AUSTRALIAN MACADAMIA SOCIETY

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NEWS BULLETIN

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The Big Heart of Australia's Macadamia Industry

AUSTRALIAN MACADAMIA SOCIETY

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Front cover. Dr Dan Manson, Leoni Kojetin and Theunis Smit (L to R) led the regional AMS Tree Water Management courses. See articles on pages 23 and 29.

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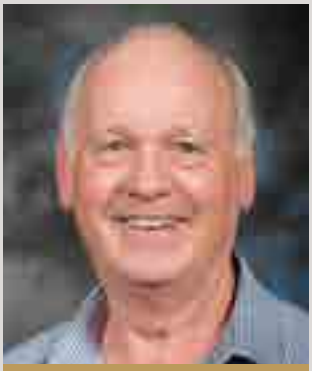
Wherever you see this logo, the initiative is part of the Hort Innovation Macadamia Fund. Like this publication itself, it has been funded by Hort Innovation using the macadamia levy and, in the case of R&D, with contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian Horticulture. Some projects also involve funding from additional sources.

Thanks to our industry partners

OUR TEAM

Our Mission

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



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CEO'S REPORT



The Australian macadamia industry has experienced unprecedented growth over the last 5 years. New plantings in New South Wales on the coastal flats and surrounds from Ballina to Coffs Harbour have seen close to 3,000 hectares added with more to come. Principally in Bundaberg, but also throughout coastal Queensland, it is likely that 5,000 hectares have been planted or are planned. Across all planting regions we expect to see another 2,000 hectares a year until at least 2025 given current industry conditions.

This growth is much needed as Australia strives to maintain our global leadership and premium positioning in the macadamia trade. It is also essential if we are to confidently service potential new markets such as India, South East Asia and eastern Europe.

Macadamias are now the most valuable agricultural industry in the NSW Northern Rivers and the third most valuable industry in the Wide Bay Burnett region. Macadamias are already the most valuable horticultural export in both New South Wales and Queensland.

However, with this new size, value and profile, comes the inevitable scrutiny of our practices and behaviour. This will be particularly so in the context of initiatives like the Queensland Government's new Great Barrier Reef legislation and the NSW Government's Cleaner Coastal Catchments initiative. However, if these worthwhile initiatives are poorly implemented and managed by regulators, it may feed into a perception that agriculture is inevitably leading to poor environmental outcomes, and this could potentially see animal rights activism applied to chemical use in horticulture.

The best way to mitigate against this risk is to acknowledge the legitimate interest of communities and consumers in how our products are grown, processed and taken to market. We are an industry that has always taken our food safety and environmental responsibilities seriously and we have much to be proud of in this space. We were one of the first industries to widely use consultants to monitor pest and disease levels, and one of the first to control a major pest (nut borer) with a biological control (Trichogramma wasp). We continue to have a major investment in integrated pest and disease management and have a number of new biological controls under development.

Irrigation is generally used efficiently and sustainably and the industry has one of the highest value returns for each megalitre of water used. Many of our growers have undertaken extensive drainage and erosion control works to avoid some of the mistakes of the past when soil loss from some orchards was unacceptable. The fact that some growers are removing productive rows of trees to achieve a better environmental and productivity outcome is a mark of how seriously the industry takes its responsibilities. The industry also has some of the best examples of remnant vegetation and riparian zone restoration and management in Australian horticulture.

It is essential that we continue to pay close attention to all our on-farm practices and the impact they can potentially have on the environment and on the communities in which we operate. We recently sent out an email reminding growers of good agricultural practice in crop protection. Please read it carefully and implement it. Also useful are NSW DPI's Plant Protection Guide and Growcom's Hort 360 best management practice program. This is an area where we are all exposed, because bad practices by an individual impact the entire industry through increased compliance and a loss of community tolerance and respect.

Trying to hide poor practices and unethical behaviour behind fences and 'No Trespassing' signs does not work, as recent media exposés clearly show. The best protection for your business and the industry is to be honest and open about your practices, to engage with neighbours and the community about their concerns, and to build the trust and respect that will allow us to come to commercially viable compromises where required. If you are involved in, or are aware of a potential issue, please contact the AMS promptly.

We are currently working towards developing environmental and sustainability measures that the industry can adopt and report on to communities and consumers to further build on our strong record to date.

I hope we can count on your support.

Jolyon Burnett, CEO

AMS BOARD UPDATE

In addition to the ongoing industry development and representation work that the Board members engage in, the following are some of the activities that Board members have been involved in over the last few months:

- A number of our Directors represented the AMS Board at a meeting and dinner with the new Federal Minister for Agriculture, Bridget McKenzie, when she visited the Northern Rivers in August.
- The Board contributed to a submission by the Australian Nut Industry Council (ANIC) towards a Commonwealth Department of Agriculture and Resources project being set up with the aim to grow the agricultural sector to $100 billion by 2030.
- Our Chair, Richard Doggett, met with senior staff at Hort Innovation to discuss the operation of the Strategic Investment Advisory Panel (SIAP) and strategic planning for the industry.
- Aimee Thomas continues to represent the AMS Board and the interests of growers as a member of the SIAP which last met in August and October.
- Board members were involved with preparations for the 2nd AMS Future Forum which was held in Brisbane on 13 November 2019.
- The Audit Committee, chaired by Craig Mills, met in September and continue to oversee corporate governance and financial audit process and reporting. Craig Mills, Richard Doggett and Larry McHugh all sit on the Audit Committee.
- Members of the board continue to attend industry events and activities such as trade fairs in Australia and overseas.
- Richard Doggett and Graeme Fleming continue as Committee Members of the Management Committee of the Macadamia Conservation Trust (MCT) and report back to the AMS Board on the work of the MCT.
- On a sad note, Graeme Fleming, Jolyon Burnett and Larry McHugh attended the funeral of Michael Donnelly in October.
- On a brighter note, our congratulations go to Graeme Fleming and Craig Mills who have been re-elected as Directors, and to Michael Russo on his election to the Board (see AMS News article on page 10).

Our collective congratulations go to AMS Deputy Chair Michael Waring who was elected in May to the prestigious position of Chair of the International Nut and Dried Fruits Council. This is the first time an Australian has held the role. It is recognition of the importance of Australian nut production in the global industry. Michael did not nominate for election at the end of his term and we extend our profound thanks to him for his work on behalf of members and the industry.

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- Investing in technology such as pasteurisation to ensure food safety for customers and ensure growers always have access to markets for their crop
- Running industry leading field days
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WHAT'S ON

DATE	EVENT	LOCATION	CONTACT
24 Dec 2019 to 6 Jan 2020	AMS office closed for Christmas break		
26 Feb 2020	AMS Board meeting	Bundaberg	AMS: Phone 1800 262 426, office@macadamias.org
19 Feb 2020	Australian Macadamia Handlers Association (AMHA) meeting	Brisbane	AMS: Phone 1800 262 426, Lynne.ziehlke@macadamias.org
2 Mar–30 Apr 2020	Norm Greber and other award nominations		AMS: Phone 1800 262 426, office@macadamias.org
29–30 Apr 2020	Commercial Macadamia Nursery Operators Workshop	TBA	AMS: Phone 1800 262 426, office@macadamias.org
13 May 2020	AMHA meeting	Brisbane	AMS: Phone 1800 262 426, Lynne.ziehlke@macadamias.org
20 May 2020	AMS Board meeting	Brisbane	AMS: Phone 1800 262 426, office@macadamias.org
21–23 May 2020	Primex	Lismore	
10–11 June 2020	Macadamia Industry Consultants Meeting	TBA	
PROPOSED: New Grower Workshops in 2020 at Bundaberg (May), Northern Rivers (Aug). Location and dates TBC based on demand. Contact AMS if you are interested, phone 1800 262 426, or email office@macadamias.org			
	MacGroups		
25 Feb 2020	Glass House Mountains		
26 Feb 2020	Gympie		
27 Feb 2020	Bundaberg		AMS: Phone 1800 262 426, office@macadamias.org
3 Mar 2020	Mid North Coast		
4 Mar 2020	Coastal Floodplain (Northern Rivers)		
5 Mar 2020	Northern Rivers		

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MACADAMIA DEMAND CONTINUES TO RISE

Lynne Ziehlke, General Manager Marketing

Supply

Supply expectations remain relatively unchanged, with Australia's October crop forecast update holding steady at 42,900 t (at 3.5% moisture). It is being predicted that there may be some upside in South Africa's crop from 58,500 to nearer 60,000 t, while China's crop is anticipated in the region of 20,000 t. Globally, total in-shell supply in 2019 is expected to be approximately 5% under the previous year.

New investment in macadamia plantings in major supply origins has continued strongly, with significant greenfield developments in South Africa and Australia. There has also been investment in new processing capacity and processing technology in both origins.

Demand

Demand for macadamia kernel from key markets continued to rise with imports to the five biggest volume markets (consuming approximately 70% of global kernel production) rising by 28% in the 12 months to August 2019 (see Figure 1).

Australia continues to have the highest per capita consumption in the world followed by the United States (Figure 2). Seven European countries represent almost half of the top 15, and per capita consumption in Asia still has a long way to go with Taiwan coming in at #5 and Japan at #10.

Australian sales

Corresponding directly to growth in global demand and a strong 2018 crop, Australian kernel sales grew +9% in the 12 months to September 2019 (see Table 1).

The strongest growth came from the United States (up 51% versus the previous 12 months), Japan (up 15% versus the previous 12 months) and Europe (up 42% to Germany, up

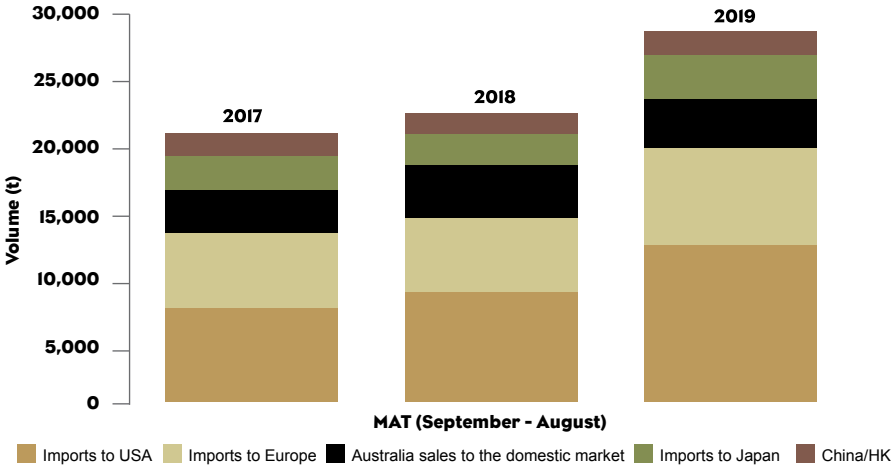


Figure 1. *Macadamia kernel imports/wholesale sales – top 5.*
Source: USDA, Eurostat, AMHA, Japan Customs, China Customs, Hong Kong Census & Statistics Department (all via HIS Markit Inc. except AMHA)

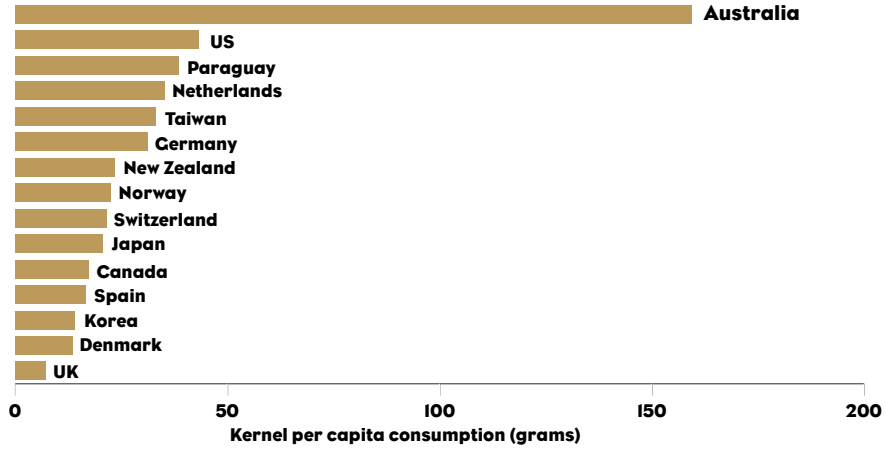


Figure 2. *Per capita raw kernel consumption – top 15.*
Source: AMHA, HIS Markit Inc and industry estimates

	2015	2016	2017	2018	2019
Domestic	3,237	3,203	3,165	3,941	3,635
USA	1,356	934	788	1,140	1,716
Japan	1,456	1,721	1,859	2,025	2,326
Korea	534	432	713	631	654
Taiwan	539	468	396	548	487
China	469	290	719	414	512
Other Asia	811	711	599	774	730
Germany	790	924	606	627	892
Other Europe	823	708	854	670	825
Other	78	161	- 124	- 0	0
Total kernel sales	**10,093**	**9,551**	**9,574**	**10,769**	**11,778**
In-shell sales	**12,161**	**13,714**	**17,432**	**7,285**	**10,441**

Table 1. *Australian macadamia 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

23% to the rest of Europe). Kernel sales to China also grew strongly, up 24%.

Sales to the domestic market fell by 8% but were the second highest recorded in the last 5 years.

In-shell sales grew 43% in the 12 months to September 2019.

Global product innovation

There was a slight increase in the number of new products containing macadamias launched in the September quarter (see Figure 3), with the majority coming from the United States and China, and most launches occurring in the snack category. Interestingly, many of China's launches were from brands other than the well-established top 6.

There were products launched in 36 countries including from less well-known consuming countries such as Egypt, Panama, Mexico, Indonesia, Saudi Arabia, Austria and Lithuania.

The *Innovation Initiative*

More than two-thirds of the Australian macadamia industry's three-year *Innovation Initiative* marketing strategy has now been executed. Designed to drive new product development using macadamias in the ingredient sector, the Initiative has achieved a host of highlights to date, including new research, trade PR, innovative product concepts from the Macadamia Innovation Challenge, hundreds of new assets for industry marketers and a growing consumer and trade audience.

