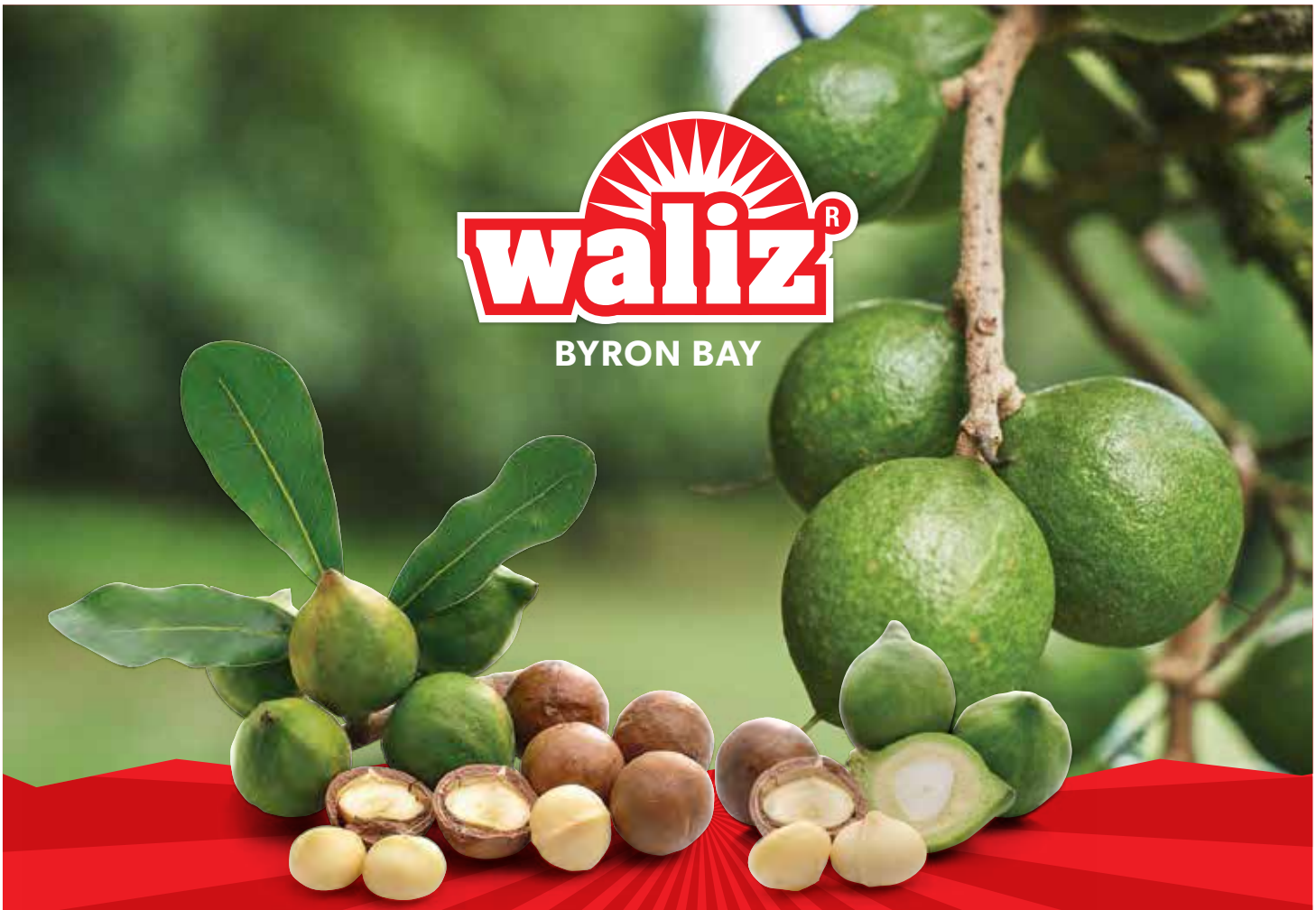
Researchers are hopeful that they will be able to germinate macadamia from an embryonic axis that has been immersed in liquid nitrogen, which could pave the way for long-term cryopreservation of macadamia genetic material.



Macadamia seed picked in the Northern Rivers, ready to dehusk and send down to the Australian Botanic Gardens at Mt Annan.

This research will be further explored through the new Australian Research Council Linkage Project that brings together scientists from the Queensland Alliance of Agriculture and Food Innovation (QAAFI), the University of Queensland (UQ), the Royal Botanic Gardens & Domain Trust (RBG), the Queensland Government Department of Agriculture and Fisheries (DAF) as well as the Australian Macadamia Society (AMS), Macadamia Conservation Trust (MCT), and macadamia nurseries and growers.





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Macadamia ecophysiology enlightening management: Water Management part A

Dr Chris Searle, Leoni Kojetin, Dr Theunis Smit and **Armand Smit**

Macadamias are only a few generations from the wild and understanding how they have adapted over millennia to their environment is essential to unlocking the tree's potential. In this issue of the News Bulletin, we continue our series of articles describing the unique ecophysiology of macadamia and how our knowledge of this can be used to better manage what is essentially a wild crop. In this article we begin to explore macadamia water management.

Macadamias have evolved in a narrow band of coastal rainforests in southeast Queensland and northern New South Wales which are characterised by warm, wet summers and cool, dry winters and springs. To survive in dry times when water is limited, macadamias have evolved features that allow them to take advantage of even small rainfall events.

Unique features and adaptations

The architecture of the macadamia tree collects and channels water down the trunk (stem flow). This water concentrates at the base of the trunk and is taken up by a dense network of roots that are highly efficient at extracting water (and dissolved nutrients) from the soil. The water and nutrients are then transported throughout the tree in xylem vessels. These vessels have a low resistance to water flow and rapidly transport water from the roots to leaves, where it is lost to the environment. This movement of water to the atmosphere is called transpiration.

Transpiration in macadamias occurs from specialised pores called stomata on the underside of the leaf. These stomata act like regulatory valves and are controlled by specialist guard cells that rapidly open and close depending on atmospheric demand and water availability.

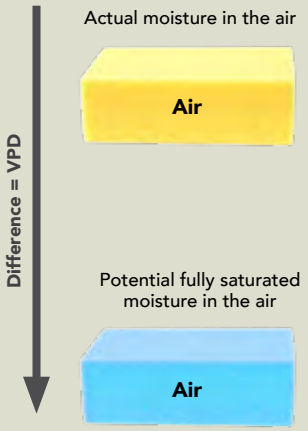
As water is lost through the stomata, carbon dioxide (CO_2) from the air enters and is broken down using energy from sunlight and recombined to produce sugars (photosynthesis). Sugars fuel all plant processes from growth through to nut development. For photosynthesis to occur the stomata must stay open. This is a trade-off for the tree, as it needs to get CO_2 to fuel photosynthesis and make sugars but risks dehydration if too much water is lost. When the tree senses that too much water will be lost through the stomata, its shuts them and waits for optimal conditions to return. This process is controlled by the stomatal response to vapour pressure deficit (VPD).

Why vapour pressure deficit is important to tree function

VPD is important for a grower to understand because it controls many plant processes. Plants need the 'pull' of transpiration to draw water and dissolved nutrients in from the soil and carry then up to the leaves. If VPD is too high, water could be pulled out of the leaf faster than it can be replenished by the roots, leading to leaf desiccation and death. This sensitivity of stomata to VPD enables the tree to limit water loss. When stomata close, photosynthesis and the production of sugars stops immediately, affecting productivity.

What is vapour pressure deficit (VPD)?

- VPD is the difference, or deficit, in the amount of moisture in the air relative to how much moisture the air could hold if fully saturated.
- Air inside stomata is always water saturated whereas the air outside the leaf is often drier and able to more water if it were available.
- This difference, or deficit, draws water out of the stomata (transpiration), as the wetter air inside the leaf tries to come into equilibrium with drier air outside the leaf.
- This flow of water from inside to outside creates a pressure gradient (or pull), the strength of which is measured in kiloPascals (kPa).
- Simply put, the drier the air outside the leaf, the bigger the deficit, the greater pull or environmental demand and the higher the VPD.
- Conversely, the wetter the air outside the leaf the lower the pull and the lower the VPD.



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Transpiration also provides evaporative cooling and exposure protection from the environment. Without this cooling, leaves can get too hot resulting in impaired cell function and possible cell death, often seen as sunburnt patches.

How does this affect where and how we grow macadamias?

In the wild, macadamia are risk averse and close their stomata at relatively low VPDs - around 1.8 kPa - which can occur even if there is ample water available in the soil. In other words, macadamias are more sensitive to the amount of water held in the air than the amount of water held in the soil. We can't easily control the amount of water in the air, so it's important to focus on what is within our control.

Sensitivity to VPD may explain why macadamias generally do better in coastal environments and near coastal escarpments where air is more humid and VPD is lower or more stable, resulting in stomata staying open for longer and extending photosynthesis.

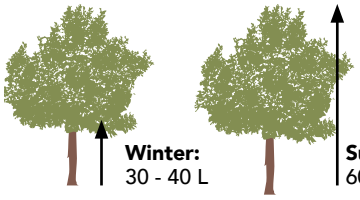
While differences in stomatal sensitivity among cultivars have not been examined extensively, trials indicate that the same cultivars do better in certain environments than others. For example, in Bundaberg, which is dry and where VPD is higher, kernel recovery for 344 ranges from 28 to 32%; in the wetter coastal flats near Ballina where VPD is lower, kernel recovery can reach 38%. Similarly, around Gympie productivity can be higher in rainfed orchards close to the coast compared to irrigated orchards in the drier environment west of the Bruce Highway.

Macadamia water use

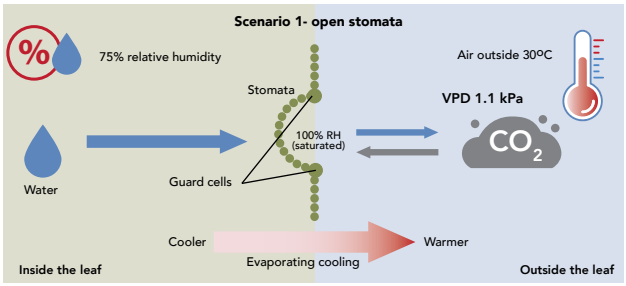
Water use depends on factors such as tree age, size, cultivar and environment. Research shows that while an average sized (7 m high) mature tree uses between 30 to 40 L/day in winter and 60 to 70 L/day in summer, there are significant differences between cultivars, e.g., 741 transpires more and uses more water than 344 trees of the same size and it has a higher stomatal closure trigger than 816, which closes its stomata at a lower VPD.

In an irrigated setting, not all water that is applied is used by the tree. Using the example above of water use in mature trees, this means that 100 L of applied water may be needed for the tree to access 70 L. How much extra water is needed will depend on factors such as system inefficiencies and orchard conditions.

The better we can match tree water use with applied water (in an irrigated orchard) or increase the amount of stored moisture (in a dryland orchard), the longer we can keep stomata open and maximise productivity.

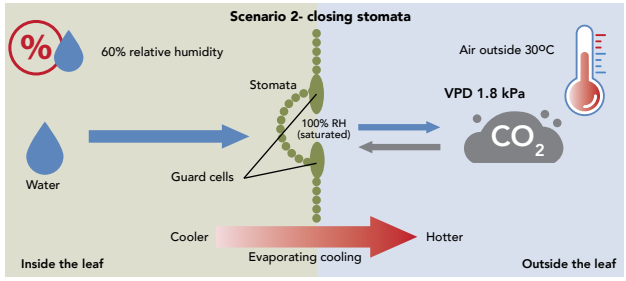


Daily water use by a mature tree



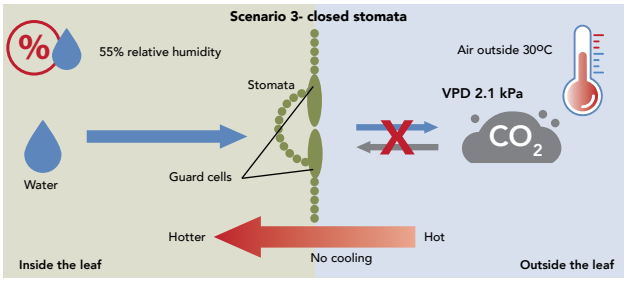
At 30ºC and 75% relative humidity, VPD is 1.1 kPa

- Environmental demand is low
- The tree can easily replenish the water lost through the stomata
- Stomata stay open allowing carbon dioxide to enter the leaves, break down and recombine to make sugars (photosynthesis).
- Leaf evaporative cooling takes place.



At 30ºC and 60% relative humidity, VPD is 1.8 kPa

- Environmental demand is moderately high
- The tree cannot easily replenish the water lost through the stomata
- Stomata begin to close to limit water loss
- Reduced transpiration means reduced photosynthesis and lower productivity
- Less evaporative cooling means leaves become hotter reducing photosynthesis.



At 30ºC and 55% relative humidity, VPD is 2.1 kPa

- Environmental demand is high and past the trigger point for stomata to close
- The tree can no longer replenish water lost
- Stomata lose hydraulic pressure and close
- Transpiration and sugar production stops
- No evaporative cooling means leaves are exposed to the full heat of the sun
- Cell function is impaired and may lead to cell death (sunburn).

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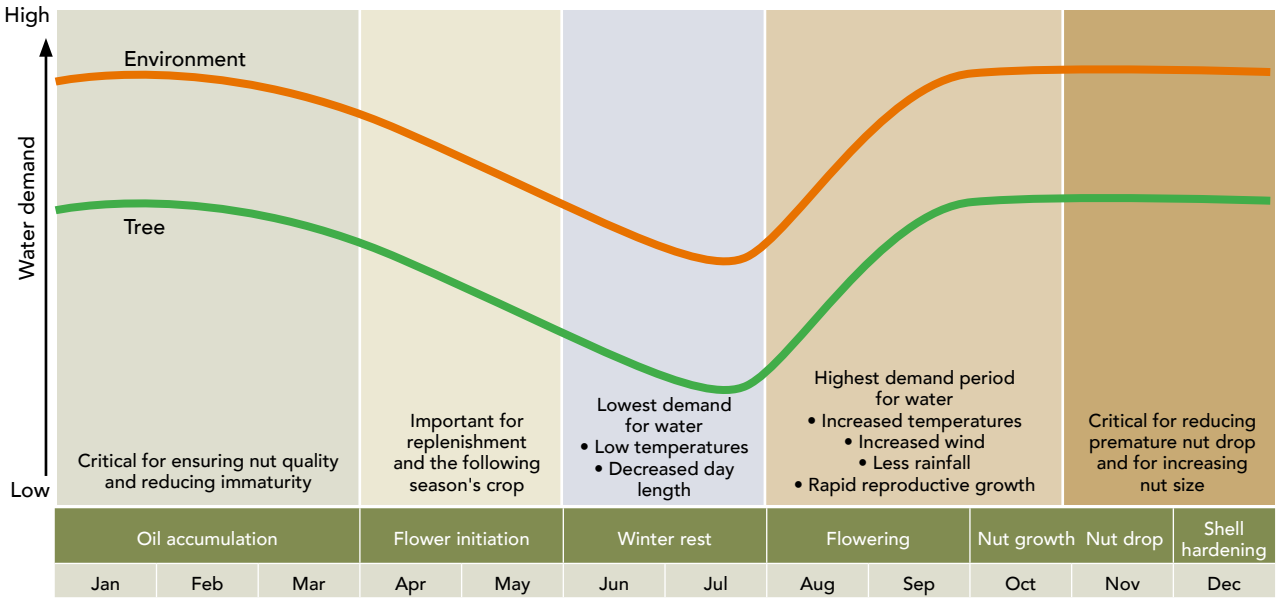
Seasonal tree and environmental demand for water

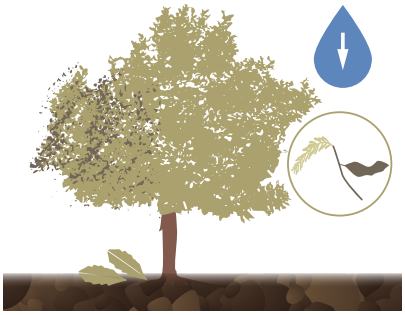


Signs that trees are under watered

Unlike plants that wilt when water stressed, the mature macadamia leaf, which is hard and leathery, does not wilt and shows almost no signs of water stress. This makes it almost impossible for growers to use leaves as a guide to the water status of a mature tree. In very hot, dry conditions, mature leaves can show brown 'sunburnt' patches where cells have died, usually on the hotter western and northern side of trees as they are exposed to sunlight in the hottest part of the day. Other symptoms include leaf loss, particularly in the top of the canopy, which is more exposed to the atmosphere where the VPD is highest.

Water is fundamental for cell expansion and growth; without enough water, leaves and flowers will be smaller and stunted. Many signs of trees having too little water appear as long-terms trends rather than as acute symptoms, e.g., sparse canopies, dull green to yellow appearance, increased incidence of branch dieback and leaf drop. By the time signs are obvious, tree damage often is extensive and productivity is significantly limited.

Drought stressed trees are at a higher risk of pest attack and disease infection, largely because of reduced sap flow.



- Trees appear dull green or yellow
- Brown, sunburnt patches on leaves (usually on the western side of the tree)
- Sparse canopy
- Soft flush wilts
- Stunted growth
- Leaf drop
- Flowers wilt or burn

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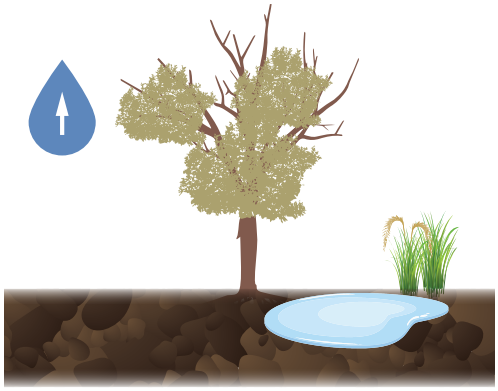
Signs that trees are over watered

While water management often focuses on the impact of too little water on tree health and productivity, too much water can be equally as damaging. Macadamias evolved on well-drained soils and can tolerate being under water only for short periods. Waterlogging excludes oxygen from the soil and impairs root function and can result in root death. Oxygen is required to burn sugars produced by leaves and without oxygen roots drown in the same way we would if water got into our lungs.

While it is hard to see root death, root loss results in above-ground symptoms such as leaves turning dull and taking on a khaki green colour, followed by yellowing and loss of older leaves. Trees often have a sparse, sticklike appearance, particularly in the top of the canopy.

Macadamias have evolved in the absence of *Phytophthora*, a water mould that causes root death and trunk canker. It thrives in waterlogged soils. The zoosphores of this mould in waterlogged soils are able to swim towards the roots and infect them. Once infected, root death and cankers on the trunk block xylem vessels that transport water up the tree. This supply deficit leads to leaf loss and a sticklike appearance, the same as when trees don't have enough water.

The solution for both waterlogging and *Phytophthora* are the same - improving orchard drainage and ensuring good soil oxygen availability. This can be achieved through surface and subsurface drainage, mounding and, crucially, applying organic matter. Good drainage removes excess water in the root zone allowing room for more oxygen and improved root function. The soil biology can then use organic matter to improve soil structure allowing even more oxygen to enter the soil. Most soil microbes that you want to be active in the system for the break down of organic matter need oxygen to function, therefore, adding organic matter without first addressing drainage issues will not give the desired soil improvements.



- Trees are sparse and sticky
- Dieback of treetops
- Leaves are dull and khaki green
- Stunted growth
- Few feeder roots
- Trunks have signs of *Phytophthora*
- Sedges present in the orchard
- Water ponding on soil
- Excessive moss growth

Managing water in the orchard

The main considerations in for managing water in different situations are summarised in the table.

Rainfed orchard	Partially irrigated orchard	Fully irrigated orchard
Implement moisture retention strategies	Implement moisture retention strategies	Implement moisture retention strategies
Manage drainage	Manage drainage	Manage drainage
Improve infiltration	Determine irrigation capacity and critical phenological timing	Apply smaller, more frequent irrigations and know critical phenological timing
Improve water retention	Use monitoring tools (soil and environment)	Use monitoring tools (soil and environment)
Improve soil carbon	Irrigate for tree health or yield	Irrigate for tree health and yield
Know your soil types	Know your soil types and match irrigation scheduling	Know your soil types and match irrigation scheduling
Nutrition can be difficult to deliver	Aim to keep leaves on trees and roots active	Develop a management strategy for each cultivar
Higher rainfall regions have vegetative bias to be managed	Understand the watering zone	Understand the watering zone and how to reduce evaporation

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While orchards range from fully irrigated through to rainfed orchards, what they have in common is the need to maximise soil water infiltration and retention so they can survive periods of water shortage while ensuring that this does not lead to waterlogging. These aims can be achieved by good drainage and good soil structure enabled by good orchard floor management.

Good drainage

- Removes excess water
- Controls water flow in the orchard
- Manages both surface and subsurface drainage
- Reduces erosion, retaining soil and organic matter

Good soil structure

- Hand in hand with increased organic matter
- Aerates soil and improves infiltration
- Provides an ideal root growing environment
- Buffers in periods of high water demand

Rainfed orchard. Improving drainage as well as soil structure and water holding capacity are the main two levers a grower has for managing water. In this environment, **maximising all possible moisture storage strategies** including ground cover is key.

Partially irrigated orchard. Growers can apply some water during times of shortage. Under these conditions, **maximising efficiency of a limited resource** is key. Applying water close to the trunk where roots are most dense will ensure it is extracted from the soil in the most shaded area where evaporation is lowest. Having a water use strategy is also important. With limited water to meet tree demands, do you irrigate in the peak growing season for crop success, or do you irrigate to ensure tree health and keep roots active to respond rapidly rain when does arrive? Each season could require a different approach.