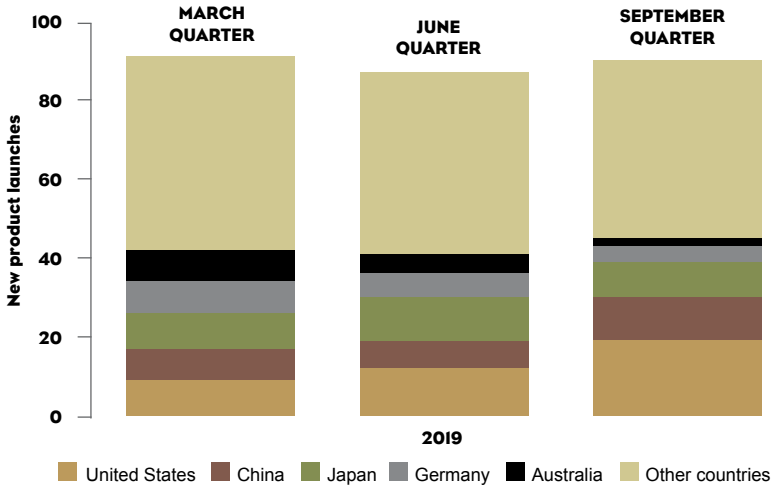


Figure 3. *New product launches using macadamias as an ingredient – by quarter and country of launch.* Source: Innova Market Insights



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WELCOME TO MICHAEL RUSSO, OUR NEW BOARD MEMBER



We are pleased to announce the appointment of a new AMS Board member, Michael Russo, who took up his position at the AGM in November (replacing Michael Waring who did not nominate at the end of his term).

Michael is a fourth-generation farmer and, with his family, operates cane and macadamia farms at Farnsfield, near Childers. The Russos have planted 100 hectares of macadamias since 2015 and plan to plant another 80 hectares in 2020.

Michael brings a range of farming and business skills to the AMS Board. His family business is well known in the cane industry for innovation, extensive on-farm trial work and use of the latest yield monitoring technology.

His motivation, drive and experience in a variety of professional management positions will be a real benefit to our organisation.

"After farming sugar cane for generations, we decided to diversify into macadamias after closely observing the industry for many years. We received a lot of assistance and guidance from the AMS", says Michael.

Michael says he's excited by the great potential and exciting future of the Australian macadamia industry and passionate about playing a part in helping it to continue to move forward.

"I'm really looking forward to being able to represent Central Queensland macadamia growers on the Board and welcome the opportunity to strengthen the AMS's engagement with all growing regions."

Michael believes there is a need for new and improved research into improving productivity, with a focus on regional issues. He says the exceptional marketing program being driven by the AMS is vital for the continued profitability of all Australian growers.

"Providing help and guidance for growers to ensure they can take advantage of the current great prices through higher yields and reduction in production losses is something I strongly advocate.

"There is a need to engage a greater number of young people into the macadamia nut industry and to continue to develop pathways for young people."

The AMS Board welcomes Michael and we know his passion and commitment to the industry will provide great benefits to growers.



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ALAN COATES WINS PRESTIGIOUS NORM GREBER AWARD



You'd be hard pressed finding an Australian macadamia grower or industry representative who hasn't benefited from Alan Coates's encyclopaedic horticultural knowledge over the last 30 years.

"It is most fitting that Alan has been awarded our most prestigious honour, the Norm Greber award, for his outstanding service to the Australian macadamia industry", said AMS Chair Richard Doggett.

A tertiary-trained agricultural scientist, Alan started out teaching subtropical crop production and horticulture at NSW TAFE in the early 1980s, helping to educate thousands of Australian farmers from a broad range of industries.

In the years following, he honed his passion – the macadamia industry – as a farmer, educator, consultant, and collaborator in insect pest biocontrol trials.

Alan has had the greatest and most long-lasting impact on our industry as an 'educator par excellence'. He has been at the forefront of our industry's education program, nurturing the vast majority of new growers who have entered our industry over the last three decades.

"Basically, I'm an educator underneath the other things that I do. That's what I enjoy being able to do, pass on things that I've learned over the years," says Alan.

"I really like that we are a very open industry as far as exchanging information goes."

Alan's courses and workshops have taught growers to understand their soil type, look after their soil and focus on achieving environmentally friendly, sustainable outcomes. His mantra has always remained the same – "Look after the soil and get the basics right". Alan has been passionate about driving the industry towards holistic approaches to pest and disease management, and understanding the orchard as an ecosystem. Indeed, it was Alan who identified the Trichogramma wasp as a parasite of macadamia nut borer eggs. Once the biggest insect problem in our industry, but now a minor issue, due largely to Alan and Richard Llewellyn's hard work, determination and support of the 'MacTrix' release program.

Alan is now one of Australia's most sought-after macadamia consultants, and the results speak for themselves. There are farms he works on that are achieving in excess of 6 t NIS/hectare.

"As a new industry, you have to challenge your views regularly because what we did five years ago might not be the best way to do it now. We are always questioning, which makes for a very healthy industry."

Alan says he was surprised and humbled to receive the award.

"I'm very honoured because there are a number of other people who I have respect for in the industry who have won it previously. The enjoyable part is that it's rare for an industry to work with an indigenous tree crop and be world leaders in that industry. I think that's exciting and attractive for a whole lot of reasons including IPM. Most of our pests are native pests, so it means we have native checks and balances in there if we learn how to manage them.

"To me, it's all about contributing to the industry and increasing our knowledge base."

2019 AMS Awards of Excellence

Congratulations to the following growers who have received AMS Awards of Excellence for their contribution to the industry. We'll have feature stories on them in the next edition!

Grower of the Year
Gary and Julie Davis (Glass House Mountains, QLD)

AMS Young Achiever of the Year
Chris Cook (Mid North Coast, NSW)

Innovation Award
Joint Winners
Gary, Julie & Mitch Davis (GJ&M Nuts)
Jim Philips (JP Water Designs)



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LEONI'S ORCHARD ROUNDS

Leoni Kojetin, Industry Development Manager

For the 22nd year in a row, macadamia have scored a perfect result in the 2018/19 National Residue Survey, the only Australian fresh product with this outstanding record. The NRS program is an operational unit within Department of Agriculture and Water Resources which conducts random testing on macadamia samples, monitoring for a range of chemical residues and environmental contaminants. Our industry's unblemished result is evidence of commendable grower practices as well as processor vigilance. This is only one aspect of sound orchard practice, but one which is pivotal to our marketing program and international premium positioning.

There are many traits that macadamia possess that aid the job of growers, such as the natural protective layers nuts have evolved. Another adaptation which sets the crop apart is its conservative and meticulously regulated water use characteristics. On page 29 you can read further about how sustainable macadamias are in climates with fluctuating conditions. That has certainly been the case in many growing regions over the last two seasons, with persistent dry conditions a concern to many growers. While flowering and nut set has been successful in most orchards, some growers have reported desiccated flowers in hot, dry conditions and higher than average lacebug prevalence. There is also an uncertainty about whether we have adequate soil moisture to underpin nut growth in regions with significantly reduced rainfall. The one benefit to the drier conditions, although with a caveat, is reduced general pest pressure, but also the emergence of opportunistic pests taking advantage of reduced sap flow in trees.

The seasons' conditions were timely for regional Tree Water Management courses which the AMS held in October 2019. Macadamia water use experts Dr Daniel Manson from Australia and Theunis Smit from South Africa educated growers on effective management of water, whether in an irrigated or dryland setting (see articles on pages 23 and 29). Some of their insights and presentations are available on the AMS website, AMS YouTube channel and in a new podcast series recently launched for growers. One key aspect of understanding and managing tree water use is reliable information from effective orchard monitoring tools. Each of these tools measure levels of 'stress' on the crop in different zones (see Figure).

Atmospheric water stress

Macadamia are incredibly sensitive to the environment and the greatest stress on trees is the massive evaporative demand from the environment. Trees respond by closing leaf stomata and consequently limiting daily productive hours. This essential relationship in macadamia has been identified as a prime determinant of orchard performance. Atmospheric stress is obviously the most difficult stress to manage or even manipulate. Trials are underway to assess the long-term potential for overhead irrigated cooling and shade netting, but for most growers simply understanding the interaction between the environment and our crop is essential. In my last column I wrote about a key environmental function – vapour pressure deficit and its impact on macadamia. VPD is a relationship between temperature and humidity and gives us an accurate measure of the atmospheric demand (refer to *Spring Bulletin 2019* for more detail). As a minimum, growers need accurate information on temperature, humidity, wind speed and direction and evapotranspirative demand. Ways that we can monitor atmospheric water stress include:

- on-farm weather stations
- public meteorological data from local weather stations.

Tree water stress

Signs of physical tree water stress are not reliable in macadamia unfortunately. They have evolved regulatory systems which strictly avoid reaching wilting point and this is usually only visible on new soft flush and nursery trees. Once you see these visual signs, it's probably too late and some damage has been done to the tree's hydraulic system. Macadamia researchers have effective tools to measure leaf and stem water potential using psychrometers and pressure chambers. Pressure chambers are an excellent indicator of water stress, but unlike industries such as almonds where growers regularly monitor using this technology, we haven't developed this tool for macadamia yet.

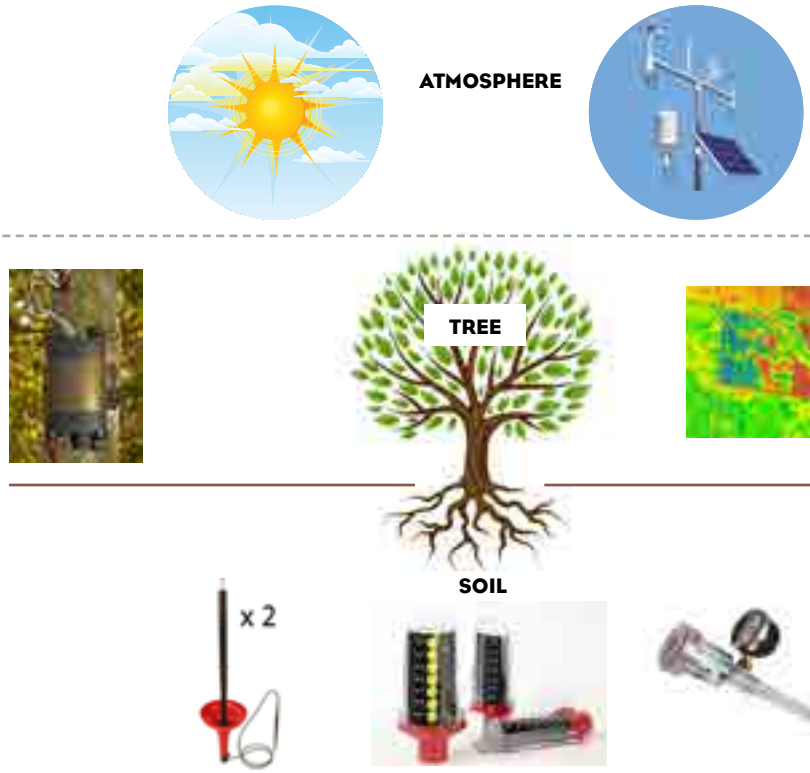


Figure. *Monitoring tools available to growers: weather stations (atmosphere); sap flow meters and crop imaging (tree); and wetting front detectors, GDOTs or traditional tensiometers (soil).*

We currently can monitor tree water stress using:

- sap flow meters
- dendrometers
- crop imaging.

If you are choosing any of these tree water monitoring tools, data analysis by an expert is strongly recommended as the information these tools provide needs to be interpreted.

Soil water stress

Understanding soil moisture is a key aspect to effective crop monitoring and there are a range of grower tools available. Orchard water stress in the soil zone is where growers have the most control and direct management over crop performance. The starting point when using any of these tools is understanding soil types including soil texture and structure which is the lens through which to read any soil measurements. Conducting professional soil classification mapping for all orchards is a great starting point, but in addition nothing beats digging test trenches for a visual assessment. These also serve to visualise crucial root zone distribution patterns and set effective depths for placing monitoring devices. Keep in mind that many of these soil monitoring tools require maintenance and periodic recalibration. Some options, all of which are discussed in the AMS Tree Water Management videos are:

- tensiometers
- capacitance probes
- wetting front detectors.

Following the Tree Water Management courses, the AMS has been able to secure discounted rates for the macadamia industry on a range of soil monitoring tools produced by the CSIRO's Virtual Irrigation Academy. They are simple, affordable and provide essential root zone monitoring. See page 13 for the VIA promotion. Management based on informed monitoring underpins orchard productivity and profitability because we can only manage what we know.

I would like to congratulate the outstanding industry participants who have taken out the annual AMS Awards of Excellence (see article on page 11) and will endeavour to bring you some of their growing success stories in the upcoming Bulletin editions.

I look forward to an exciting year ahead in 2020 and to seeing you at the AusMac 2020 Industry Conference (20–22 October 2020) and our next MacGroups:

Classhouse Mountains – 25 February 2020
Cympie – 26 February 2020
Bundaberg – 27 February 2020
Mid North Coast NSW – 3 March 2020
Coastal Floodplain Nth Rivers NSW – 4 March 2020
Northern Rivers NSW – 5 March 2020

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SOUTH AFRICAN MACADAMIA STUDY TOUR, JULY 2019

Leoni Kojetin, Industry Development Manager



KwaZulu Natal Young orchard established on former cane area

In July 2019, a group of Australian growers led by the Australian Macadamia Society conducted a study tour of the South African macadamia industry visiting the largest growing region in Mpumalanga and the expanding coastal region of Kwa Zulu Natal. The tour group investigated the recent growth in the South African industry and assessed orchard management principles and advancements in horticultural practices, visiting several orchards, nurseries and processing facilities during the week-long tour.

Macadamia industry in South Africa

The South African industry started humbly in the 1960s and has burgeoned over the past few years, overtaking Australia to become the largest producer of macadamias globally. Macadamias are believed to be the fastest growing tree crop in South Africa. The industry estimates more than 5,000 new hectares are being planted annually, in addition to the 36,000 hectares currently planted. These are operated by roughly 700 growers on an average farm size of 45 hectares.