Fully irrigated orchard. Water is usually less limited and in general there is enough water to meet tree demands throughout the year. In this environment **water monitoring to ensure application is matching tree requirements** is key. Monitoring tools can be simple gypsum blocks, through to sophisticated sensors measuring sap flow or dendrometers measuring daily trunk expansion and contraction. When considering a system, familiarise yourself with what sensors measure and how this informs irrigation scheduling. Many measure different parameters such changes in soil moisture and tree/atmosphere interaction and responses. Each have their place but too much uninterpreted data can be confusing.

Managing irrigation timing and efficiency

An irrigation schedule needs to be flexible so it can respond to the changing environment and the water needs of trees. Sensors are not usually snapshots, rather they depict trends over time that can build your knowledge of tree and environment interactions. When combined with short-term weather forecasting, they allow proactive rather than reactive irrigation management.

Three basic steps for managing irrigation in macadamias

Determining when to irrigate →	Determining how much to irrigate →	Ensuring irrigation efficiency
Use a shovel or probe to determine when the soil is dry	Use probes along with environmental conditions to decide if more or less water is required	Check the irrigation system pressure. Failing to check the pressure could lead to systematic under irrigation and inefficient wetting patterns
If soil is moist in the top 40 cm, determine the time taken (in days) for soil to dry out. If dry, irrigate immediately	Once a volume is decided on, use a shovel or probe to check how far water has infiltrated into the soil	Check irrigation system wetting patterns. Ensure that water is applied effectively and evenly over the soil surface as determined by the emitter rate
Once the period of time to dry is determined, set a fixed irrigation cycle and reassess this cycle multiple times in the season	If a large amount of water is observed below the root zone (top 40 cm) then the irrigation volume should be reduced	Apply moisture management strategies: • Mulch • Groundcover • Drainage Mulch/groundcover can reduce the amount of evaporation from the soil surface by up to 80%. This increases irrigation efficiency and the organic matter increases water holding capacity and infiltration rate
When in doubt, apply small amounts more often rather than large amounts less often	Once the irrigation cycle and irrigation volume are determined, a fixed irrigation plan can be established. This plan should be reassessed to account for changes in demand by trees and the environment	

Information

Look on the AMS website for more water management and tree water use resources, including a simple-to-use VPD chart. We will conclude this topic with an article on management implications in the Autumn 2022 edition.

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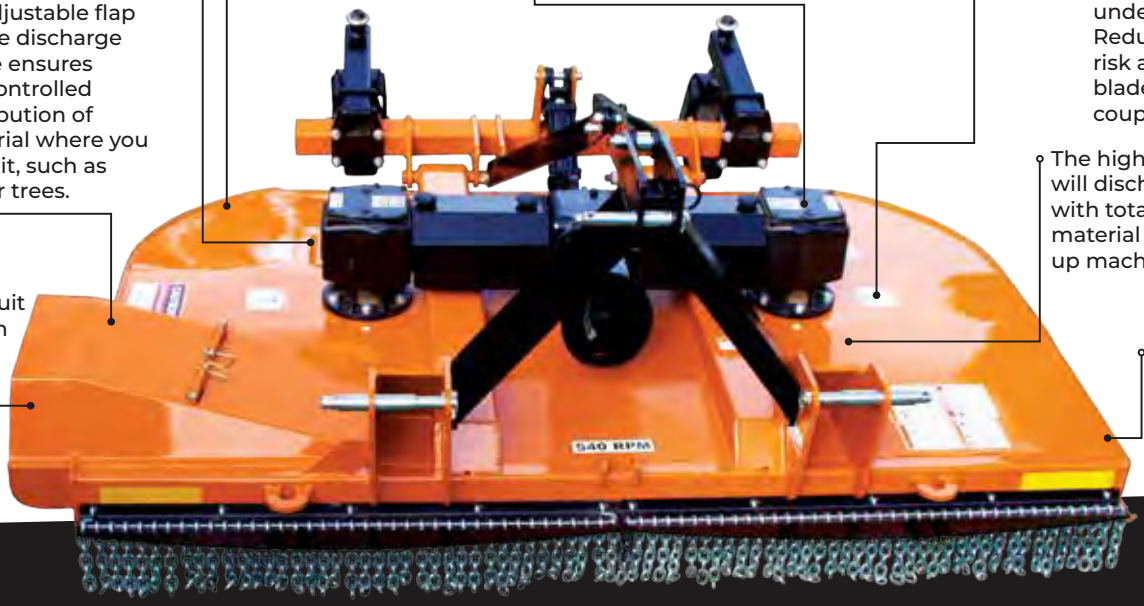

"EVEN WHEN SLASHING IN HEAVY MATERIAL NOTHING IS LEFT BEHIND, GIVING MY ORCHARD A MOWER FINISH AND NICELY DISCHARGING MATERIAL UNDER MY TREES."

Mark Taylor
Orchardist & Woods Owner

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Reinventing chocolate macadamias with plant-forward flavours

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



Brigid Woolnough

Brigid Woolnough lets her chocolate do the talking. Best known for her Australian confectionery brand, KOKOPOD (featured in our Macadamia Change Makers video campaign), Brigid's handcrafted chocolates are a delicate blend of edible art and science, combining the highest quality European couverture chocolate with the best Australian-grown flavours.

Her newest plant-based chocolate brand NOMU NOMS is described as "deliciously vegan plant-based chocolate for people and planet." It's a range that puts macadamias front and centre and showcases their ability to carry highly innovative and indulgent flavour combinations including raspberry and beetroot, strawberry and balsamic, coconut white chocolate, and passionfruit white chocolate.

The NOMU NOMS range was extensively tested to determine which flavours combined best with macadamias. "NOMU NOMS was a big behind-the-scenes project that we did for nearly a year," recalls Brigid. "We had a group of one hundred consumers called 'Project X' and we would send them samples of all the different flavours we were trialling."



NOMU NOMS Strawberry Balsamic pack



NOMU NOMS Coconut White Chocolate ingredients

Matcha, chai and coffee were all ruled out by taste-testers, before the final six flavours for the range were decided.

Brigid's desire to provide sustainable packaging options for ethically minded consumers was a key driver behind the development of the NOMU NOMS range. It led to the discovery that plant-based chocolate behaves differently - and in some ways more favourably – than dairy-based chocolate. "Vegan chocolate has a longer shelf life and better sensitivity to heat than dairy-based chocolate," explains Brigid.

By making the NOMU NOMS range 100% vegan, Brigid has been able to embrace more innovative sustainable packaging solutions. The NOMU NOMS range is sold in a corn-based compostable packaging, that can break down in a home compost bin in just 26 weeks.

NOMU NOMS is based on Australia's Sunshine Coast, and Brigid says using Australian ingredients is a core part of its offering. "It goes without saying that we use locally grown macadamias in our products," she says. "Our customers definitely expect us to use Australian grown – it's synonymous with quality. If we used anything else, I would have my door bashed down!"

Brigid and her team are currently focused on the domestic market, ensuring they can scale production to keep up with demand. But export opportunities are calling. "The longer shelf life of vegan chocolate makes it well suited to export, and macadamias are popular with consumers in many other markets. We're definitely investigating options to take NOMU NOMS beyond Australia."

Research shows macadamias are the gift worth giving this holiday season

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

Consumer insights research has delivered good news for manufacturers and retailers including macadamias in their line up for the 2021-22 holiday season, with the findings showing most consumers perceive macadamias as gift-worthy.

With Christmas and Chinese New Year approaching, research commissioned by the Australian macadamia industry revealed the strength of macadamias' association to gift giving, with 61% of respondents globally agreeing that macadamias were suitable for gifting.

The research carried out in Australia, Japan, China, Taiwan, South Korea and the USA, also found that compared to all other nuts, macadamias universally owned the gift-giving space across every market surveyed. These findings formed the basis of a recent global trade PR campaign targeting food manufacturers and retailers in the pre-holiday buying season.

What makes macadamias gift worthy?

The research shows that the answer could lie in how they make people feel during a consumption moment.

It revealed that macadamias evoke feelings of being the most special and superior of all nut types. In Japan, macadamias are also considered to be the richest tasting nut, while in Taiwan they're seen as being from trustworthy origins, more so than other nuts.

On top of this, 57% of respondents associated macadamia nuts with luxury and indulgence, while 61% see them as premium. Based on this, it's clear that featuring macadamias as an ingredient in gifting products makes a gift more special.



Macadamia, fig and honeycomb chocolate bark



Macadamia and white chocolate cookies

Reconnecting through macadamias

The ongoing pandemic has left many people feeling disconnected and out of touch from friends and family again this year. As the holiday season rolls around, gift-giving will be a way for people to reignite their connection with those close to them, whether in person or by sending a package from afar.

More than a third of consumers across all markets said socialising was key to their wellbeing, and the holiday season offers the perfect opportunity to reconnect with loved ones.

Macadamias have the potential to bring people together in social consumption moments. In the research, they performed twice as well as other nuts in relation to social consumption occasions such as casual gatherings with friends and family, hanging out and socialising and at celebrations or parties.

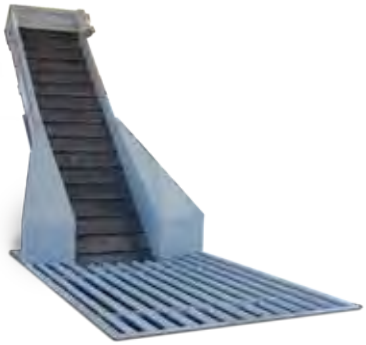
With health a hot topic in 2021, many will be mindful of how they can best benefit the person they're buying for this holiday season. Gifting products containing macadamias not only signal indulgence, but also add a 'health halo' as an ingredient that offers up physical health and mood-boosting benefits.

We look forward to seeing this year's macadamia gift products as they hit retail shelves.

About the research: In late 2020, Australian Macadamias commissioned research based on 6014 individual surveys with consumers in Australia, China, South Korea, Japan, Taiwan and the USA. Conducted by the Singapore regional office of independent research agency Kantar, the research was conducted between August and October 2020 and findings delivered in December 2020.



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



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



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

SAVAGE

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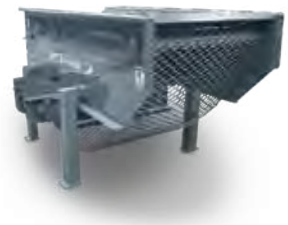
The Stone Remover has two stages: one that removes heavy debris and one that takes out light debris. Available in 36" and 48" widths.



The sorting table is availabe in various sizes. This one includes the Vision, dual-spectrum sorter, capable of sorting 15,000 pounds per hour.



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



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

www.savageequipment.com | www.youtube.com/savageequipmentinc.
Contact us today: info@savageequipment.com | 00-1-580-795-3394

Macadamias take centre stage at live 'Chill Day' event in Taiwan

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



Chef and YouTuber Nanaco shows off his macadamia caramel tart during a live event in Taiwan.

The benefits of Australian grown macadamias were on show at a live event in Taiwan that attracted a 25,000-strong crowd. ET Today Chill Day is an all-ages outdoor festival featuring a range of attractions including a foodie market, photo booth, and live music performances.

Hosted by major Taiwanese online news and entertainment channel ET Today, this year Australian Macadamias was a Chill Day sponsor, delivering valuable brand exposure and the opportunity to conduct a macadamia cooking demonstration in partnership with a popular Taiwanese food influencer.

While COVID-19 meant crowds were a little smaller than usual, this was made up for online, with the livestream on Facebook viewed 250,000 times. Brand exposure took place via a host of promotion by ET Today not only on the day of the event, but in the lead up and afterwards too. In total, the activity reached an audience of more than half a million people, exceeding expectations.

The highlight of the sponsorship was a macadamia cooking demonstration conducted by influencer Nanaco on the event stage. Nanaco is a professional chef and popular YouTuber, who boasts a social media following of more than 230,000 people. He is well known in Taiwan for his delicious desserts and signature humorous presentation style.

Nanaco showed the crowd how to make a macadamia caramel tart, with the demonstration livestreamed on ET Today's website, app and Facebook page. He also posted about his demonstration on his social media channels on the event day and afterwards, further amplifying and sustaining our brand messaging and exposure. ET Today shared the demonstration again on social media in the days following the event, which resulted in thousands of additional views by fans who missed the event day or wanted to follow along as they recreated the tarts at home.

The sweet aroma of the cooking demonstration had the crowd drawing closer to the stage, intently watching Nanaco combine the macadamia nuts with the caramel sauce. As he worked, he shared his knowledge of macadamias and the various ways he likes to cook with them.

The demonstration was capped off with Nanaco conducting a fun Q&A session with the crowd, with several fans winning packs of macadamias from popular Taiwanese brand Thank You Nuts.

In a time when live events have become difficult to run, it was fabulous to once again have the opportunity to engage live with macadamia fans in one of our most important markets.



Nanaco with macadamia prizewinners.

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Rejuvenation breathes new life into an old orchard

The benchmarking team, Department of Agriculture and Fisheries, Queensland
T: 07 5381 1334 **E:** macman@daf.qld.gov.au



Farm: Ferndale

Owner operator: Steve and Cathy Ferndale

Location: Dorroughby, Northern Rivers NSW

Size: 3280 trees 10.5 ha

Average age: 34 years

Spacing: 10 x 10 m, 10 x 5 m, 10 x 2.5 m

Cultivars: 660, 246, 508, 741, H2, 816, 842 & 849

	NIS/ ha	SK/ ha	SKR (%)	RKR (%)
Avg. 2009-14 before current IOM program	3.0	0.9	32	4.5
Avg. 2015-20 current IOM program	4.5	1.4	34	3.2

Steve and Cathy Ferndale own a macadamia farm bordering the idyllic Whian Whian state conservation area in Dorroughby, NSW. The farm is at one of the highest altitudes in the district, meaning it is isolated from other farms and potential pest threats. However, the altitude also comes with challenges, including very steep slopes, which result in soil, nutrient and nut loss.

Despite these challenges, Steve and Cathy's orchard has consistently featured in the top 25% of the benchmark sample. Steve believes most answers to issues affecting orchards are simple, and taking action is what produces results. He states that while growers will have different solutions to address their unique situations, the principles of good integrated orchard management (IOM) remain the same.

Approach

Canopy management. Steve observed that his older trees were growing closer together over time. In 2015, he decided to open up his trees and inter rows to improve productivity, achieve better spray coverage and re-establish ground cover.

His solution was to remove limbs growing into the inter rows, allowing light back into the canopy and orchard floor, which has encouraged productivity lower in the canopy and growth of ground cover and reduced erosion on the steep slopes.

Steve's approach was to remove major limbs from the trees. By removing a section of the limb halfway between the dripline and the trunk, a window is created in the canopy. He has done this on a three-year cycle on a third of his orchard each year, so there has been no reduction in yield.

Steve's advice for growers contemplating this strategy is not to leave it too long or you will lose the centre of the tree.

"If you lose the centre, it will mean a longer turnaround to get back into production. It's usually a three-year turnaround between visiting the same tree and my production hasn't gone backwards since commencing the program," he said.

Although he was initially apprehensive, Steve is now convinced that this approach works, especially if timed correctly.

"My aim is not pruning – I do not use the word pruning – it is tree rejuvenation. The whole thing is about the tree getting more growth down low, letting the light in, getting growth down the bottom of the tree, and get more nuts down low," he said.

Before 2015, Steve had always undertaken canopy management himself using pole saws, however, the game changer was when he invested in experienced contractors to do the work.

His new three-year program using a contractor has resulted in greater efficiency, getting around the orchard quickly by the use of bigger machinery.

He has been so pleased with the efficiency gains that he now uses experienced contractors for other orchard management practices, such as drainage works and pest and disease spraying.

Drainage. The slope of the orchard makes drainage difficult to manage. "Most drainage work has not been in the orchard. We've focussed on drainage around the orchard, either preventing it from entering or moving it out," said Steve.

This approach was designed to reduce run-on and the speed of water that enters the orchard. Visiting other farms looking for solutions helped immensely, and putting the ideas into practice has improved drainage and reduced erosion in his orchard.

Orchard floor. Steve sought advice to rectify what he calls the 'horrendous' orchard floor on his farm. "The orchard had a lot of root exposure, which not only affected tree health, it also damaged machinery," he said.

He tried using a profiler to cover the exposed roots but found that the problem was that it was necessary to have soil to profile.

"In my circumstance, profiling actually increased the erosion and loss of soil," he said.

After attending a field day that focused on improving tree health, Steve began to introduce large quantities of compost to the orchard floor to rectify his issues. While he has watched some of it wash away, he explained that his production has gone up. He now applies compost and woodchip under the canopy on the lower side of the tree, putting the woodchip over the compost to prevent it from washing away when it rains.

Nutrition. Steve has soil tests conducted annually and has been on a journey of improving soil health over the last seven years. "I originally started using chicken manure which disappeared really quickly, but now I've moved to cow manure plus wood chip and nut husk. My organic matter levels are now over 10%," he said.

Although Steve originally used compost mainly to cover exposed roots, he has also seen a big improvement in tree health. They started by applying 250 L/tree and tried other volumes (200 and 150 L), but they were not as good.

"At 250 L/tree, everything starts to happen. The coarse woodchip is also no problem for the finger wheels at harvest, which is a huge bonus," he explained.

Steve also uses synthetic fertilisers to address any deficiencies.

The future

Steve will keep on building his orchard's resilience by continuing his canopy and orchard floor program and drainage works.

While this has meant spending more in the orchard, particularly over the last two years, the investment is seen as essential for maintaining high long-term yield.

"Good farmers reinvest back into the farm. The big drivers are yield and price, costs are less important in the scheme of things. An annual spend of $20,000 on compost and woodchip seems like a lot until you work it out. If you go up by around four tonnes across the whole farm, you've covered your spend," he said.

Steve and Cathy are also venturing into a new partnership with another couple, something that has produced a "new energy" around the farm. This partnership will allow Steve and Cathy to keep enjoying macadamia farming into the future.

Challenges

Steve's biggest challenges have been from washout and soil loss, which he will constantly be working on.

"We've been trying to get the grass to spread between the rows, which has been hard. Where the light is, grass will grow, but in some areas where there is no soil, the grass will not establish," he said. "When we get around and spray, we tend to scar the ground a bit, particularly when using machinery when it is wet, there's no real way around this though."

Steve said the contours of his orchard have made drainage challenging. While drainage work has improved water flow throughout his orchard, there's still more work to do.

Benchmarking results

Before starting the current IOM program, the Ferndale's farm averaged 3 t/ha (seasons 2009 to 2014). Over the last six seasons, productivity has increased to an average of 4.5 t/ha. Steve attributes this increased production to two key IOM practices; the improved canopy management and applying compost.

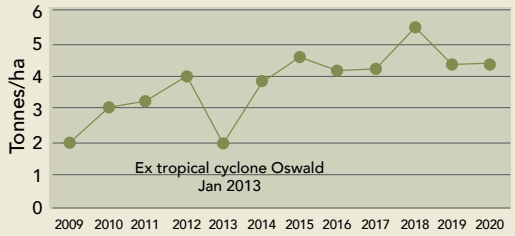

Figure. *Ferndale farm nut-in-shell yield, 2009 to 2020.*

He has participated in the industry benchmarking project since 2009 and is a big supporter of the benchmarking project as it allows him to compare the farm with other like-minded farmers who have similar issues.

"Our report is very helpful, it helps make sure you're on the right track," he said.

Steve also regularly attends benchmark group meetings, which allows him to compare and discuss his seasonal results and trends with other growers. "Benchmark Groups are an excellent way of identifying subtle differences in how we do things between similar farms," he said.

For Steve, the solutions to many aspects of growing macadamias are slow coming and he believes patience is the key when undertaking rejuvenation work. "Sometimes it might take three years to see if you've made the right decision. Benchmarking is a good learning tool that can track the results of changes you've made in the orchard," he said.

This case study has been developed as part of the 'Benchmarking the macadamia industry 2019–2021' project (MC18002), which is 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.

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Field trials to improve orchard systems

Dr John Wilkie, Carola Parfitt, Hanna Toegel and **Bridie Carr,** Department of Agriculture and Fisheries, Queensland and **Scott Allcott,** Macadamia Farm Management

Project snapshot

Intensive orchard systems have delivered significant productivity improvements for some tree crop industries in recent decades. The National Tree Crop Intensification in Horticulture Program (AS18000) is attempting to improve productivity through intensive orchard systems in the less advanced tree crops - macadamia, avocado, mango, citrus and almond.

For macadamia, this project is a continuation of the Small Tree – High Productivity Initiative. We are continuing some of the long-term field trials, such as the Macadamia Planting Systems Trial (MPST) Phase 1 in Bundaberg. We are also starting new work, including establishing additional long-term field trials in MPST Phase 2.

In the following article, we discuss the lessons learnt in our previous work and how that has guided the design and establishment of a second phase Macadamia Planting Systems Trial. This intensive macadamia orchard systems trial is planted in a commercial orchard near Bundaberg and is examining the effect of scion cultivar, tree structure and vigour management using plant growth regulators on orchard productivity. This experimental trial sits alongside a commercial scale demonstration trial.

Macadamia Planting Systems Trial: Phase 1

Lessons learnt

The main characteristic that defines intensive orchard systems is that they are planted at greater tree densities than conventional orchard systems. In high-density apple orchards, this greater tree density coupled with the precocious nature (flowering and fruiting at a young age) of modern apple scion and rootstock varieties, promotes high yields early in the orchard's life.

During the early orchard life of phase 1 of our MPST (up to six years after planting), the medium (6 x 3 m) and high (5 x 2 m) density systems tended to yield more per hectare than the conventional low-density (8 x 4 m) systems, and A203 produced greater yields than 741. Once we tease the components of the orchard systems apart a little, the reasons for this become quite clear.

One of the biggest effects on early productivity in our MPST was scion cultivar, with A203 having significantly greater yields than 741. Cultivar A203 also produced far more racemes than 741, which was the main factor leading to A203's greater productivity at three, four and five years after planting. If high, early yields are to be achieved in intensive systems, cultivars capable of precocious flowering must be selected.