There are threew major growing regions, namely:

1. Mpumalanga, inland from the eastern coast, producing around 55% of South Africa's crop
2. Limpopo, the northern province and original growing region, producing around 25% of the crop
3. Kwa Zulu Natal, the rapidly expanding coastal region planted largely on former sugar cane land, producing around 20% of the crop.

There are two emerging growing regions further to the south in the Eastern and Western Cape.

The industry's average total kernel recovery is 30%, although many of the growers we met, particularly in coastal regions, were achieving kernel recoveries up to the high 40s. Many older orchards with low kernel recovery varieties, such as in the Limpopo area, are lowering the overall figure.

Some of the challenges faced by the South African industry include political uncertainty and the risks that land reform changes pose to long-term farm security. Crime is another impediment, with growers reporting significant crop losses to opportunistic theft as well as organised syndicates. Infrastructure such as razor wire fencing and security patrols add to establishment and operating costs.

The rapid expansion of the industry has outpaced their capacity to build national leadership and resource structures. A statutory levy is in place and has recently been increased to 50 South African cents per kilogram nut-in-shell, of which 20% is allocated to transformation projects that empower black South Africans. The remaining levy funds research projects, some generic marketing and a contribution towards the peak body, SAMAC. The industry admits to significant under expenditure in both R&D and marketing considering the size of the South African crop.

The industry peak body lists more than 20 processors or handlers within South Africa who collectively export 98% of the crop; this compares to 70% exported from Australia. Historically much of the South African crop has been exported as NIS to markets in Asia such as China. Shifts in the Asian market and anticipation of increased Chinese domestic supply has led South Africa to decrease their reliance on the Chinese NIS market. The South African processing sector has proactively invested in increasing their cracking capacity and in 2018, 67% of the crop was exported as kernel to large markets such as the USA, Asia and Europe; compared to roughly 50% kernel and 50% NIS in 2017.

The study group visited several processing facilities which highlighted expanding operations, and increases in kernel processing capacity. We saw advancements in processing automation and new technology, but by and large the processing sector was labour-intensive. South Africa doesn't currently have the ability to process all of the crop coming into production. This sector's expansion has been aided by global collaboration and investment from international processors, including Australia.

Growers have been affected by legislated wage increases of over 15%, with even higher wage increases expected in the near future. There are approximately 20,000 workers on South African farms, nurseries and factories, with an average of around 15 workers per 50 hectares. This compares to Australia's 2.2 workers per 50 hectares for managed farms, and 3.4 workers per 50 hectares for owner-operated farms.

The most prolific variety planted in South Africa is Beaumont, making up more than 60% of the current trees planted, although it is less favoured in the newer orchards due to its lower kernel recovery (32–35%). Beaumont is also the industry's preferred nursery rootstock. Other planting choices are the Hawaiian bred 816, 814 and 788; locally bred Nelmak 2; and the Australian variety A4 is widely planted.

Average spacing for established orchards is 8 x 4 metres, but we encountered a vast range of tree spacing from 6 x 3 metres to a trend on newer orchards to space out to 9 x 4.5 metres. Australian tree density lessons had clearly been learnt by South African growers. With a heavy reliance on manual labour in South Africa, there is concern over maintaining productive canopies in advanced, over-crowded orchards and the further difficulty in removing rows.

There were three clear South African orchard management advantages identified by the study group:

1. Undisturbed, rich root zones

We discovered that very few growers were replacing labour functions with mechanised solutions. This is due to a number of factors; mainly the considerable unemployment in the country, a sense of social responsibility to employ workers as well as the concern of social unrest if labour were to be reduced. Other considerations are orchard layout, with many clearly not suited to mechanisation.

Growers also expressed hesitation to automate because of the potential negative impact machinery would have on their undisturbed root zones. Most orchards are established with tree rows on mounds or 'ridges' formed by excavators or graders. Without the constraints of requiring access or consistency for machinery, the orchard floor is layered with mulched prunings, leaf litter swept from the interrow back under the trees and other organic matter such as husk and composts. This encourages a vast network of feeder roots left undamaged by compaction or displacement that in many cases forms a thick mat – so thick they were difficult to dig into with a shovel!



Most orchards are established with tree rows on mounds or 'ridges'.



The orchard floor is layered with mulched prunings, leaf litter and other organic matter, resulting in a vast network of feeder roots.



Machinery is not an option in rocky orchards.

2. Shortened and efficient harvest

Hand harvesting is standard. Growers continuously test maturity and use Ethephon and the labour force to strip the crop effectively and finish the season timeously. Workers harvest nuts from the trees using long sticks, rakes and pick nuts off the orchard floor. Top performing growers focussed on harvest frequency with

some having as little as 3 days between harvest rounds. Hand harvesting improved nut quality, reduced harvest losses, left root zones undisturbed and, crucially, reset the orchard much earlier, allowing time for other operations before flowering. Our study group believes that the physiological advantage of being able to remove a season's crop and allow earlier phenological reset is a distinct difference.



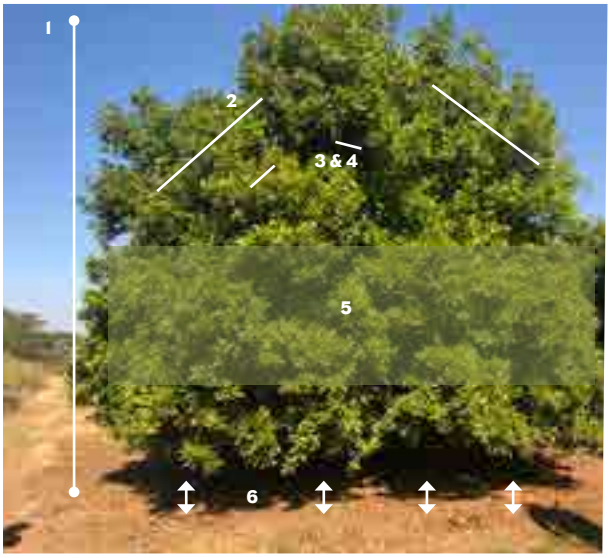
Hand harvesting is the norm in South Africa.

Most farms have a major investment in highly managed on-farm storage facilities with the capacity to both dry down and store between 25% and 50% of their crop. For many growers this is a requirement of their supply agreement to processors and penalties are in place for delivered crop moisture and high reject levels. Clearly the expectations on the growers is much higher, and they have a key role in nut handling.

3. Robust pruning and canopy complexity

Much effort goes in to controlling tree height and maintaining the ratio of maximum 80% tree height to row width. The general pruning regime is performed by trained labour teams and starts with 'cutting windows', or 'removing shoulders', to allow light into the canopy. This encourages the vast complexity of lower growth and fruiting wood further down the canopy and a productive tree centre. Then in subsequent prunings, limbs are selectively removed. Regrowth on pruned limbs is actively managed by either painting the stump with plant growth regulator, or hand-removing the regrowth a few weeks after pruning.

Skirts are left very low to conserve moisture and keep the crop within reach. There is a strong focus on maintaining optimal height for spray efficiency, open canopies for light interception and, crucially, complex productive canopy low to the ground. All prunings are chipped and incorporated into the orchard floor. Hand pruning, even though extremely labour intensive, is favoured because well-trained pruning staff can manage canopies with a precision and deftness far superior than current machinery.



The pruning regime in South Africa. 1. Tree height controlled, 2. 'Shoulders' cut out, 3. Selective limb removal, 4. Selective limb maintenance, 5. Goal: Complexity & constant renewal of lower fruiting wood, 6. Low skirts.

Other horticultural benefits

Intensive irrigation and nutrition

All growers use a nutrition program formulated by an independent consultant based on annual soil and leaf tests carried out in November. Requirements are based on a crop replacement model and tailored to specific soil types. Many growers have gone to great lengths to map and understand soil types, managing blocks differently. As 85% of the current industry is irrigated and all new plantings are irrigated, most growers use fertigation and some broadcast fertilising which is irrigated to ensure precise application and plant availability. Fertilising regimes are smaller and more often.

Effective irrigation is a critical part of productivity in South Africa. After years of drought, growers have an intimate knowledge of their orchard water budget. Availability of water supply is a significant concern and a major factor limiting new development.

Expansion of the industry has dictated a rationalisation in overall water use, yet many growers report increased productivity with diminished irrigation volumes. Irrigation scheduling follows close orchard monitoring. A trend in irrigation towards lower volume delivery systems was evident, though not adopted by all in the industry. The study tour noted significant investments by a number of growers to increase the sophistication of their irrigation and fertigation systems.

Collective crop monitoring

Close orchard monitoring, including pest scouting, is essential due to high pest pressure. In contrast

to the Australian system, growers train farm staff in pest identification and undertake monitoring activities themselves. They use a range of tools including an industry-wide drop sheet protocol and pre-determined thresholds to inform crop protection applications. Growers also take part in area-wide groups on platforms such as "whats app", keeping in constant communication about local pest movements.

Application technology was fairly standard, but much higher water volume rates were preferred, using 3,000–6,000 L/ha for the five to seven spray events per season. Some growers are concerned with potential resistance from over-use of a specific mode of action as well as secondary pest flare-ups.

Nurseries techniques and expansion

Nursery visits highlighted the rapid expansion in the country, but more widely into Africa with many African trees grown in South Africa. Beaumont is the main rootstock variety and some also grow on Nelmak 2. The quantities of trees demanded faster nursery turn-around times and propagation techniques include traditional grafted seedlings, micro-grafting and many rooted cuttings. Cuttings are favoured by many growers and they do not consider these trees inferior to grafted seedlings.

Commercial nurseries have large infrastructure and various climate-control areas designed for micro-grafting and cuttings. Potting volumes are generally smaller and air pruning techniques are used to facilitate healthy root structure.

The study tour expected to see stricter nursery standards in place following the stringent Seedling Growers Association of South Africa guidelines SAMAC has adopted, but this was not the case in all situations. Nursery tree demand, similar to the demand in Australia, has clearly seen adherence to standards waning, but on a whole nurserymen were highly professional and innovative.

Market related payment system

The system by which growers are paid for their crop is unique and based on style spread. Ultimately as in Australia, higher total kernel recovery and lower unsound levels drive consignment prices, but with some differences. Remembering that much of the drying takes place on farm, a continuous bulk sample of 2.5% of the consignment weight is taken on each delivery. This sample is used to determine moisture content and kernel recovery. Unsound kernel is then assessed and the remaining sound kernel is categorised into wholes, halves, pieces and discoloured (or darks) according to style spread.



Propagation methods included cuttings and micro-grafts.

Growers get paid more for whole kernel, than halves, and the least for discoloured kernel.

The South African payment system is arguably more market-related and based on quality. When converting the price growers were receiving for their crop and taking into account the added complexity of the US dollar conversion they have to go through, it was on par with the price Australian growers receive.

Innovation and professionalism

On the whole, the study tour found the growers to be professional and have excellent agricultural skills, with many generational growers. Having the labour force helps the average grower to fulfil a greater management and strategic role on farm and the use of consultants was standard. Innovative practices, such as where mounds have been covered with weed matting to conserve moisture and limit weeding, were developed out of necessity and lack of resources. In a farming system constrained by finances, resourcefulness prevailed. The expansion in South Africa is set to continue and we believe they will retain their place as the largest global macadamia producer for some years to come.

A video of the tour will be available on the AMS website – look out for the link in upcoming *ENews*.



New orchard with mounds covered by weed matting, Mpumalanga.

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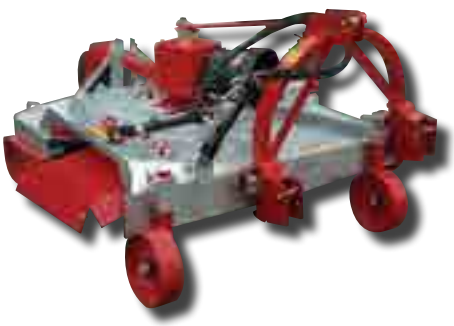
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TREE WATER MANAGEMENT SPECIAL FEATURE

The AMS's two-day Tree Water Management Courses were held in Gympie, Bundaberg, Yamba and Northern Rivers in October 2019. Senior scientist and tree physiologist Dr Dan Manson, and horticulturist Theunis Smit led the courses which examined the essential role of water management in irrigated and dryland orchards.

Dan's article below provides a summary of the major findings from macadamia tree physiology research in South East Queensland and provides us with a basic understanding of plant physiology and the tools available to growers to monitor and manage tree water use for optimum productivity.

In his article on page 29, Theunis explains how macadamia trees react to different environmental conditions. By understanding the trees' physiological responses, your soils and environment conditions, growers can make informed decisions regarding water management.

Videos and PowerPoint presentations of the course are also available on the AMS website and YouTube channel.

SAP FLOW DATA IMPROVES IRRIGATION EFFICIENCIES

Dr Dan Manson, Tree Physiologist

Sap flow data has shown that macadamia trees are generally using much less water than we previously had estimated using conventional methods. Water use also varies across the seasons and across different varieties. These findings have important implications for irrigation scheduling and water management in macadamia orchards.

The research now being conducting in the Queensland macadamia orchards represents a new approach to irrigation management which begins with an understanding of plant physiology and measuring the water moving through tree stems in the orchard. Sap flow meters are used to measure daily water use patterns and stem psychrometers measure water stress of trees. The data gained allows us to irrigate trees at the right time of day, and at the right volumes to minimise stress and so maximise productivity.

Understanding water stress in plants

Understanding transpiration

It's important to understand the atmospheric demand on the plant, and consequently the way water moves through a plant, as well as the hormonal signals that are triggered by moisture stress in the soil profile.

Being a species from the rainforest margins, macadamia can be incredibly sensitive to changes in atmospheric conditions and have evolved hydraulic limiting mechanisms in response to the significant environmental demand the atmosphere places upon it. Research has shown the close link between macadamia growth, transpiration and production in relation to atmospheric water demand. Of particular importance is the combined effect of temperature and humidity, encompassed by vapour pressure deficit (VPD). VPD refers to the difference in water vapour in the atmosphere as opposed to how much it could potentially hold if it were saturated (100% humidity). VPD explains the atmospheric driving force behind transpiration and is commonly expressed in kPa.

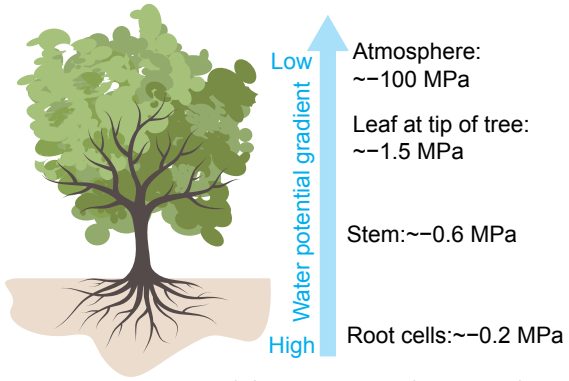
One can visualise that a plant is made from a bundle of narrow tubes (or straws) running from the roots to the leaves. These straws are being acted upon by the atmosphere, drawing water through the tree. The root end of the tube is open to allow water to enter, but at the top of each tube there is a shut-off valve on the underside of leaves called a stoma. Stomata tend to be open during the day and closed at night. The stomata control their aperture during the day in response to atmospheric conditions to regulate a constant and sustainable rate of water loss. The stomata play a critical role in protecting the tree from potential hydraulic damage to internal structures during extreme atmospheric conditions or during times of limited soil moisture availability.

Stomata can be highly sensitive to hormonal signals (abscisic acid) from the roots warning that there isn't enough water in the soil to supply the water lost to the atmosphere.

Water moves through the environment and plants across gradients from regions of high pressure to regions of low pressure (see diagam over page), this

movement of water through leaf stomata is referred to as transpiration. As water is lost from the leaf, an essential exchange is made whereby the plant receives carbon dioxide, essential for photosynthesis. With water being pulled up through the stems and leaves, the roots extract moisture and dry the surrounding soil, this establishes moisture gradients in the soil which can draw large amounts of water from the entire soil profile toward the tree roots where it is pulled across the soil-root boundary through water pressure differences. Water is essentially sucked up from the soil to the atmosphere through the canopy of the plant.

The stomatal aperture is regulated as the guard cells around them shrink and swell in response to water supply (turgor), light intensity and hormonal signalling. Opening in response to daylight allows them to process carbon dioxide and water into carbohydrates, synthesising light energy to sugars, hence the name photosynthesis.



Negative water potential draws water into the root and transpiration draws water from the leaf.

The transporting vessels or tubes through which water moves from the roots to the stems and leaves are the **xylem** which is the internal part of the stem. The inner part of larger trees is made up of non-functional xylem, called heartwood, which does not transfer water.

Sugar is transported from one part of the tree to another in the **phloem,** conductive tissue in the outside of the stem just under the bark and these vessels can transport both up and down.

Hormonal signals and water stress

The xylem can also communicate hormonal and chemical signals from the roots to the leaves whilst the phloem is the most common vessel for communication from the leaves to the roots, completing a two-way communication stream. The abscisic acid signalling from the roots to the leaves can regulate stomatal aperture in response to soil moisture stress and so can regulate how much water the tree uses depending on how much water is available in the soil profile.

In macadamia, during different phenological cycles, especially those with an active sink such as nut growth and vegetative flushes, sugars are transferred to these newly growing parts of the tree. At other times of the year when the tree is dormant and isn't carrying nuts, these sugars are transferred to the storage organs, the branches, stem and roots.

Initial research has indicated varietal differences in stomatal responses to the hormonal signals coming from the H2 rootstock can explain some of the vigour differences observed between the commonly planted grafted macadamia varieties. The varied sensitivity of the scion to hormonal signals from the rootstock can also go toward explaining the reports of improved performance of some varieties on a hybrid rootstock (Beaumont) when compared to the *M. integrifolia* H2 rootstock.

Water stress usually refers to any deficit in the soil water that limits plant growth. However, plants can also be stressed as a result of atmospheric water deficits (or atmospheric droughts caused by low vapour pressure deficit) or physiological reasons (e.g. salt water). When soil moisture and atmospheric moisture stress events occur at the same time, the compounding effect can have a significant impact on productivity if this occurs during critical phenological periods, the most obvious effect being premature nut drop.

Using sap flow meters to measure water use

One of the key tools we've been using over the last few seasons to measure water use and stress in macadamia is the sap flow meter. These tools measure the amount of water that trees use and exactly when they are using that water. Alec Downey from University of Western Australia, who has pioneered sap flow instrumentation and the introduction of sap flow monitoring in macadamias, has demonstrated in trials at Gympie that smaller volumes of irrigation delivered more frequently at times of need as determined by the sap flow data is the key to reducing water use and maximising macadamia productivity.

The sap flow meter design consists of three needles that get installed into the stem of the tree, using a pulse of heat to determine the velocity of the water moving through the stem, measured very accurately in 10-minute intervals.

We can extrapolate this information over the entire tree on a single day to carefully calculate how much water the tree is using throughout the growing cycle.

Trees using less water than we thought

Sap flow data indicates that trees are using considerably less water than we previously estimated through conventional evapotranspiration models using

a crop factor. This has important implications regarding the amount of irrigation needed to sustain a healthy and productive orchard.

There is some variability in the different varieties and how much they may use on any given day in winter or summer. Results based on averages across mature nut-bearing trees (i.e. > 10 years old) on an 8 x 4 m spacing indicate a range of 30–40 litres of water used per day in winter and 60–70 litres of water used per day during peak water usage times and in the middle of summer.



Overwatering trees can seem like a simple insurance policy and cause no obvious harm, especially if water is available. Overwatering though can lead to a number of problems such as increased disease susceptibility especially to *Phytophthora*, leaching essential and expensive nutrients, creating anoxic conditions and trees with reduced vigour.

Sap flow meters are able to identify the early onset of even small amounts of stress in the orchard on a real-time basis (Figure 1). They can tell us how the plant's water requirements change in response to changes in the atmosphere and soil profile. When we observe a change in the water use rates following an irrigation event, it is indicative of a tree's release from water stress. Measuring day and night time water use also reveals that this can be a cumulative stress from day to day.

We've shown that you can significantly reduce tree stress just by changing the irrigation scheduling.

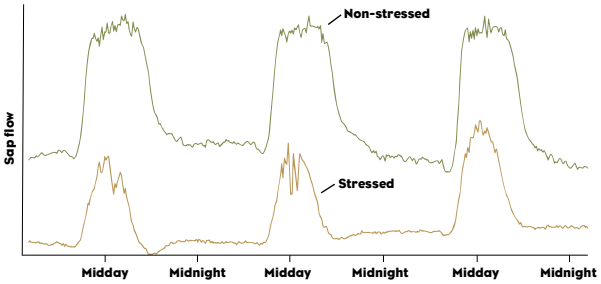


Figure 1. *A comparison of two different trees' day and night sap flow over 3 days. It highlights the significant reduction in productive daytime potential between the non-stressed and stressed tree. Stomatal restriction in response to mild atmospheric conditions driven by significant soil moisture drought stress dramatically reduces transpiration and consequently productivity losses occur.*

Small amounts of water applied frequently are key to productivity

Some of the on-farm trials we have been conducting in Bundaberg over the last 12 months have looked at changing irrigation scheduling based on the data we are receiving from the sap flow meters.

The trials have looked at increasing irrigation from once or twice a week, to watering more frequently, and the results have been dramatic.

We've found that applying large amounts of water (300–500 L/tree) once or twice a week is much less effective at reducing cumulative tree stress compared to applying smaller, more frequent (often daily) applications of water amounting to an average of 70–80 L/tree/day. Irrigation application rates and frequency are also soil type dependent and orchard infiltration rates need to be considered.

Ideally you should be giving your trees small amounts of water frequently, pre-dawn for maximum efficiency and consequently maximising production.

(continued over)



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Orchards on sandy soils are most likely to benefit from daily irrigation events, ensuring applied water remains available in the soil profile to tree roots. On heavier clay loam soils that are prone to over-saturation, much smaller irrigation volumes applied frequently ensure adequate water is available to tree roots without the effects of waterlogging. Maintaining plant available soil moisture is paramount to reducing cumulative stress in the trees, particularly in high atmospheric demand situations and can mean the difference between producing a crop or not.

Key times to water

Not surprisingly, sap flow data has shown that the amount of water macadamia trees use varies throughout the phenological cycle too (Figure 2). We have found that there are specific times through the year when water stress can lead to critical reductions in productivity. Balanced, supplementary irrigation is essential throughout the year, but there are certain phenological times to prioritise.

These events may come at any time during the year, but it's important to remember that when a tree suffers from severe drought, the impacts caused by the damage can last years if it results in physical internal damage. So if you need to rationalise water use, the most efficient time to apply what you have is when your tree is under the most severe water stress.

Continuous monitoring of plant water use with sap flow meters provides the empirical thresholds to match the plant's water use requirements with irrigation. Sap flow data identifies and quantifies these most severe water stress periods and enables the right volume of water to be applied at the right time to minimise long-term damage to the tree and maximise plant productivity.

Second to those severe drought events, the other key phenological times when water stress should be avoided is around flowering and early nut set, and then again during nut growth. This is the same as the finding by Downey 1994 in wine grapes. Suffering stress at these critical times would result in yield loss. This is not a case for doubling irrigation volumes in those critical cycles, but rather focusing far closer on orchard water use and stress monitoring in these times.

The right tools for the job

The basic requirement for precision irrigation is using appropriate monitoring tools, whether it's soil moisture or plant-based monitoring such as sap flow meters. These tools will give you invaluable information on how to increase the efficiency of water use in your orchard by managing soil profiles, application times, frequencies, volumes and avoiding overwatering.

Soil moisture monitoring is your primary monitoring tool to ensure you are watering to an appropriate depth and keeping moisture in the root zone (based on your soil and subsoil type). Once you become expert at monitoring your orchard's soil, you can take it to the next level and start monitoring your plant. There is a new range of plant physiological monitoring tools, including sap flow meters, which you can install on-farm, many of which allow you to stream real-time data to your smart phone. But as a first stop we should all be monitoring our soil to see if water is getting to an adequate depth on a frequent basis.

The key to effective irrigation management is understanding the interaction between the plant and its environment, with a goal of maintaining a constant balance within the soil, tree and atmosphere continuum.

Information
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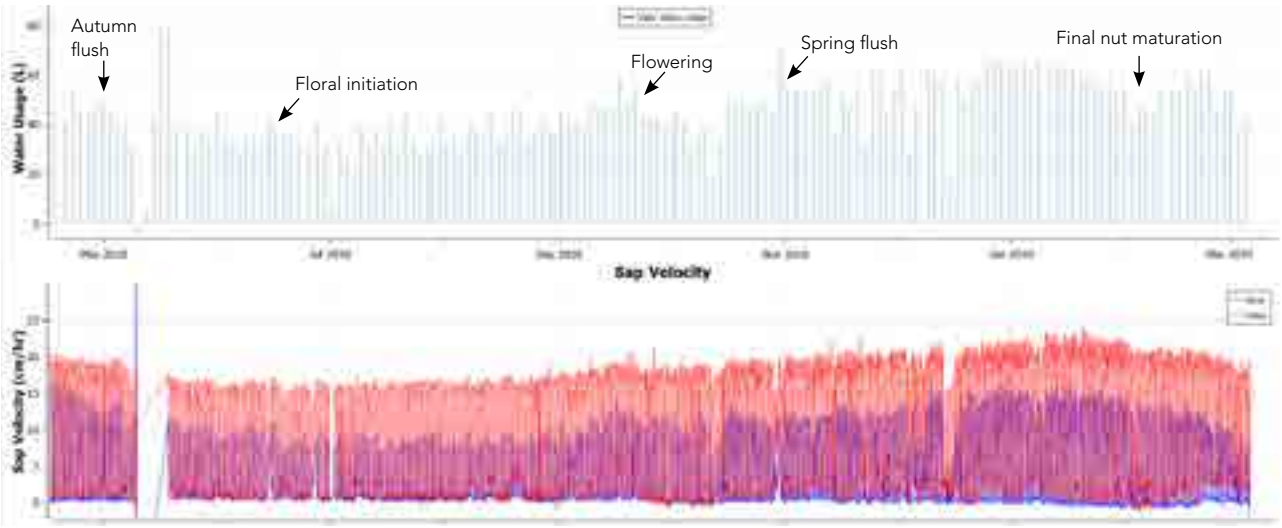


Figure 2. *Macadamia daily water usage (top) and sap velocity over the phenological cycle.*

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MACADAMIA: THE SUSTAINABLE WATER USER

Theunis Smit, Horticulturist, Darwin Hort

With its sclerophyllous and hypostomatous leaves (i.e. stomata only on the underside), it is no surprise that macadamias have earned the title of being a conservative water user. Previously published research has further aided us in classifying macadamias as being an 'isohydric' crop.

What does isohydric mean? In rather simplistic terms, it implies that macadamias can meticulously control the loss of water from their leaves (transpiration), especially under conditions of high evaporative demand.

To put this in perspective, imagine a hot and dry summer's day. The environment demands a substantial amount of water throughout the hot and dry day, and this demand can be quantified by the calculation of potential evapotranspiration (ETo). Most crops try to supply the amount of water demanded by the atmosphere through transpiration, and one would therefore assume that a linear relationship exists between supply and demand (i.e. transpiration will increase as potential evapotranspiration, ETo, increases), given that the crop has sufficient access to water. This is, however, not the case in macadamias. Retrospective analysis of macadamia transpiration studies has shown that the relationship between supply and demand is rather non-linear in nature (see Figure 1) which would suggest that the trees have a large degree of control over transpiration.

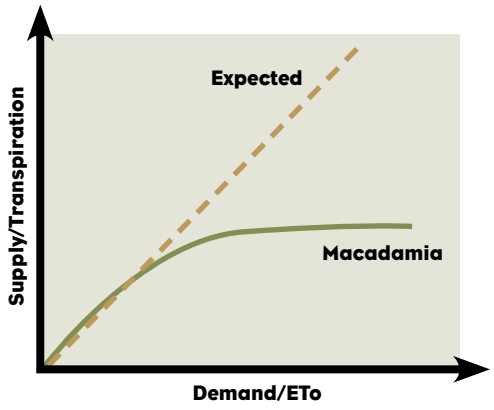


Figure 1. *Crop supply and environmental demand function of water in agricultural systems. Macadamias deviate from the expected linear relationship between supply and demand as they control transpiration meticulously.*

Why would macadamias control transpiration?