In our MPST we also found that the high-density systems (5 x 2 m) developed greater canopy volume per hectare than the conventional low density systems (8 x 4 m) during early orchard life. This greater canopy volume per hectare in the high-density systems, in turn, led to greater light interception. This is important because light interception is correlated with yield per hectare, which increases with light interception up to at least 85% (Olesen *et al.* 2007; Wilkie *et al.* 2021). The greater light interception in the higher density systems provided a higher yield potential during early orchard life. The precocious flowering in A203 allowed this greater yield potential in the higher density systems to be converted into high early nut in shell (NIS) yield.

The MPST also looked at the effect of early tree training and pruning systems on early canopy development, flowering and yield. We compared central leader training systems with the early mechanical hedging system often seen in Bundaberg over recent years.

There were some very early differences in canopy size and raceme production, but these differences have proven to be commercially insignificant as the trial has progressed. We had hoped to see benefits in terms of early flowering and production from intensive early tree training such as seen in apple. The central leader tree

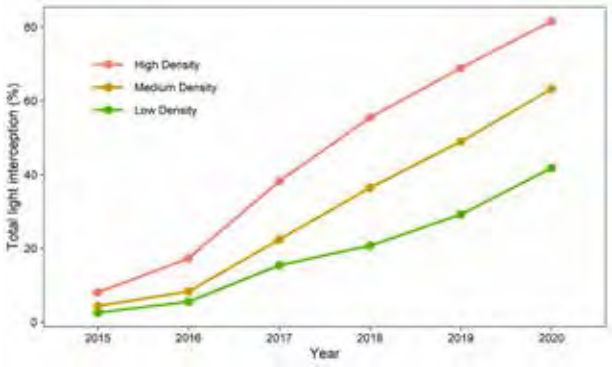

Figure 1. Total light interception over time in the Planting Systems Trial, averaged across 741 and A203. Significant effects included cultivar, year, density and their interactions, and the interaction between density and tree training treatment.

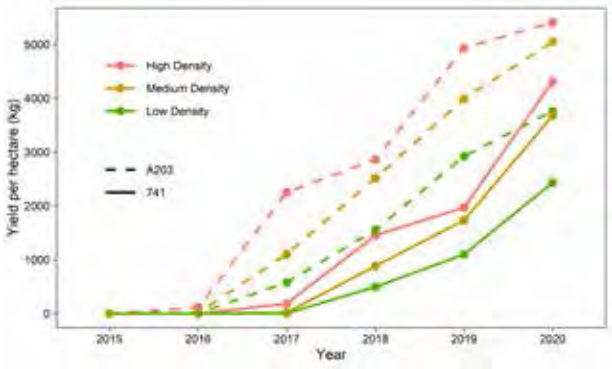

Figure 2. NIS yield per hectare over time for the Macadamia Planting Systems Trial from 2015 until 2020 (six years after planting). Significant effects included cultivar, density, year and their interactions.

structures imposed early in the trial are being continued in the mature systems, so it is possible that benefits of central leader tree structures through improved light distribution in the canopy may be seen in the future.

As the trial moves into its mature orchard phase, it is obvious that the medium- and high-density systems need more time and effort in pruning, to stop canopy crowding, when compared to the conventional low densities, for which we have done basically no pruning to control tree size so far. So as expected, developing tools to prevent orchard crowding effectively and economically will be essential.

Many visitors to the MPST over the years have commented on the deep, fertile red soil that we have planted on. Our philosophy when establishing the trial was that this fertile soil would benefit us through healthy trees and strong early growth with resultant early yields. By and large, we have seen these benefits, but as the trial moves into its mature orchard phase and we are trying to manage tree crowding, we would prefer a less fertile soil type.

Lessons learnt by thinking about resource allocation within the tree

If we assume that one hectare of macadamia orchard can produce a fixed amount of photosynthate (energy for growth and development), then how that energy is shared among different organs has a big effect on productivity. For example, energy can be allocated to shoot growth, flowering and fruit production, root growth, carbohydrate storage, etc.

When there are many organs growing on the tree at one time, the demand for resources can be high. In these situations, the organs can compete for available resources. For example, if many shoots are growing at once, these shoots compete with each other resulting in shorter shoots than if fewer shoots were growing at once. Additionally, after a heavy flowering and successful early nut set, the young developing fruit compete with each other for resources, resulting in the abscission of fruit that the tree cannot support.

The timing and type of orchard management activities can have a huge effect on the allocation of resources within the tree. The most studied of these is pruning. It has long been known that hedging around flowering time leads to strong vegetative re-growth that can out-compete the developing nuts and reduce yield (McFadyen *et al*. 2011; Toegel *et al*. 2019). Hedging later and triggering the post-hedging flush to begin once the nuts are larger and growing faster allows the nuts to out-compete the growing shoots for the available resources (Toegel *et al*. 2019).

We also found that the type of pruning affects the allocation of resources. We compared mechanical hedging and topping with selective pruning in a three-year trial in a high-density orchard near Bundaberg. The hedging and



topping generally led to much greater post-pruning shoot growth than the selective pruning. This was presumably due to growth of multiple shoots from remaining buds on the decapitated stem. Across the three years of the trial, the selectively pruned trees yielded significantly more NIS than the hedged and topped trees, presumably due to less competition between fruit and shoot growth in the selectively pruned trees.

This conclusion is supported by the reduced shoot growth and significantly greater NIS yield (in one of three years) of hedged and topped trees that were also treated with the plant growth regulator Uniconazole (not registered for macadamias).

Macadamia Planting Systems Trial: Phase 2

The first MPST has so far been successful. We have demonstrated that high early macadamia NIS yields can be achieved using intensive planting systems. We are aware, however, that we do not know how these high performing systems are going to perform later in orchard life. We also acknowledge that it is very likely that these intensive orchard systems that we developed in the first MPST can be improved upon.

So, having learnt these lessons from the first MPST and other work in the previous project, we set out to design another trial with second generation orchard systems more likely to be highly productive and able to be managed commercially long term.

We approached Scott Alcott from Macadamia Farm Management (MFM) about locating an intensive orchard trial in one of the MFM managed orchards. Scott has been a member of the first MPST's trial advisory group from the beginning and so had made a range of his own observations, which also fed into the design of the trial.

We settled on a trial comparing the effects of scion cultivar, tree training and vigour management treatment on tree development and productivity and was planted in March 2020 near Bundaberg.

Tree density

The trial was planted at a density of 667 trees/ha, 5 m between rows and 3 m between trees. This density was chosen to take advantage of the intensive planting density effect on early light interception and yield potential. The within-row distance is 3 m, compared with the 2 m in the high-density systems in the first MPST. We increased this within-row distance because we were not convinced that all the cultivars would flower early enough in the life of the orchard to take advantage of the additional light interception the closer within-row spacing would provide.

When designing the trial, we discussed whether we should use the row width in the MPST high density (5 m) or medium density (6 m) treatments. The obvious trade-offs were that the narrower row spacing should provide higher early yield, whereas the slightly wider row spacing will not require pruning to stop canopy crowding until later in its life.

Fit-for-purpose scion cultivars

Given the substantial effect of scion cultivar on early orchard NIS yield in the first MPST, the cultivars were chosen after careful consideration. Based on the first MPST, the obvious focus was for precocious scion cultivars to take advantage of the high early light interception from the higher density.

The second criterion we used was tree size. Certain tree crops can take advantage of rootstocks that restrict the canopy size of the scion cultivar grafted on top of them. We do not have access to these vigour-managing or dwarfing rootstocks in macadamia; however, there are quite large differences in canopy size between scion cultivars. We chose scion cultivars known to have smaller canopies.

The scion cultivars chosen for the trial were:

- A203. Also used in the first MPST, A203 is extremely precocious and in the MPST produced on average more than 100 racemes per tree at two and a half years after planting resulting in a NIS yield of 2.4 kg per tree three years after planting. It is not a particularly small tree, but we felt we needed to include it given its performance in the first MPST.
- A16. This is a relatively precocious cultivar that is still regularly planted in Bundaberg. It is a small tree and has been reported to have a high yield efficiency (NIS yield per canopy volume).
- P. This is one of the newly released cultivars from the industry breeding program. It is reportedly a small tree and relatively precocious.

Early tree training and tree structures

Even though we found only minor effects of early tree training in the first MPST, we felt it was important to continue testing the effects of early tree training and tree structure on early orchard and mature orchard productivity. This is partly because it has been shown to be important in other tree crops. It is also partly because a tree training system of some form, however minimal, needs to be used in young macadamia orchards. Two tree training treatments are being trialled.

The first tree training treatment is called our 'complex' tree system. Because of the importance of early flowering for early yield, it is important to have some canopy complexity (branching) to bear these early flowers and fruit. The approach in this tree structure is simply to create canopy complexity by tipping shoot axes that grow more than 30 to 40 cm without branching. We have yet to decide at what tree age or size we will stop doing this.

The second tree training treatment is a vase tree structure. We are attempting to create vase structures because previous tree structure research in macadamia identified that vase canopies had higher yield efficiency than the other treatments (Olesen *et al.*, 2011). We are aiming to select four evenly spaced leaders on each tree that are spreading upward and outward into the alley way, thus creating a vase structure. From a practical point of view, it is challenging to create vase

tree structures in Bundaberg due to the strong and consistent prevailing winds.

Vigour management

Our experience from the first MPST and other work have shown us the importance of improved vigour management systems. Our vigour management strategies are three-fold.

First, two of the chosen cultivars are recognised as producing small trees. Second, the trial has been planted on land of low to moderate fertility, which should provide some limitation to tree growth. Third, the trial includes a vegetative growth limiting plant growth regulator (PGR) treatment.

The trial was planted with the trees allocated to the PGR treatments, but no PGR has yet been applied because it only makes sense to do this when the trees need to have their growth slowed. In fact, we are not even certain what the PGR treatment will be. We know that certain PGR applications do reduce vegetative growth in macadamia, but the timing and types of PGR application have never been optimised. Work is also starting in the project to identify the most effective timings and types of PGR applications to reduce vegetative growth and improve allocation of resources to cropping.

Demonstration trial

The phase 2 Macadamia Planting Systems Trial sits alongside a larger intensive macadamia orchard block, also planted at 667 trees per hectare (5 x 3 m). This orchard block is being monitored as a commercial scale, intensive orchard system demonstration trial. The project team is working with MFM to collect orchard establishment and management cost and production data (when the time comes). The data will be used to better understand the economics of intensive macadamia plantings and how they compare with conventional plantings.

Acknowledgments

Thanks to Macadamia Farm Management for their collaboration in this trial and to the Macadamia Planting Systems Trial Advisory Group from the previous trial for helping us sift through these learnings and the recently formed AS18000 Macadamia Crop Reference Group.

More information

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On the 'AS18000 National Tree Intensification Program', contact: Adrian Hunt (Hort Innovation) on adrian.hunt@hortculture.com.au

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The 'complex' tree system in the phase 2 MPST near Bundaberg a little over 1 year after planting. Shoots that have grown more than 30 to 40 cm without branching are tip-pruned to promote canopy complexity.



The vase tree system in the phase 2 MPST near Bundaberg a little over one year after planting. We are aiming to have four leaders pushing upward and outwardinto the alley to create a vase structure. This tree has just been pruned and the open centre of the vase structure is visible.