In most tree crops, and especially evergreen trees such as macadamias, this strict control of transpiration is often linked to an underlying hydraulic limitation. In other words, the pipes supplying water to the atmosphere are not capable of transporting the volumes of water required at the rate which is required. Trees would therefore make use of 'control valves', more commonly known as stomata, to ensure that hydraulic integrity is maintained within the tree stem and water conducting tissues. Failure to control transpiration would lead to embolism (or collapse) of water conducting tissues, which if occurring frequently, could lead to complete loss of water conducting tissues and ultimately tree death.

How does this influence the way we manage water?

Reimagine standing in the orchard on a hot and dry summer's day (i.e. during a time of high water demand). The trees are in full flower, and your first thought is to start the irrigation system, that is if you have one. The irrigation system is running, water everywhere, yet the flowers and new flushes are still wilting, and we are perplexed.

Considering that macadamias are only able to supply a maximum amount of water through transpiration during high demand periods, applying additional water would have almost no effect. Wilting flowers and flushes are therefore, more often than not, poor indicators of soil water stress in macadamia, but are excellent indicators of environmental or atmospheric water stress.

During periods of atmospheric water stress or high water demand, increased water application rates would lead to no increase in yield or quality, but would lead to significant decreases in nutrient and water use efficiency.

Now, imagine that we have a cool and partially cloudy day with a slight breeze and a hint of humidity. Will macadamia trees use more or less water than compared to a hot and dry day? Instinctively, we would say trees would use less water, however, given that the supply is able to keep up with the demand during these conditions, trees might use the same amount or more water compared to high demand days.

Water management during these days is therefore rather critical, as a shortage in soil water during these moderate days will lead to a supply limitation and as a result the stomata will close to prevent desiccation of plant tissues. We should therefore note that a thorough understanding of the crop, soil and environment is needed if one is to make informed decisions regarding water management.

Are macadamias the crop for a drier and climatically variable future?

Even though it is impossible to accurately project what the climatic future of the world is, one of the well-known facts is that freshwater will become increasingly scarce, especially in semi-arid subtropical regions. It is in these drier than normal areas where the distinct control of transpiration by macadamias will become increasingly advantageous.

Given that macadamia growers employ sustainable farming practices which limit soil evaporation (i.e. mulching) and carefully manage soil water through irrigation scheduling within the root zone of the trees, macadamias could be some of the most sustainable crops in the world agricultural sector. As research continues, and we learn more about this exciting crop, we will be able to exploit the abilities of macadamias to manage their water loss to better suit a range of production environments.

Information
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cheers

a toast to the 2019 season



Our sincere thanks to all suppliers for your support throughout the 2019 season; your contribution has made a real difference and added value for all shareholders.

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We wish you a very Merry Christmas and a Happy New Year.

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SOIL HEALTH IS THE KEY TO ORCHARD HEALTH

Alan Coates, Coates Horticulture

Alan Coates explains how to improve the health of your orchard soils. His take home message: get the basics right.

Macadamias originate from the margins of rainforests between Maryborough and Lismore in soil environments that are generally high in organic matter with a mulch layer that protects a shallow, fibrous root system. This provides a healthy soil environment to support tree growth with no added fertilisers, pesticides, herbicides, machinery impacts and an ecosystem buffered against environmental extremes.

In order to maximise nut production in an orchard situation we apply chemical fertilisers, insecticides, fungicides, herbicides and irrigation in conjunction with many machinery passes per season to a soil environment and root system that evolved in a buffered forest floor. Orchards are often established on soils that are low in organic matter, have poor nutrient levels and pH, are compacted with poor soil structure and often have shallow topsoils with poorly drained subsoils. In other words, the soil health is poor!

Soils are a living dynamic ecology

Soil health in agricultural ecosystems is indicated by a living dynamic ecology that provides the needs for healthy plants. The components of this system are:

- adequate air–water balance
- micro- and macro-organism activity
- appropriate nutrient availability.

Management of this complex ecosystem involves management of:

- soil physical properties – structure for air–water balance
- soil biology – organisms and organic matter for micro- and macro-organism activity
- soil chemical properties – pH and minerals to provide appropriate nutrient availability.

The interaction of the soil's physical, biological and chemical aspects needs to provide a suitable environment for tree root growth and health in order to have sustainable macadamia production.

The consequences of poor soil health are:

- lower production and higher costs of production
- poorer tree health and increased tree stress, particularly with environmental extremes
- increased disease pressure, especially phytophthora
- poor soil hydrology
- increased soil degradation
- increased erosion
- increased environmental problems.

Improve soil health

Assess and monitor soil health

This can be achieved by using the **Macadamia Soil Health Card** which can be downloaded from the Soilcare website (visit www.soilcare.org). We look at the above-ground parts of our orchards, but rarely look at or below the ground surface. The Soil Health Card is a series of simple tests that enable us to look at and identify issues with soil health.

Identify, prioritise and manage risks to soil health

These risks are often the fundamentals of good soil management, such as compaction, erosion, poor water infiltration and drainage, poor root density, poor biology as indicated by low earthworm numbers and little biodiversity.

Maximise groundcover, control water flow and minimise erosion

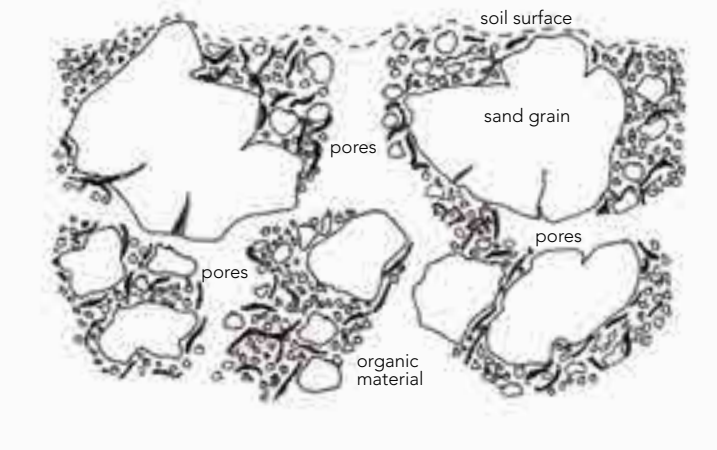
Topsoil is the most fertile productive part of our soil and must be protected. Uncontrolled water flow is the major cause of soil loss in orchards, even on mounded rows on level ground. Changing climate patterns and intense rainfall events require better soil protection and management of water flow. An appropriately designed water management system is essential, particularly if there are any slopes.

Increase and manage organic matter which is the key to managing soil health

Organic matter levels in most orchards are significantly below levels that are optimal for soil health. Organic matter is crucial to support soil biology, has huge impacts on soil hydrology, is the key to improving soil structure and has major implications for soil-borne diseases and soil nutrition. Input and management of organic matter is ongoing in macadamia orchards, becoming more critical as orchards age.

Manage soil structure

As orchards age, soil structure comes under intense pressure due to erosion, machinery operation and particularly harvesting, some of which is carried out in wet conditions. Compaction is a major issue in most older orchards and has a huge impact on root density and tree performance. Managing compaction is about maintaining pore space between soil aggregates to allow for air and water movement, root penetration and a suitable habitat for soil organisms (see figure). Mechanical intervention with aerators and agroploughs in conjunction with organic matter inputs and groundcovers is critical for management of soil structure.



Soils are made up of soil particles (like sand as in this example, or loam or clay), organic matter, micro- and macro-organisms, and pores. The pore spaces are vitally important for allowing water (with nutrients) and air to reach plant roots, and for good root penetration.

Improve soil and tree nutrition

Nutrition should be about feeding the soil which in turn feeds the tree. Good nutrition involves addressing organic matter, pH, cation levels and balance, phosphorus, trace elements and nitrogen inputs to the soil system. Feeding the soil also involves feeding the soil biology with appropriate carbon sources and suitable minerals. Macadamias are a perennial tree crop that requires a long-term nutrition management strategy.

Promote beneficial soil organisms

We do this by providing a soil environment that is supportive to them with adequate food (organic matter), moisture, somewhere to live (good soil structure) and protection (groundcover). Minimise practices detrimental to soil organisms such as salty acidic fertilisers, excessive pesticide and herbicide use, compaction and removal of groundcover. Provide a suitable environment and they will come! Earthworms in orchards are a really good example of this. Minimal benefit is gained if organisms are added to an inhospitable environment. Effective functioning soil biology is crucial to good soil health.

Increase biodiversity

The greater the above-ground biodiversity the greater the below-ground biodiversity and the more balanced and buffered the soil system is against events such as waterlogging, disease outbreak and nutrient leaching.

Improve organic matter levels

There are various ways growers can improve organic matter levels in their orchards, including:

- add compost, mulch, nut husk and/or animal manures
- establish and manage groundcovers
- maintain healthy trees that drop leaves, produce root exudates and mulch or chip prunings under trees
- reduce or change herbicide practices
- reduce mowed area and the number of mowing passes per season, particularly when outside harvest season – a manicured orchard floor is not necessarily best practice
- increase lignin (woody material) input
- manage nitrogen inputs to minimise carbon loss
- minimise erosion.

Functioning soil biology is critical to soil health as soil organisms perform a range of tasks that support root and tree health. Some of the important tasks they perform include retention of nutrients so they don't leach or volatilise, cycling nutrients in root zone area, building soil structure, suppressing disease, protecting plant surfaces, producing plant growth-promoting substances and decomposing toxic compounds. These are free services in a healthy soil.

Key message: get the basics rights

Most macadamia orchards have some soil health issues due mainly to limitations in the basics critical to soil health: soil structure, soil biology and mineral balance.

Managing a macadamia orchard to optimise soil health needs to start before trees are planted and during young orchard development, rather than when we run into production and tree health issues in older orchards which are usually a result of poor soil health.

By understanding your soils (e.g. structure, texture, compaction, organic matter and nutrient levels) you can start to implement good management strategies to promote and maintain healthy soils in your orchards.

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WHAT TO LOOK FOR IN A QUALITY COMPOST

Keiran King, Rocky Point

We all know how important compost is to orchard health, and in this article Keiran King explains what growers should look for when buying compost.

The hum of machinery is a familiar early morning sound as the sun rises over the compost production site of Rocky Point between Brisbane and the Gold Coast. These sounds signal another busy day blending and manufacturing products, but beyond the normal morning work activity there is an army of silent workers; billions of tiny microbes, fungi and beneficial bacteria going about their business in complete silence. They are busy breaking down organic material and turning it into rich dark compost.

To produce a high standard compost takes time, some know-how, a constant supply of raw ingredients and some patience. Further to these essential elements, composting on a commercial scale requires significant investment in plant and equipment, is labour intensive, occupies a large area and requires stringent environmental controls and approvals.

Australian standards should be used as the starting point of quality, and this is the minimum requirement used by reputable suppliers.

During the year as I am talking to growers, before harvest even finishes, they are already looking ahead to managing their orchard floor and improving soil health. One of the vital steps in many orchards is the application of compost. Growers are essentially working on the long-term health of their soil and their orchard by applying compost each season. Growers see many benefits from applying compost, including:

- improving soil organic matter
- increasing soil carbon
- increasing soil microbial activity
- suppressing disease
- protecting against erosion
- improving tree health
- increasing yield.

To get the maximum results year on year it is important to source a good quality compost. But how do you know you are getting a quality product? What should you look for and what should you be asking of the supplier? Here are some of the basics.

How to identify a good quality compost

Good compost will be easily recognisable and will have the following characteristics:

- **Smell** – an earthy smell, with no bad (sour, rotten or ammonia-like) smells
- **Texture** – moist and earthy, not wet and sloppy or dry and powdery; and easy to mechanically spread
- **Appearance** – dark soil-like particles, in which original organic materials are not distinguishable.

As well as what the product should look, feel and smell like it is important to do some homework prior to purchase. Make sure you know your compost.

Raw ingredients

If you want to finish with a quality product it is important that the supply of material is consistent in its makeup.

- You should know what feedstock is used to produce the compost.
- You should know if manures are used in the blend you are buying.

The composting process

Make sure you are receiving a fully composted and pasteurised product. Properly composted material will exclude weeds, pathogens, potential disease-carrying organisms and physical contaminants. It is important to do some homework prior to purchase, and you can start by asking your supplier the following questions:

- How long has the product been composted for?
- What temperatures were reached during the composting process? Has the product being pasteurised?
- Were any liquid wastes used in the compost manufacture? If so, what were they?
- If manures were used, at what point in the composting process were they added?

The correct manufacture of compost is particularly important to those growers and suppliers who have Freshcare Standards or HACCP requirements.



Supporting documentation

In addition to knowing the composting process and the makeup of the compost, the supplier should also be able to provide you with documentation to back up their claims. Some examples of this can include:

- An independent analysis for the product from a reputable laboratory. The product should as a minimum be tested to Australian Standard *AS4454 Composts, soil conditioners and mulches.*
- An organic product certification. This is vital if anyone is considering growing organically and will also give any grower the assurance that only quality ingredients are being used.

Finally, by taking some of the guesswork out when using compost it becomes much easier to manage other inputs and simply becomes another tool you can use to manage your crop and tree health.

Information
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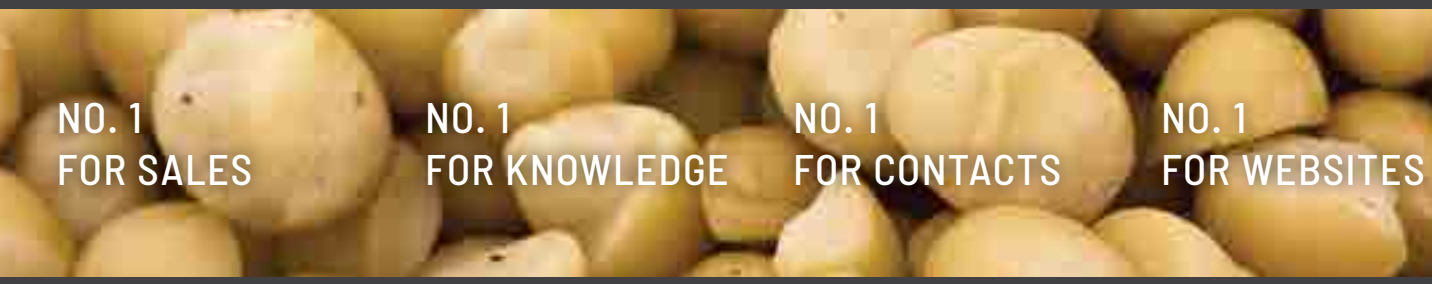
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WE ARE WHAT WE EAT ... OR DRINK

Ray Norris, Stahmann Farms

We asked industry specialist, Ray Norris, about the key factors to achieving orchard health.

"We are what we eat" is a term that most of us have heard before; and I am thinking our orchard health is not much different. "We are what we eat" being all of the different aspects of orchard growth and development. The way I look at it, water-holding capacity and nutrient-holding capacity are the major issues for an organism whose 'eating' is actually 'drinking'.

It has been said, by many experienced macadamia growers, that it is easy to grow macadamia until the orchard starts to age. Not unlike ourselves, the health of a mature orchard is significantly influenced by the way it was looked after in its youth. This is something that we all need to remember as our new orchards chew holes in our pockets before coming into production, and we wonder where we can save a few dollars.

Given the above it is probably no real surprise that my discussion around orchard health would probably focus on how we are feeding our trees. My experience in the Bundaberg region has been on fragile, shallow soils, which are often referred to as 'Sunday soils' – too wet on Saturday and too dry on Monday. They are generally soils with low organic carbon, <1 usually, and are generally very variable within a paddock, or even a row. They have very little structure and often have low infiltration rates. All of these factors have led to a number of issues that, in our mature orchards, we struggle to keep on top of. (The signs of a misspent youth?)

So for me, in Bundaberg, a healthy orchard has two aspects: good design and healthy soil.

Good design

The sole purpose of a good design allows for efficient and effective management of the orchard.

This will include the following aspects:

- soil and variety matching
- efficient and effective irrigation
- orchard layout that allows for the ease and efficiency of regular, (and just as importantly) timely, input applications
- a design that minimises the negative impact that the orchard can have on the environment (erosion, quality of water runoff, chemical drift etc.)
- consideration for the long-term canopy management of the 20-year-old trees.

With the above in place, the second aspect becomes more manageable.

Healthy soil

Without healthy soils, healthy plants are difficult to maintain, and healthy plants will be the basis of a healthy and productive orchard. Healthy soils will have a few key components:

- good physical characteristics
- microbial activity
- balanced nutrition
- good water- and nutrient-holding capacity.

Water availability totally controls the growth of our trees, the stress they are under, and our production potential. Because trees are 'drinking' rather than 'eating', soils with a good water-holding capacity are essential. Improved water-holding capacity comes from high inputs of organic matter, the microbes to stabilise it in the soil, the balanced nutrition to feed the system, and the irrigation to create the environment for the root structure to thrive.

A healthy root system in a healthy soil are key to maintaining a healthy orchard.

Ray Norris, Stahmann Farms
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BENCHMARKING IDENTIFIES THE INDUSTRY'S TOP PERFORMING ORCHARDS

Grant Bignell and Shane Mulo, Queensland Department of Agriculture and Fisheries

The benchmark project has been looking at farms that consistently achieve high yields over multiple seasons to try to identify common approaches that may lead to sustained high productivity.

What makes a 'top performing' farm?

Within the benchmark sample, 'top performing' farms are those that consistently fall within the top 25% over a minimum of four seasons, including the current season. Average long-term productivity is measured as saleable kernel per bearing hectare.

Top performing farms were located in all major production regions and were proportionate to the number of benchmarking participants in each region. Top performing farms averaged more than half a tonne of saleable kernel per hectare more than other farms (1.32 compared with 0.77) as shown in Figure 1.

Top performing farms spend more on crop protection and nutrition

When looking at the data on costs of production and total costs per hectare, on average the top performing farms spent 24% more per hectare than all other farms that supplied data. Top performing farms spent 30% more on both crop protection and crop nutrition than other farms. Even though their overall costs per hectare were greater than other farms, the increased yields of top performers meant that the cost per tonne of saleable kernel was 30% lower than other farms in the sample.

Comparing revenue

We compared the revenue (based on $5.80/kg NIS) of top performing farms with other farms. Top performing farms producing an average 3.9 tonne per hectare had a revenue of more than $22,500 per hectare (Figure 2).

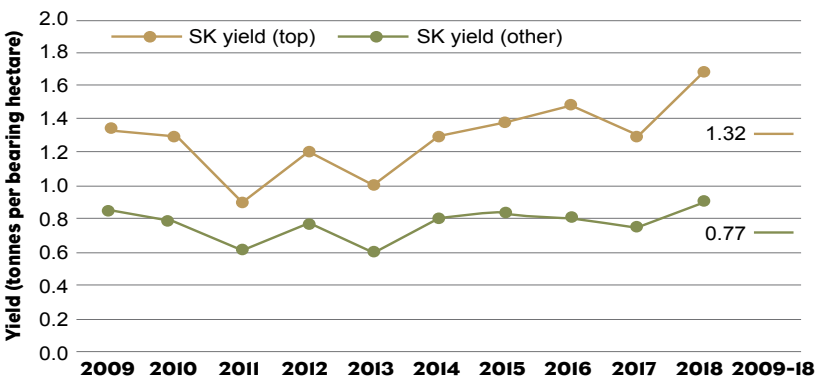


Figure 1. *Saleable kernel yield for top performing farms versus other mature farms in the benchmark sample (2009–2018).*

Other farms averaging 2.5 tonne per hectare achieved a revenue of around $14,500 – a difference of around $8,000 per hectare.

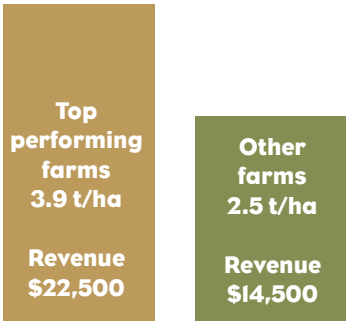


Figure 2. *Average NIS yield and revenue for top performing farms versus other mature farms in the benchmark sample (2009–2018).*

Note: Revenue based on $5.80/kg NIS

Key management practices

A survey of top performing farms was undertaken to identify common approaches to orchard management. Growers were asked to list key management practices that they believed contribute to their orchard's high productivity, and these were:

- attention to detail
- a balanced nutrition program
- using consultants
- continuous learning.

Attention to detail was the most common response, which included ensuring timeliness and forward planning of important tasks including pest management, nutrition and harvesting. Regular monitoring and observation were also key components of this.

"Being pro-active in the orchard, having a plan of what you are going to do and having the infrastructure to perform tasks when they need to be done and spending money on inputs to make the orchard run as well as the weather conditions of that year allow."

"Keeping an eye on nutrition, frequent harvest rounds, clean orchard floor and

perimeter, pest scout and just doing all the little things."

"I think it is attention to detail and timeliness of each operation. It's not just one thing, it's a combination..."

"Boots in the paddock (most important). If something changes in the paddock it is acted on immediately, not tomorrow or when scout comes in 2 weeks' time but immediately."

"Timing is so important but it is the experience of your own orchard that drives the implementation of the plan."

Nutrition rated highly with nearly all respondents, emphasising the importance of a balanced program that supports both soil and tree health. Most respondents achieved this through the application of mulch, compost and both soil and foliar fertilisers.

"Application of compost and fertilisers every year would be the main factor, since we have been applying compost in generous amounts our production has been improving."

Another common response in the survey was the **use of consultants** to inform pest management and nutrition programs.

Growers also acknowledged that seasonal environmental conditions could severely influence productivity and undo even the best management practices.

"Our records strongly indicate that our high productivity is linked strongly with weather conditions, especially as we are a non-irrigated farm."

"It doesn't matter how good your management practices are, rain at peak flowering will severely affect your crop."

Growers reinforced the importance of **continuous learning** through attending industry events to identify new ideas and approaches to orchard management.

"Treat the orchard as a business. Attend all AMS, DAF and NSW DPI field days. (Keep informed)"

Other management practices believed to contribute to high productivity included canopy management, erosion control and effective spray coverage.

The macadamia industry strategic investment plan has set a target average of 5 tonnes of NIS per hectare by 2021. This is approximately double the current long-term benchmark average. However, it is clear that there are some farms already achieving this using effective planning, monitoring, observation and timing. The next edition of the *News Bulletin* will include some further insight into top performing orchards.

Information

A video case study called *'What makes a top performing farm?'* provides more detail about this analysis of top performing farms. The video is available on the Queensland Agriculture YouTube channel.

This article has been produced as part of the Hort Innovation project *Benchmarking the macadamia industry 2019–2021* (MC18002). This is a joint initiative of the Queensland Department of Agriculture and Fisheries, the University of Southern Queensland and NSW Department of Primary Industries, with support from the Australian Macadamia Society.

For more information about participating in the benchmarking project, contact one of the following team members, or email macmawn@daf.qld.gov.au, Queensland: Grant Bignell, QDAF, (07) 5381 1334, New South Wales: Jeremy Bright, DPI, (02) 6626 1346 or 0427 213 059.

Participation in benchmarking is free and individual farm results remain completely confidential. The benchmarking service provides growers with an opportunity to confidentially compare their yield, quality and optionally costs with averages of similar farms.



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VISIT TO THE HEART OF *MACADAMIA JANSENII* HABITAT

Denise Bond



Exploring Macadamia jansenii *habitat.* Photo: Dallas Nock

MCT members and supporters had the privilege of visiting endangered *Macadamia jansenii* in its natural habitat this September. The trip highlighted three points – the very real danger posed by wildfire, the insidious threat of invasive weeds, and the magnificence of the rainforest habitat that sustains this rare species.

Keith Sarnadsky has been leading expeditions to look for new *Macadamia jansenii* individuals for over a year now and offered to show us some trees that were not too far from a road – most of the others require quite a hike through the bush. Unfortunately, the trip coincided with the first serious bushfires this year, and Keith had to stay to protect his property. Memories of the catastrophic fires last October and November are still fresh, and to have fires already in September is a worrying start to the summer. Ray Johnson, President of Gin Gin Landcare has lent his botanical and bush craft skills to many of the *M. jansenii* expeditions and smoothly took over leading the group, but it was a sobering experience to drive up to Bulburin National Park through still smouldering forests.



Stone and timber bridge on old logging road, Bulburin National Park. Photo: Dallas Nock

The approach to the park follows a road cut through the Dawes Range in the early 1900s to access hoop pine and other timbers. We traversed low hills of dry eucalypt forest, with lusher vegetation in the gullies, and remnants of quaint timber and stone bridges.

Finally we arrived in a wide valley carpeted in rainforest with emergent hoop pines and spectacular king orchards. To find *M. jansenii* we had to leave the main creek bed and head up a smaller tributary. About 3 metres from the creek bank, Ray showed us a group of three *M. jansenii*. They had a scattering of flowers and even more importantly, we found seedlings nearby, welcome proof of ongoing recruitment.

The group dispersed to look for more trees, following Ray's instructions to look for slim dark horizontal branches, as in the shade the species seems to have a habit of sending out long thin branches to reach patches of the dappled sunlight. We were rewarded by some more finds and noticed that all the trees were multi-stemmed with quite a sprawling habit. We even wondered whether some groups of trees were vegetative reproductions of a single genotype that has coppiced, possibly in response to fire, and over time, spread along the ground from rhizomes.

There is still so much to find out about this species, and the diversity across even 43 individuals was amply illustrated the next day at Gladstone's Tondoon Botanic Gardens, where cuttings taken from 43 of the original population are now 6 years old. These young trees exhibit a range of characteristics – single vs multi-stemmed; the occasional branch with four leaves per whorl; first flush from coppery brown to red; and sparse vs dense canopy. A visit to Tondoon is another highly recommended (and very pleasant) way to observe *Macadamia jansenii*.

It was a great experience to see such a rare species in its natural habitat, but although remote, we all saw how effectively weeds are using roads, creeks and birds to infiltrate the park, and how vulnerable the forest is to fire.

Macadamia jansenii recovery projects are supported by MCT through funding by the Australian Government's National Landcare Program, the Foundation for Australia's Most Endangered Species (FAME) and Hinkler Park Plantations.

Macadamia Conservation Trust supporter profile

What drives people to go above and beyond to look after wild macadamias? Here we profile Andrew Burnside, an active member of MCT's Conservation Committee.



Andrew is in a rather unique position in that he can combine his day job with one of his passions. He works for MWT Foods Macadamia Division, providing grower liaison and operations services along the east coast, but MWT also authorises him to use his time, skills and network of contacts to further the aims of the Macadamia Conservation Trust.

Over 35 years building a career as a horticulturalist, Andrew has worked with macadamias, cashews, avocados, custard apples, citrus, mangoes and cut flowers, including managing Arnott's Biscuits Hawaiian macadamia holdings. He was a founding member of AMS's Research and Technical Advisory committee and has sat on numerous horticulture industry and government advisory bodies.

For MCT's current major project, establishing a wild macadamia arboretum, we need skills in propagation, nursery management, planning and logistics – all things which Andrew has in spades, so having him on board is a great contribution.

Along with committee members Ian McConachie and Paul O'Hare, Andrew has also been discovering new stands of wild trees and battling invasive weeds (see the before and after photos below).

Much of the Trust's work is made possible by the voluntary input of its dedicated and skilled committee members. MWT's contribution of Andrew's time and skills is a welcome boost to the capacity of the Trust to protect the foundation of the macadamia industry.