This is a project of the National Tree Crop Intensification in Horticulture Program, funded by the Hort Frontiers Advanced Production Systems Fund, part of the Hort Frontiers strategic partnership initiative developed by Hort Innovation, with co-investment from Queensland's Department of Agriculture and Fisheries, Queensland Alliance for Agriculture and Food Innovation - The University of Queensland and the Western Australian Department of Primary Industries and Regional Development, and contributions from the Australian Government.



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Understanding macadamia tree and fruit growth through modelling

Inigo Auzmendi and **Jim Hanan** Centre for Horticultural Science,
Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland

The QAAFI team for horticultural plant physiology and modelling is collaborating with horticultural researchers in the Queensland Department of Agriculture and Fisheries (DAF) to better understand how orchard design and management practices affect the growth and yield of macadamia trees. This work is part of the *National Tree Crop Intensification in Horticulture program (AS18000).*

Modelling is a valuable and cost-effective tool used by researchers to predict likely outcomes to different tree crop scenarios, such as planting system design and management strategies, and to test ideas quickly instead of completing long-term trials. More simplistic models are also useful to growers as decision support aids, such as irrigation scheduling and nutrition budgeting tools. To develop the capability of and confidence in models, modellers invest much time and effort in establishing strong foundations by inputting datasets obtained from research and industry projects.

Modelling tree physiology and growth

Models of plant physiology and structure combine mathematical functions that describe plant physiology, development and growth. These models are run on a computer to create virtual plants or simulations that can be used to understand how plants grow and to test ideas that would be hard to measure in the field; for example, how carbohydrates are shared between fruits, leaves and stems in the tree.

The growth and productivity of a macadamia tree depends on many interacting factors, some of which are hard to control in an orchard, e.g. temperature, light, air humidity or soil moisture. Through project AS18000, modellers and researchers are learning that how a plant responds to these factors is not easy to predict or understand.

The macadamia project is investigating how much some of these factors can be manipulated to deliver improved orchard productivity and sustainability through orchard design and management practices. The researchers are investigating how training trees to certain shapes and heights, either by pruning, using size-reducing rootstocks or plant growth substances, will help to achieve more intensive macadamia production systems.

Virtual macadamia trees can be used to integrate environmental and internal factors, such as light and carbohydrates, to better understand the principles of tree physiology and horticulture. These principles can then be used by researchers to develop guidelines for orchard design and management practices that will improve the productivity and sustainability of orchards.

To develop this kind of model for macadamia, the team at QAAFI and DAF first needed a good understanding of how individual organs such as leaves, fruits and stems grow and how not getting enough carbohydrate at some stage will affect the final size. This knowledge on organ growth has been combined with specific software and programming techniques to integrate the different aspects that determine plant growth, including: organ size and position within the canopy, light interception, and carbohydrate production, demand and distribution.

To determine organ size and position in the canopy, the research team records them in an orchard tree using digitisation, and simple growth rules are used to create tree structures that resemble real plants. Once the size and position of every organ in the canopy has been defined, a realistic 3D visualisation of the tree is generated using computer graphics techniques.

Simulating factors that affect growth

Using this virtual canopy, the model simulates processes influenced by external factors like phenology (dates of flowering and budbreak) or light environment of individual leaves during a day, as well as internal plant processes like photosynthesis and carbohydrate distribution. This mimics how carbohydrates produced by leaves are available for individual organs in different parts of the canopy. For example, fruits will share this resource with other organs such as leaves and stems which are growing at the same time.

The model simulates the competition for carbohydrates between vegetative growth and fruit during one growing season, as well as between individual fruits in the canopy. This simulation assumes that carbohydrates produced in one unit (branch, branchlet or limb) are not exported to other units.

Comparing simulations with a measured macadamia canopy indicated that autonomous units were like individual two-year-old branches, rather than the whole macadamia tree. This is called branch autonomy, and it may explain how carbohydrate availability influences the presence of longer shoots, as well as bigger leaves and fruits, in the top and external parts of the canopy. These branches receive more light and produce more carbohydrates, which they share with other organs within the same branch, not within the whole plant. If all carbohydrates were equally shared within the plant, similar size organs could be expected to exist across different parts of the canopy.

Implications of branch autonomy

One of the implications of branch autonomy is the importance of considering smaller parts of the canopy rather than the whole canopy in carbohydrate studies. For example, when applying an experimental treatment, it might not be necessary to apply it to the whole canopy, only to the autonomous part (two-year-old branch).

For orchard management, well-lit branches might not have enough fruit to use all the carbohydrates produced, which would translate into more carbohydrates available for vegetative parts, and a lot of vegetative growth. Meanwhile, shaded branches might not produce enough carbohydrates to grow fruits of an acceptable size. This underlines the importance of having a good light distribution throughout the canopy, to avoid branches without enough carbohydrates used for growing fruit.

In general, carbohydrate distribution and branch autonomy in plants are not very well-known processes, mainly because we cannot measure them easily. The preliminary macadamia model is very simple in comparison with the real plant, and the results of simulations should be taken cautiously. Nevertheless, computer simulations are proving helpful not only to better understand macadamia tree physiology, but also as a basis for defining innovative orchard design and management practices. This could lead to improved orchard productivity and sustainability through horticultural intensification.



Visual 3D representation of a virtual macadamia tree canopy at around 5 years after planting, including the growth simulated during the last season. The canopy includes stems (brown), leaves (green) and fruits (yellow). Simulated leaves and stems growing in the present season show a lighter green colour. Image: Auzmendi and Hanan (2020)

This work started in the *Transforming Subtropical/tropical Tree Crop Productivity (AI13004)* project and is continuing as a component of research within the *National Tree Crop Intensification in Horticulture Program (AS18000)*, funded by the Hort Frontiers Advanced Production Systems Fund, part of the Hort Frontiers strategic partnership initiative developed by Hort Innovation, with co-investment from Queensland's Department of Agriculture and Fisheries and Queensland Alliance for Agriculture and Food Innovation - The University of Queensland, and contributions from the Australian Government.

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Growers have their say on new selections from the breeding program

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The national macadamia breeding and evaluation program (project no. MC19000) is currently evaluating more than 10,000 new macadamia progeny in Queensland and New South Wales. This involves measuring growth, yield, quality and resistance to pests and diseases. While the project team undertakes this task annually, it is also extremely valuable to obtain growers' participation on the selection process before moving new selections into the regional variety trials.



Growers evaluating new macadamia seedling selections at Bundaberg Research Facility

Grower evaluations

Evaluation and selection of progeny is the first step in the long process of developing new macadamia varieties. In a field day on 11 March 2021, growers were invited to inspect the breeding trial at the Bundaberg Research Facility. As part of a field walk, they were asked to evaluate the top-performing selections in a block of hybrid seedlings that were planted in 2013. The elite selections included high yielders with small tree size and spreading habit. The March timing provided an opportunity to see the full crop before harvest and to observe the large variation in tree growth habits on the eight-year-old trees.

Three promising new selections were visually evaluated by growers using the following criteria:

- estimated yield per tree (kg)
- canopy density rating from 1 (very open) to 9 (very dense)
- tree habit rating shape from 1 (upright) to 9 (spreading)
- husk spot severity rating, indicated by symptoms, from 1 (none) to 9 (severe)
- commercial potential from 1 (low) to 9 (excellent) with 7 being commercially acceptable.

Performance data

The following descriptions are based on performance data collected from seedling trees planted in the Bundaberg progeny field trial.

Selection 127007 is a medium size tree with an open canopy; it is an early-mid season dropper and produces large nuts with a kernel recovery of 45%.

Selection 127008 is a medium to large tree with a spreading canopy; it is an early-mid season dropper and produces a high yield (about 15 kg/tree at age 6) with a kernel recovery of 43%.



Selections 127007 (left), 127008 (right) and 127009 (bottom).

Selection	Density rating	Habit rating	Husk spot rating Commercial Potential	Commercial potential	Grower NIS yield per tree estimate (kg)	Actual NIS yield per tree (kg)
127007	3.8	5.5	3.0	6.6	10.0	6.3
127008	6.7	5.1	2.5	7.3	11.4	15.1
127009	7.4	6.8	4.0	6.9	8.9	8.2

Table 1. Average results from 2021 grower evaluations of eight-year-old trees

Selection	Positives	Negatives
127007	Large nuts, open canopy, easy to prune	Hard to spray, leaning, wind blown
127008	Medium to large nuts, thin husk, open canopy	Large tree, vigour
127009	Large nuts, thin husk, short tree	Discoloured husks, thick shell, too much leaf

Table 2. Grower comments on new macadamia selections

Selection 127009 is a small to medium tree with a moderately dense canopy; it is an early dropper and produces a high yield with a kernel recovery of 43%.

Table 1 shows results from grower evaluation of the three elite selections on show during the field walk. Visual estimation of yield was compared to actual yield following harvesting. Generally, growers had a keen eye for estimating total yield, particularly for selection 127009, where estimated yield was within 700 g of the harvested yield.

Selection 127007 exhibits a spreading habit and was rated as the most open canopy. Selection 127008 was rated as having the highest commercial potential, which corresponded with the highest yield of the three selections evaluated.

Growers were also asked to comment on positive or negative traits of each of the selections (see Table 2).

Grower evaluation has supported the decision to progress these selections to the next stage of testing in regional variety trials where they will be tested in a range of environments. Industry consultation has also helped guide prioritise traits in the breeding program. Input from growers and industry stakeholders throughout different stages of the breeding program will lead to the development of new varieties designed to suit a range of environments, growing systems and ultimately the needs of growers.

The project has been funded by Hort Innovation, using the macadamia research and development levy and contributions from the Australian Government. The Queensland Government and the University of Queensland have also co-funded the project through the Queensland Alliance for Agriculture and Food Innovation (QAAFI).

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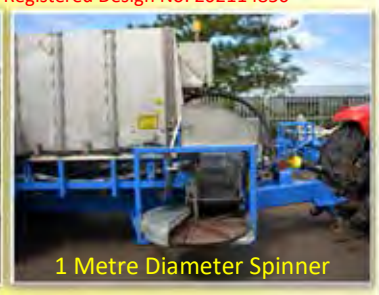

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Forecasting macadamia yield at block and farm level

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and **Professor Andrew Robson P:** 02 6773 4085 **E:** arobson7@une.edu.au,
Applied Agricultural Remote Sensing Centre, University of New England

Forecasting macadamia production provides valuable information for decision making around factors including nut storage, transport and finance. However, macadamia yield is notoriously difficult to predict before harvest.

Estimates can be based on seasonal conditions and yield history, but the processes guiding seasonal fluctuation of yields are not well known. Visually inspecting a number of selected trees, assessing factors such as flowering, nut size or nut count can help prediction. However, estimates are uncertain, and the inspected trees may not be representative of **all trees** in a block or a farm.

The year-to-year fluctuation of macadamia yield may be due to complex combinations of carbohydrate storage and cycling, climatic conditions and management factors.

This is why this project team at the University of New England has been investigating yield forecasts that use information gathered from satellites to remotely observe all trees in each orchard block, **multiple times** during current and previous seasons (as previous season conditions affect future yield), in addition to weather observations.