Andrew with master gardener and volunteer Jan McConachie, having rescued a wild M. integrifolia *from cat's claw creeper at Amamoor. Note the size of the trunk in relation to the canopy which has been severely restricted.*
Photo: Ian McConachie

Other MCT news

More support for wild macadamias conservation

Silica Gel Australia has continued its support for wild macadamia conservation with a welcome donation of several hundred dollars-worth of orange silica beads. These beads allow MCT to prepare leaf samples so that they are suitable for both long-term storage and DNA testing.



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WHAT'S THE VALUE OF ADVICE IN A POST-ROYAL COMMISSION ENVIRONMENT?

sunsuper

Sunsuper has released its 2019 Value of advice report confirming the value of financial advice, with research showing that 80% of Australians who have received financial advice believing it has given them more peace of mind and 77% believing it has helped them feel better prepared for retirement.

The research, conducted by CoreData on Sunsuper's behalf, follows three everyday Australian households at various stages of retirement and highlights the financial and lifestyle benefits of financial advice.

Also highlighted in the report: 75% of people believed the advice they received was more than worth the cost, and 72% feel they have a better understanding of what to expect in retirement.

Sunsuper's Head of Advice and Retirement, Anne Fuchs, said that at Sunsuper, we know that most Australians have a dream for retirement and our research shows that financial advice can help ensure suitable retirement planning strategies are put in place early enough for those dreams to be achieved.

"Advice can also help support people to understand what their retirement will look like financially and put their mind at ease during this major life shift. And clearly, those who receive advice think it's "worth it" – for their lifestyle, financial security and peace of mind."

While findings from the Banking Royal Commission shone a light on the damage and impact poor financial advice results in, Sunsuper's Value of advice report highlights that great financial advice can truly change people's lives for the better.

"Financial advice provided by trustworthy experts with their clients' best interests at heart contributes significantly to the financial wellbeing and retirement preparedness of a vast number of Australians.

"We know that some clients often struggle to appreciate the benefits of financial advice and in turn, can lead them to question the upfront investment in great financial advice."

> *"Our research validates the value of the service we provide to clients in helping them achieve their best possible retirement."*

The case studies in the 2019 Value of advice report model the outcomes of financial advice on the lives of three everyday Australian households at various stages of retirement preparedness. The milestones in the case studies reflect those many Australians experience. By also modelling the households' outcomes without financial advice, the modelling shows the difference between the advised and unadvised scenarios and highlights the financial and lifestyle benefits of financial advice – today and for the future.



The resilient couple

Meet David and Jenny

David and Jenny are both 60 and close to retirement. David is a self-employed tradesperson, and Jenny is a part-time teacher.

Although the couple are comfortably heading into retirement, they want to be as prepared as possible for the changes coming in their lives. The couple seek a financial adviser to remove the burden of management from themselves, which is fortunate as David is suddenly forced to retire early due to an injury.

David and Jenny's financial position

Income:	David $180,000 p.a. (self-employed) Jenny $60,000 p.a.
Living expenses:	$55,000 p.a.
Additional expenses:	$8,000 p.a. in retirement for holidays
Superannuation balance:	David $100,000 Jenny $250,000
Business value:	$700,000
Non-super financial investments:	$150,000
Home ownership:	Yes
Investment property:	$700,000
Mortgage:	$350,000 (investment)
Other liabilities:	$10,000 car loan
Insurance:	Both David and Jenny have $25,000 Sunsuper default life + TPD cover

David and Jenny's goals

HIGH	• Sell their business: David wants to sell his trade business so he no longer needs to worry about the physical demands and financial management. • Retire aged 65: David and Jenny have planned to retire at the same time so they can begin the next phase of their lives together.
MEDIUM	• Maintain comfortable standard of living: David and Jenny want to enjoy their retirement in style after both working all their adult lives. • Leave a bequest: David and Jenny would like to leave something behind for their three children and grandchildren.
LOW	• Reduce management burden: David and Jenny want to make the right decisions and spend less time doing it all themselves. • Lower their financial risk: David and Jenny want to diversify their assets so they are protected financially during retirement.
CHALLENGES	David's work involves a high risk of injury, and two years into the scenario, the model assumes that David is forced into early retirement. They therefore want to sell their business and invest the proceeds effectively, but also diversify away from property. The couple has $350,000 in mortgage debt and $10,000 in a car loan.

The value of advice for David and Jenny from age 60 until Jenny's retirement - age 65.

-$34,000
Total tax saved

+$54,000
More draw-down from *Retirement income accounts* in first year of retirement

-$39,000
Less in total debt to pay off

+$465,000
Additional net assets at Jenny's retirement

+$269,000
Additional net earnings on superannuation balances

-$20,000
Less loan liability outstanding

The value of advice for David and Jenny from age 60 until age 90.

+$227,000
Additional investment income outside of super

+$45,000
More draw-down from *Retirement income accounts* each year of retirement

+$353,000
Additional Total & Permanent Disability payout to David

+$695,000
Additional net assets at age 88

+$802,000
Additional net earnings on superannuation balance

*David and Jenny paid for financial advice: **$3,000** up front + **$1,500** each year from age 60 until Jenny's life expectancy at 90.*

sunsuper

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INGENIOUS MOBILE DEHUSKING & PROCESSING PLANT A REAL GAME CHANGER

Belinda and Daniel Blanco, Belmac Logistics

The AMS spoke to Belinda and Daniel Blanco about their ingenious mobile dehusking and sorting plant which has enhanced their harvesting efficiencies and improved the quality of their harvest.

Can you tell us about your orchards?
We have three orchards. Our first orchard, the home farm, consists of 6,200 trees over 22 hectares, has 18 blocks and is located at Wolvi, Gympie. Our second orchard consists of 7,100 trees over 32 hectares, has 17 blocks and is located at North Deep Creek, Gympie. The third farm consists of 26,000 trees over 80 hectares, has 14 blocks it is located at Boreen Point, Cootharaba. Both North Deep Creek and Boreen Point are 30 minutes from our home farm at Wolvi.

What made you decide to design your own mobile dehusking plant?
We made the decision to build the dehusking plant, rather than rebuilding and refitting three individual sheds, to handle the amount of nut that we are expecting to pass through each shed on a daily basis in a limited amount of time.

The cost to build the Agri-Mac 20 was equivalent to upgrading the sheds. We found with having two farms and one harvester that the shed could still not keep up with what the harvester could collect. We knew that taking on another farm required the purchase of another Monchiero harvester. With this we knew the sheds could not handle what the harvesters could deliver. The Agri-Mac 20 was not delivered until the middle of March which was half-way through our first round and the sheds were struggling.

Our fabulous team at the end of a successful harvest day. L to R top row: Joel, Lockalyin, Alizee' and Domenik: L to R below: Alex and John (harvester operators), Susann, Belinda, Elisa and Michelle.

The plant is foldable for road transport. We pull the Agri-Mac 20 with our 6155 John Deere Tractor, and when we arrive at the farms the plant is ready to use within minutes. Being able to transport a dehusking and processing plant to a paddock that the harvesters are operating in reduces time and capital involved in transporting nut to a fixed location. It also reduces the amount of time that the nut sits in a trailer or delivery pit waiting for the husk to be removed. With our current operating sheds we could only do 800 kg/hour but under trials this plant has been able to do 4 tonne of processed NIS/hour – a massive increase! Through the year we ran the machine at 25 tonne in a 10 hour day which was a sustainable pace, with a staff of six.

Can you describe the Agri-Mac 20 dehusker?
The Agri-Mac 20 is a road registered tandem 9-metre long tag trailer that is towed by a John Deere 6155 from farm to farm. It easily folds and retracts chutes and elevators for road transport. Once on site it is only a few minutes and the machine is ready to receive the harvested nut.

It has a delivery hopper that holds two full Monchiero harvester bins. From the delivery hopper, product goes up an elevator and falls through a variable speed air sheer which removes grass and leaf and then onto a large stick and rock removal chain which drops the



The Agri-Mac 20 on its way to the next farm to dehusk and process nut.

waste on the ground on one side of the machine. The nut-in-husk falls through the chain and heads into a double trommel which filters out soil, small rocks and foreign debris, and then delivers the nut-in-husk into an upstairs air-conditioned room with a sorting table that can hold three people. Any remaining foreign material is removed here. Most of this year we had two people depending on the surface of the harvesting area.

When the nut leaves this room it then passes through a Keba Engineering 3 drag tyre dehusker which removes 100% of the husk from the nut. After leaving the dehusker, the nut enters another trommel which removes loose husk and any nuts smaller than 16 mm. This waste product falls onto the ground on the other side of the machine and we can put this back under the trees as a mulch after harvest.

From the trommel, it passes through an air chute which removes any excess loose husk or any nuts that have rat damage or immature light weight. The nut then enters the final air-conditioned sorting room which can hold four people seated at a sorting table. With final sorting done in this room, it is then elevated into a waiting truck which takes the nuts to the shed and delivers straight into a waiting silo or direct to the processor.

How did you come up with the design?
When Daniel and I took on the third farm in August 2018 we needed to look at the speed required to process and travel between all three farms in a small harvesting window. We had seen a small dehusking trailer in action and thought what about adding everything that the sheds do onto a tag trailer, or should we improve on three shed sites that were already operational?

Daniel spoke to Cameron Greaves from Argi-Con Equipment in Bundaberg who generally work and build within the sugar cane industry, and from there the designing started. Daniel and I, Cameron, Paul Greaves, Cameron's design team and Andrew Pierce from Macadamias Direct have all been part of the successful outcome of the Agri-Mac 20. The machine is powered by one diesel hydraulic engine and one diesel generator and only uses 11 litres of fuel per hour.

Did you have to make any changes to your original design?
As part of the design process we made a point of only incorporating high quality, reliable components and this has proved to be a great decision. As all protype machinery goes, we did have a few teething issues in the beginning with nut flow, but once that was rectified the machine has been running at its optimal ability. After processing 450 tonne the machine has now returned to Agri-con Equipment to have some small modifications done to make the throughput even more efficient. The only part of the machine that needs to be replaced is a delivery belt (due to the amount of nut put through the plant).

What are the main benefits of the Agri-Mac 20?
Having three farms within an hour of each other, the ability to move from one farm to the next farm with our united team has delivered great benefits in our eyes. The speed at which we can harvest and process is noticeably faster. We are finding that our premium nut and commercial nut percentage has dramatically improved, and we believe this is due to sending large volumes of nuts more efficiently off farm to be dried down faster. Throughout the 2019 season we never had nut in farm storage for more than 3 days! Also, the versatility of the machine makes it hireable for any location and saleable at any time.

Daniel and I are very conscience about having a happy and safe workplace. Our team was noticeably happier and more content with the work environment. The social factor of everyone being together as well as the dollar factor returns at the end of the day were better for everybody because the throughput was so much higher so we could share it with our work colleagues. The work environment was generally better than it has been in the past.

The versatility and capital cost factor of the Agri-Mac 20 makes it an attractive and viable new option for new developments of macadamia orchards, particularly for growers who haven't yet fitted infrastructure onto new properties that are away from their home bases, or for properties that are at a distance from existing processing plants.

You can see the machine in action on YouTube: Macadamia Nut processing plant Gympie Australia: https://youtu.be/A4_BbnLgjUE.

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ADVANCES IN MAPPING TECHNOLOGY HELPING ON-FARM MANAGEMENT

Bob Howard, GES Mapping

Aerial photography technology has come a long way over the past few decades. New technologies like drones and LIDAR mapping, coupled with improved geographic information systems have provided a range of new tools to help manage existing orchards and plan new orchards. In this article, Bob shows us the types of mapping products that are currently available.

Mapping technology has advanced significantly in the past 40 years. My early mapping projects were based on black and white aerial photograph blow-ups from the RC9 series. These were part of a federal government national mapping project that covered Australia with 1:80,000 black and white aerial photography collected over a 15-year period ending in 1975. They formed the basis of the 1:250,000 map series and are the only dataset that has Australia-wide coverage. These old black and white photos are now redundant due to satellite imagery.

Combining drone images with LIDAR mapping

Today one can use an inexpensive unmanned aerial vehicle (UAV) to fly over a farm capturing images that can be stitched together into an orthophotograph in a matter of hours (Figure 1). The same images can be used to generate 3D models. There is always a 'WOW!' factor in watching computer software convert 2D images into a 3D digital surface model (DSM) like the one shown in Figure 2.

The locational accuracy of these images is in the order of 1–5 m which can be further improved by using surveyed ground control points. The widespread use of this technology has seen the development of survey-grade mapping UAV's which fly with the combination of a local base station (see photo above) and result in a location accuracy of 3 cm.

The main issues with using a UAV for data collection is the need to fly in light winds and low shadow conditions (noon) and the output for orchards is compromised by the tree canopy cover. These issues are overcome with an aeroplane-based LIDAR system which is the current gold standard and provides the most accurate location and elevation data available today for farm-scale mapping. Fortunately, all macadamia farms in New South Wales and most in Queensland are covered by state government captured LIDAR which is now publicly available.

Digital terrain models create maps of natural features

Processing the LIDAR data provides detailed and accurate 3D models from which the buildings and trees can be removed to give a 'bare earth' digital terrain model (DTM) like the one shown in Figure 3. The high accuracy of this dataset allows further processing without introducing artefacts.