Aim

This project provides growers with yield forecasts for 10% nut in shell (NIS) production in early January. The forecast models are based on free satellite imagery and weather datasets, enabling forecasts to be produced for any orchard within Australia.

Method

Queensland's Department of Agriculture and Fisheries (QDAF) have forecast regional yield for the Australian Macadamia Society (AMS) using a variety of predicting variables including weather (Mayer *et al* 2019).

Previous projects led by our group (Applied Agricultural Remote Sensing Centre at the University of New England) have sampled nuts manually from selected trees on a number of blocks and correlated the per-tree yield with canopy reflectance properties as measured with high resolution satellite imagery.

This showed that imagery is able to model much of the yield variation (Robson *et al* 2017). We have also produced a satellite image based model of tree age for the macadamia industry (Brinkhoff *et al* 2020, Summer 2020, *News Bulletin*).

Forecasts that use such deep spatial and time information are now theoretically possible, with the availability of frequent satellite imagery and interpolated (5 km grid) weather data. This project used such data, together with historical block-level yields provided by growers from multiple farms covering the main growing regions in Australia.

We obtained block yield data from collaborating growers. The data covered three regions (Bundaberg, North NSW coast, South NSW coast), 101 blocks, and

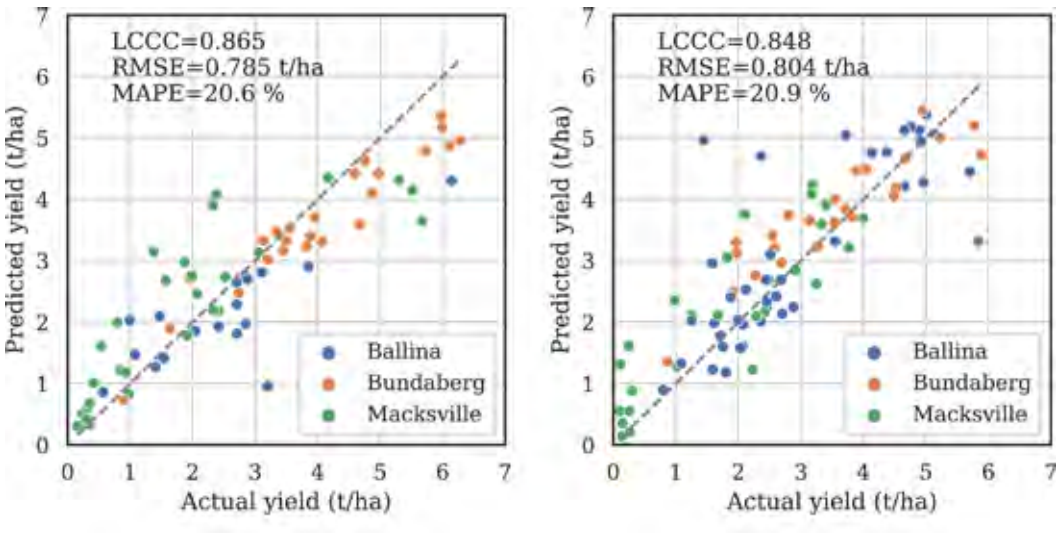

Figure 1. Block level forecast and actual yields in 2018 (a) and 2019 (b).

from 2012-2019. This gave 475 data points. Recently, more growers have become involved, some of whom have NIS data only at the farm level, but this is still valuable for improving models.

Satellite imagery is able to observe how the tree canopies reflect light in many different wavelengths (colours), some of which human eyes can see (red, green, blue) and some which they can't (near and shortwave infrared). These reflectances can indicate tree health, leaf flush intensity, nutrient and water status, and tree responses to soil and weather conditions.

The precise link between variation in canopy reflectances and the physical drivers may not be well known, but by using statistical and machine learning techniques, models can be trained to forecast future yields.

Model inputs are free satellite reflectance information, together with weather data and historical yields. These models can then forecast future yields.

We used free satellite imagery with 30 m pixel size, and free weather data gridded to 5 km cells. Weather and satellite data was grouped per quarter (Jan-Mar, Apr-Jun, Jul-Sept, Oct-Dec) from the two years prior to the harvest year, to predict yield in January of the harvest year. This has been done for collaborating growers for the past two seasons, providing both farm and block level forecasts.

Results

Of the weather variables, the average minimum temperature in April-June in the year before the harvest was the most important predictor variable, explaining around 15% of the variation in block yields.

However, the most significant predictor was from the satellite data in the same time period. It was the green normalized difference vegetation index (GNDVI), which uses reflectance measures in the green and near infrared bands, that was able to describe around 62% of the variation in the block yields.

A model built using GNDVI gave average block level forecast errors of around 25%.

We then built a complex machine learning model using many satellite bands over the eight time periods discussed above. This model produced more accurate predictions, with average block level forecast error in 2018 and 2019 of better than 21% (Figure 1). The January 2019 forecast and the actual measured yields for an example orchard are shown in Figure 2. The model is able to describe much of the difference in yield performance between blocks.

Regional level predictions (Bundaberg, Macksville, Ballina) were made by aggregating block predictions. Prediction errors were less than 15%, with Bundaberg having the lowest errors.

The future

During the 2021 season, the project team has so far engaged with 10 companies and farms, providing forecasts to them in early 2022.

The more growers with historical yield data we are able to work with, the more accurate the models will become, as they will include a wider range of climate conditions, regional differences and tree conditions. All farm data is kept confidential and is not shared with any third parties.

We would welcome the opportunity to include more growers into the program. Please contact James at james.brinkhoff@une.edu.au

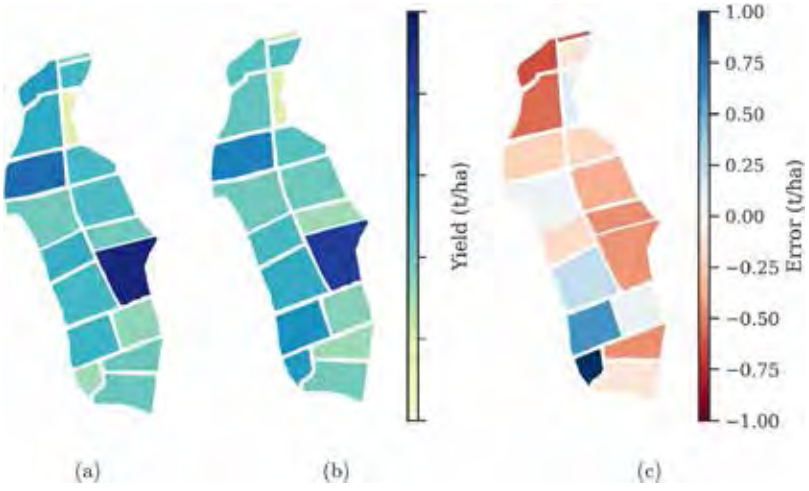

Figure 2. Actual yield (a), predicted yield (b) and prediction errors (c) in 2019 for an example orchard.

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Decortes Private Regional Variety Trial – Roundup

Lindsay Bryen, Northern Rivers grower and **Dougal Russell,** Department of Agriculture and Fisheries, Queensland **T:** 07 5381 1330 **E:** dougal.russell@daf.qld.gov.au

In 2012, a private Regional Variety Trial was planted by the Bogg family on a property called "Decortes" at Welcome Creek near Bundaberg. Stahmann Farms took over ownership and management in 2018 and the trial was continued.

Selections for the trial were sourced from the then CSIRO B1.1 and B1.2 progeny seedlings. Two of the selections - MIV1-G and MIV1-E - were included in RVT3 trials in Queensland and NSW. Also included in this planting was MCT1, since released by the Macadamia Conservation Trust, and standard industry cultivars A16, 741 and 816.

This trial was laid out in six tree plots, replicated four times randomly in the block. Each plot had three trees each on Beaumont seedling or Beaumont cutting rootstocks. Cultivar 816 trees were bought from the nursery on H2 seedling rootstocks. While data was collected on nut and tree characteristics from year four (2016), only two years of data are presented in this article.

The article shows average yield and kernel results from 2019 and 2020, or years seven and eight, tree size and volume for all 19 cultivars (Tables 1 and 2) and goes on to provide nut drop pattern and a brief description of the best performing (top nine) cultivars in Figure 3 and Table 3.

In February 2022, the Macadamia Industry Variety Improvement Committee (MIVIC) will view the trees, assess the potential 2022 yield and make decisions on commercialisation for the macadamia industry.



The Macadamia Industry Variety Improvement Committee visited the Decortes farm in February 2020 to examine the trial. Pictured: Lindsay Bryen addresses the group.

Cultivar	Mean sound NIS @1.5% MC	TKR (%)	Premium (%)	Commercial (%)	Reject (%)	SKR (%)	SKR kernel yield @1.5% MC
MCT1	9.297	42.8	41.4	1.2	0.2	42.6	3.956
BAFF 1532	8.779	41.6	34.5	1.9	5.2	36.5	3.202
HIN 210	6.566	42.1	33.0	9.0	0.1	42.0	2.758
BAFF 426	7.575	45.2	32.0	4.1	9.1	36.1	2.738
BQRS 215	7.469	38.2	35.1	1.5	1.5	36.6	2.736
BAFF 1917	6.851	39.6	39.0	0.5	0.0	39.6	2.710
HIN 54	6.599	41.4	39.6	1.0	0.8	40.6	2.678
BQRS 2004	7.579	40.2	32.3	2.3	5.6	34.5	2.618
A16	6.212	42.3	38.7	1.5	2.1	40.2	2.495
MIV1-G	6.384	38.6	36.9	0.5	1.2	37.4	2.385
BQRS 631	5.954	39.1	36.2	2.2	0.8	38.3	2.281
BQRS 1207	6.104	37.4	32.2	3.6	1.6	35.8	2.187
BAFF 1508	7.573	36.9	24.2	4.5	8.2	28.7	2.173
MIV1-E	5.681	37.9	33.1	3.5	1.3	36.6	2.078
BQRS 202	3.725	39.1	37.5	0.6	1.0	38.1	1.420
741	4.181	35.8	30.5	1.7	3.6	32.2	1.348
HIN 35	3.498	37.5	36.8	0.4	0.3	37.2	1.302
HIN 55	2.961	40.2	33.4	5.0	1.8	38.4	1.138
816	1.688	40.3	36.3	2.1	1.8	38.4	0.649

Table 1. *2019 Decortes kernel analysis and yield*

Cultivar	Mean sound NIS @1.5% MC	TKR (%)	Premium (%)	Commercial (%)	Reject (%)	SKR (%)	SKR kernel yield @1.5% MC
BAFF 1532	13.673	42.40	42.40	0.68	0.66	41.74	5.707
MIV1-G	12.606	41.41	41.41	1.60	1.12	40.29	5.078
MCT1	10.927	42.94	42.94	2.15	0.48	42.47	4.640
BAFF 1508	12.178	37.04	37.04	2.03	0.72	36.32	4.423
HIN 210	10.359	44.17	44.17	11.21	2.02	42.15	4.366
MIV1-E	11.723	38.54	38.54	2.35	1.59	36.95	4.332
A16	10.270	42.18	42.18	1.80	0.87	41.31	4.242
BAFF 426	9.668	43.83	43.83	2.40	0.71	43.12	4.169
HIN 54	9.944	41.49	41.49	0.97	0.20	41.29	4.106
BAFF 1917	10.233	40.06	40.06	1.69	0.37	39.70	4.062
BQRS 215	10.301	39.08	39.08	0.48	0.36	38.72	3.989
BQRS 1207	10.562	37.93	37.93	1.45	0.68	37.25	3.934
BQRS 2004	9.647	39.72	39.72	2.47	1.93	37.80	3.646
BQRS 202	9.021	38.89	38.89	0.40	0.55	38.34	3.459
741	7.317	37.01	37.01	2.35	1.84	35.17	2.573
BQRS 631	7.012	36.86	36.86	0.22	0.28	36.58	2.565
HIN 35	6.636	38.23	38.23	0.62	0.24	37.99	2.521
HIN 55	5.875	42.74	42.74	7.39	2.80	39.94	2.347
816	5.159	43.62	43.62	1.90	1.43	42.19	2.176

Table 2. *2020 Decortes kernel analysis and yield*

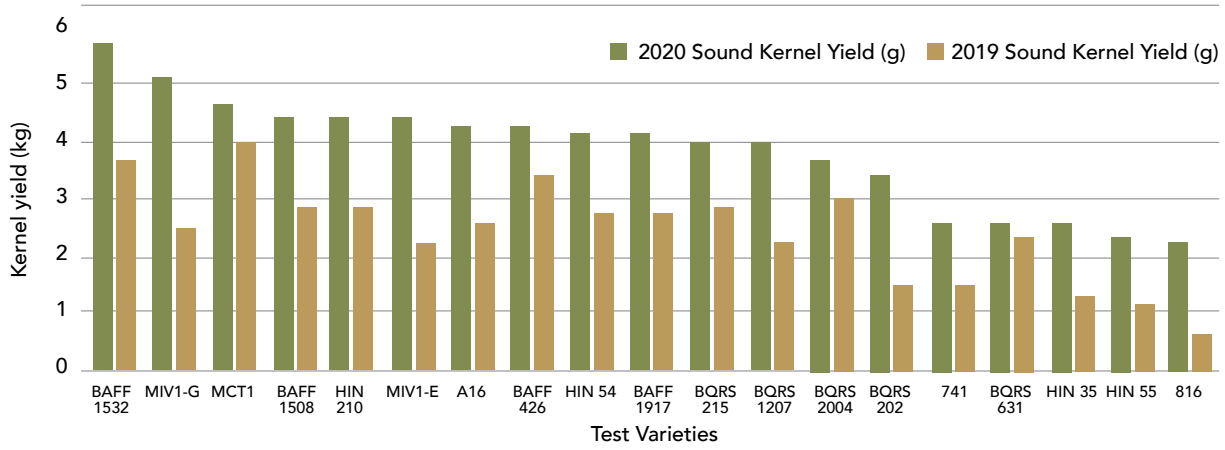

Figure 1. 2019 and 2020 kernel yield sorted on 2020 average tree yield.

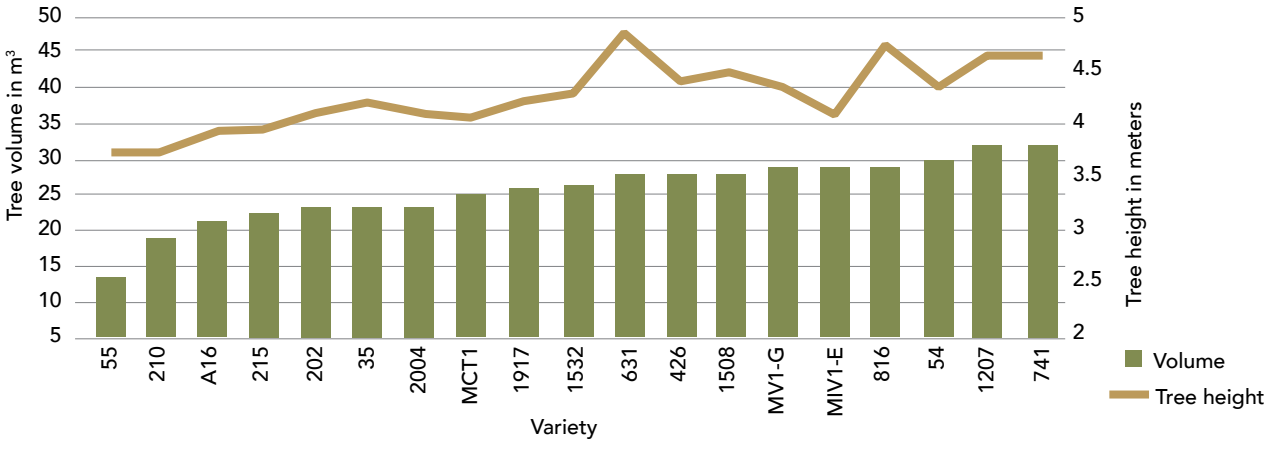

Figure 2. 2020 tree measurements ranked from smallest volume to largest

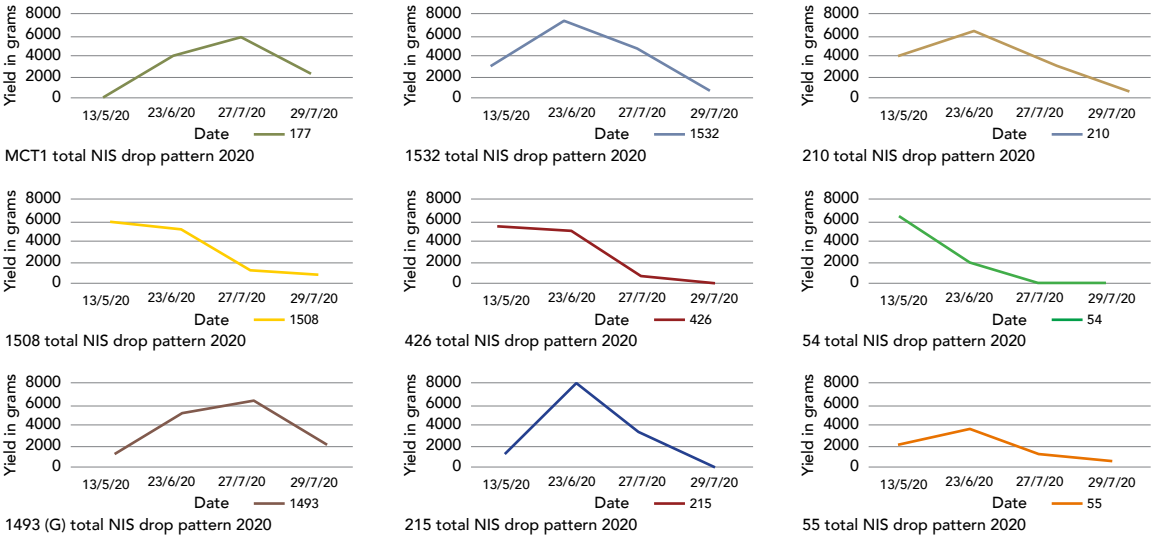

Figure 3. Nut drop patterns at Decortes in 2020. Four harvest dates starting in May.

Variety	Tree size	Tree shape	Precocity	Drop pattern	Positives	Negatives
177 MCT1	Small to medium	Spreading	Yes, early producer	Medium to late- June July August	Precocious, high yielding small to medium tree size	Very thin husk and shell prone to insect stings. High performer requires extra resources to maintain productivity. Rain fed sites will limit productivity.
"MCT1" Not self-fertile, requires a pollinisor						
BAFF 1532	Medium to large	Upright	Yes, early producer	Early April - May Small percentage stick tights Late July	Precocious, consistent, high yielding. Self-compatible suit single or two variety large block planting. Early dropping variety.	Small NIS size difficult to handle, some losses from undersized NIS. Some stick tights possible, prone to HS. Needs good resource supply. Kernel - low whole count. Range between 18 and 21 mm.
"BAFF1532" Highly self-fertile. Very small NIS, some below 18 mm, harvest and handling difficulties						
BAFF 1508	Medium to slightly large	Spreading	No, not precocious	Mid-season, May to June	High yielder of NIS. Open tree, good to spray and improved air flow.	Not precocious, limits early cash flow. Husk spot risk. Lower kernel recovery 37%.
HIN 210	Small	Globular	Yes, early producer	Mid-season, May – June. Nil strip end July	Precocious, consistent high yielding. Large nuts and kernel.	Not many vices. Distinctive golden–amber coloured shell.
BAFF 426	Medium to slightly large	Upright – limbs break off in wind	Not precocious	Early to mid-season, April, May to June	High yielder of NIS. Open tree, good to spray and improved air flow. TKR highest in 2019.	Limb breakages make it a messy tree.
HIN 54	Medium	Globular, dense canopy	Yes, early producer	April to June. Bulk in May	Good producer of NIS and kernel.	Dense canopy is the major issue.
MIV1-G	Large	Upright to spreading	Yes, early producer	Bulk in May, some June July	Good yielder, industry release. Number 2 kernel production 2020	Not many vices.
"G" Best of new releases, consistent high yields and good kernel recovery.						
BQRS 215	Medium	Globular, dense canopy	Not precocious	May and June	Good producer of NIS. TKR of 38% slightly limits kernel yield.	Late yield, dense tree leading to poor spray and air flow.
HIN 55	Very small	Upright to spreading, open canopy	Yes, early producer	May and June	Suitable for high-density planting. Highest canopy efficiency of kernel per canopy volume.	Due to its small nature and high efficiency needs ideal condition and management not for the mass planting on low maintenance program.
"HIN 55". Truly the smallest tree in the RVT.						

Table 3. Best performing varieties and characteristics.

The last two years of this project were funded by Hort Innovation, using the Macadamia Industry research and development levy and contributions from the Australian Government.

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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	All states and territories except VIC
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	All states and territories except VIC
Diazinon	PER14276	Macadamia lace bug	• Product containing 800 g/L diazinon: 120 mL product/100 L	14	NSW, QLD & WA only
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	NSW, QLD, WA & NT only
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	NSW & QLD only
Methomyl	PER90592	Banana fruit 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	QLD only
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	NSW & QLD only
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	NSW & QLD only
Emergency permits					
Chlorantraniliprole	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 + 5 g active/100 L non-ionic surfactant/ wetting agent	10	All states and territories except VIC
Indoxacarb	PER89278	Fall armyworm	• Product containing 300 g/kg indoxacarb: 25 g/100L	42	All states and territories except VIC
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	All states and territories
Spinetoram	PER89241	Fall armyworm	• Product containing 120 g/L spinetoram: 40 mL product/100 L	7	All states and territories except VIC

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.

Growers wishing to use a chemical in the manner approved under a permit should obtain a copy of the relevant permit from the APVMA and must read and comply with all the details, conditions and limitations relevant to that permit.

AUSTRALIAN MACADAMIA SOCIETY

NSW GOVERNMENT Department of Primary Industries



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