Figure 1. *Orthophoto from 151 images collected with a drone (DJI P4 UAV)*

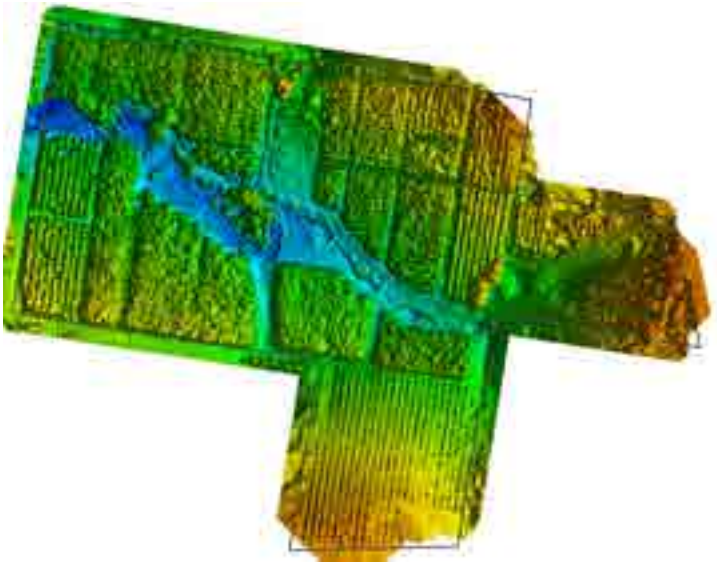


Figure 2. *Digital surface model (DSM) generated with OPM software.*

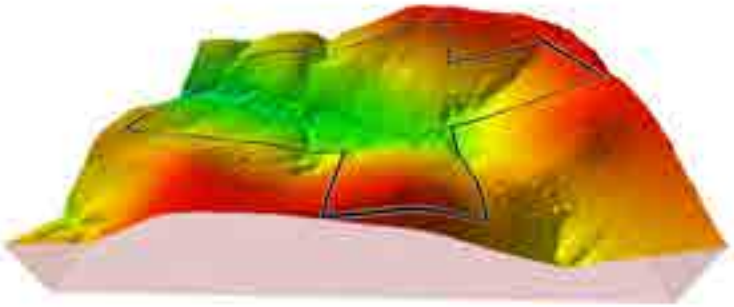


Figure 3. *Digital terrain models (building and trees removed) generated from LIDAR.*

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The DTM can be used to map all the natural features on a property to highlight the natural variability. Many of these features are related to soil depth, soil type, soil temperature, soil moisture and even to timing of flowering. No doubt there is also a link to production numbers, but we are still waiting for yield mapping to use as overlays for confirmation.

Some of the maps generated from the DTM are elevation, aspect, slope (Figure 4) and flow accumulation (Figure 5).

Using digital terrain models to manage soil erosion

In the macadamia growing areas of northern NSW and southern Queensland, soil erosion results from high intensity rainfall events. Areas susceptible to sheetwash erosion can be mapped using the Length–Slope factor and areas likely to develop gully erosion defined by the Stream Power Index. Maps of these erosion hotspots (see Figure 6) allow farmers to better-manage sensitive areas.

The original DTM can be modified to simulate the impact of profiling or 'digging-in' drains. The amount of soil loss from a property can be mapped in tonnes/ha/year with the Revised Universal Soil Loss Equation (RUSLE) shown in Figure 7. By combining these options, it is possible with modelling to measure the soil loss before and after drains are constructed, as well as before and after trees are removed, to allow optimisation and prioritising of erosion mitigation measures.

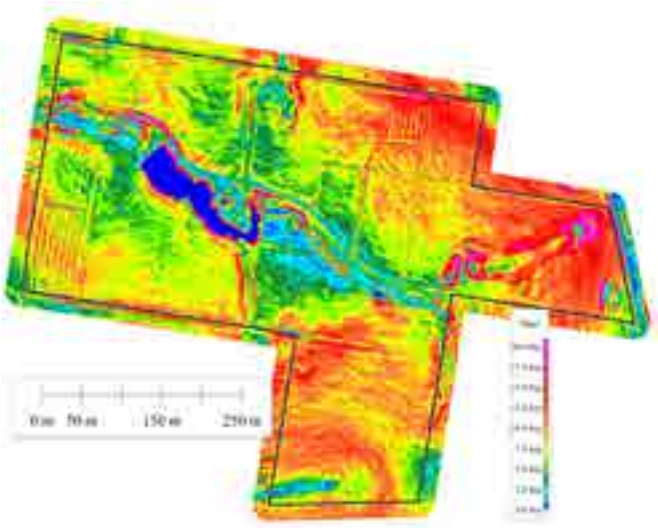


Figure 4. Slope *is an image of the slope gradient. It is also a major factor in the speed of water flow and has an impact on soil depth.*

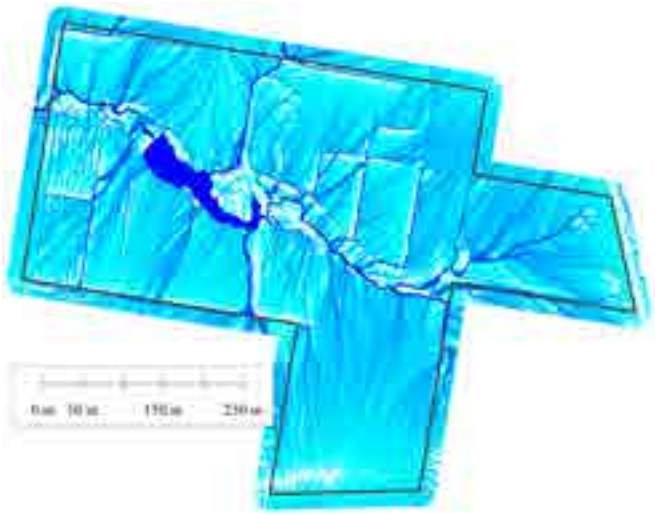


Figure 5. *The* ***flow accumulation*** *map outlines all areas of concentrated surface water flow.*

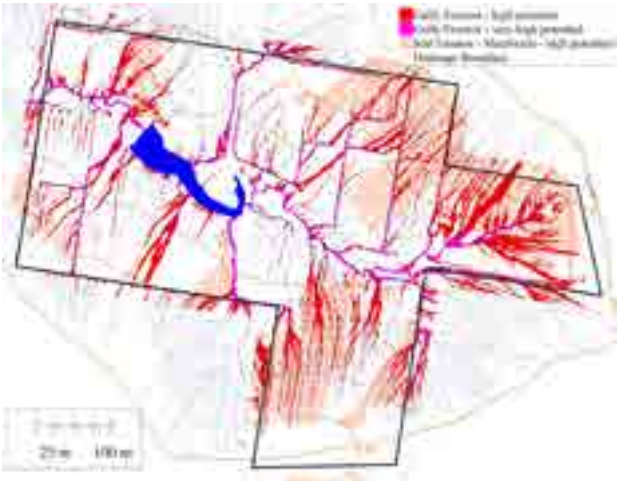


Figure 6. *Soil erosion maps highlight areas with high or very high potential for gully erosion.*

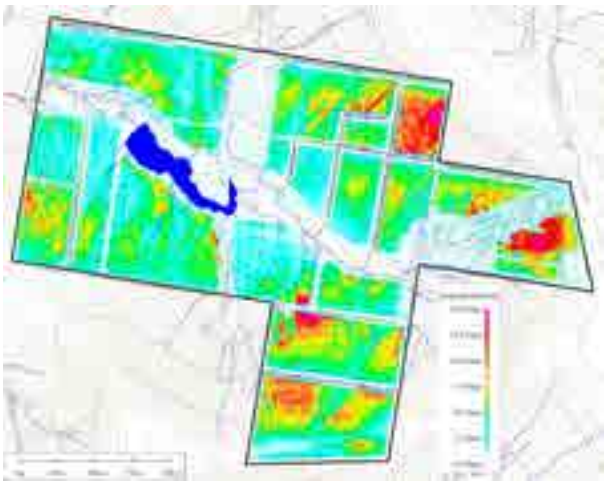


Figure 7. *A map showing Revised Universal Soil Loss Equation (RUSLE) which shows tonnes/ha/year of soil loss.*

The location of trees in an orchard can be mapped and used on mobile devices such as tablets or smart phones to record farm activities such as spraying.

Orchard design is a growing area of interest

There are many advantages in planning an orchard on a map prior to planting. Multiple scenarios of tree line orientation and tree spacing can be tested and total numbers calculated. The water flow direction at the base of each tree can be mapped to optimise the tree line orientation downslope. The tree lines can be sent to graders via Trimble Civil to construct profiles. The tree lines and tree locations can be sent to tractors via Trimble Ag to allow the tractor to auto-steer on the tree lines and tree planters to be activated by the tree locations. The contours can be used by irrigators in AutoCAD to design the required irrigation system and the whole process can be monitored on a smart phone or tablet loaded with the orchard design map.

Mapping can provide a wealth of information about a property. It is surprising that new buyers generally do not have a property mapped before purchase. Steep slopes do provide great views but are a major issue in farm management. A slope zone map could provide an easy comparison between properties so the new owner is then fully aware of potential problems. If you are purchasing land down on the floodplain, are you aware of its elevation or more appropriately, how low the land is? For new purchases, an overlay of the DP property survey over aerial photography can also confirm boundary fences are in the correct location.

Over my 40 years in mapping I've observed the development of digital cartography and geographic information systems (GIS). It is difficult to predict the future, but accurate location data is required in agriculture for autonomous field equipment and I expect it will be a lot of fun playing with UAV's and mobile mapping techniques.



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FIRST NUT SCANNER TO SORT GREEN NUT-IN-HUSK

Geoff Stonehouse, Garlate Holdings

An Australian processor is using a new nut scanner which sorts wet nut-in-husk. Geoff Stonehouse explains how the scanner works.

Scanning technology has been used in the Australian macadamia industry for some time now, however these scanners have only been able to deal with dry nut-in-shell. Now, in a world-first, we have a machine operating in Australia that is capable of sorting wet hut-in-husk (moisture content of 17–20%).

The M12NIS Advanced Plus, manufactured by Spanish company Multiscan Technologies, uses high resolution digital cameras and optical scanners to sort the nuts. The nut-in-husk are sorted in a single pass through the vision and LED lighting system, and are sorted into three different categories:

1. Brown and wet green nut-in-husk go through one exit
2. Black defect nut-in-shell go through another exit
3. Good quality nut-in-shell go through the third exit, ready for drying.

The nut-in-husk from the first exit chute are then put through a dehusker and put through the M12NIS scanner for a second pass.

The scanners come with software that provides a range of information including throughput volumes and number of nuts, and the percentages of each defect category.

John Manera, of Macadamia Enterprises in Bundaberg, purchased a M12NIS scanner half-way through the last season. He says, "I really wanted to eliminate any nut-in-husk going into our intake bins before we sort, and to ensure that no nut with husk was going into the silo. That was my main motivation.

"We use an in-field dehusker but there's always some husk that isn't removed so this means time in the shed sorting the nuts and manually removing the husk. The colour sorter selects out the nuts with husks and we can then put just those nuts through a second dehusker and the rest of the nuts are not going through another dehusking process unnecessarily.

"It's let us relax our in-field dehusking because we can deal with it efficiently in the shed, so we can run the dehusker a little bit quicker in the field and have a bit of flexibility in managing the dehusker rubbers and other components. All up we think it's been a good investment."

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The feed material which goes into the hopper.



Brown/black and wet green nut-in-husk are removed through one exit chute, ready to be fed through the dehusker.



Black nuts are removed through the second exit chute.



Final, accepted nut-in-shell ready for drying.

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MODERN, CLEAN TECHNOLOGY USED IN NUT DRYER

Brett and Alysha Horne, Horne Machining and Fabrication, Ballina

A new macadamia nut dryer using macadamia shells and modern technology is showing potential. Brett and Alysha explain what's involved.

Drying nuts with nuts is not a new idea. In the late 1980s a New Zealand company designed and built a coal-burning heating / drying unit for agricultural purposes, which was then modified to use the shell of the macadamia as fuel. A few of these machines are still in action today, but beginning to show a fair amount of wear and tear.

We were approached by a local macadamia farmer with the task of building a new dryer using modern technology and meeting current EPA regulations. The result is a drying unit that is currently drying 2,500 tonne of macadamia using just 50 tonne of shell; completely eliminating the need for any non-renewable energy sources. The dryer is using the latest technology in variable speed drives and controlling systems and can be run from anywhere in the world using a mobile phone as the control centre. The technology provides up-to-date readouts for the processor of both burner and silo temperatures, allowing flexibility in air:fuel ratios to ensure an extremely clean burn.

The heavy construction and 1,200°C flameproof paint makes the machine robust and hard wearing. With a 6 mm floor and 10 mm combustion chamber wall, the HMF nut burner can withstand high temperatures in excess of 600°C to effectively dry the nut. The nut shell burner has various fire safety controls inbuilt. The major mechanical control is our custom centrifugal suction fan. This fan is placed at the end of the exhaust air system meaning all potential fire danger is being extracted from the burner. There are also various electrical controls that can be put in place depending on individual user requirements.

Paul Hudson of Waliz Nuts has been using one of the dryers and says, "It provides more than the required heat to the system using a renewable fuel source, macadamia shell. With a custom recirculation system, we are able to dry 100 tonne in 6 days at a fraction of the cost of traditional fuel sources like natural gas."

The possibilities for this technology are endless, including using it to generate cool water for hydroponic systems (we are in the process of making a prototype to test our theory).

Another opportunity for the shell burner is a process called gasification. This involves the shell being burnt without oxygen, meaning it will not catch alight. This then produces methane which can be harvested and used to run a modified diesel generator to power factories. The by-product of this process is biochar, a mineral that has the ability to improve soil fertility and improve crop yield.

Using renewable energy sources and recycling by-products are options that many modern farmers are investigating in a move to more sustainable systems.

Information
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NEW RESEARCH REVEALS MACADAMIAS ARE WELL PLACED TO DISRUPT THE CHOCOLATE CATEGORY

Lynne Ziehlke, General Manager Marketing

New consumer insights research has revealed macadamias to be the ideal ingredient for manufacturers looking to shake up the chocolate confectionery category.

Commissioned by the Australian macadamia industry, the research examined the category in both Western and Asian markets, and looked at the role macadamias could play in ensuring chocolate remains relevant to consumers into the future.

Chocolate: the universal indulgence

Chocolate holds a cherished place in people's lives, with a universal appeal that transcends geography, age and gender. It represents comforting reward and soothes the hardships of everyday life.

The research found that consumers typically consume chocolate to *indulge, de-stress, uplift or re-energise*, with macadamias well positioned to play a role in all four of these motivators.

Macadamias ripe to disrupt the category

Nuts and chocolate have an established relationship, with consumers globally familiar with chocolate products containing peanuts and hazelnuts in particular. However the research found that while these are popular pairings, they have also become commonplace and routine, exposing an opportunity for disruption within the category.

The findings concluded that macadamias are the ideal disrupter, as they can build on the established nut and chocolate relationship but also inject extra excitement.

The role of macadamias in chocolate purchase motivation



There are four key benefits that only macadamias can bring to chocolate:

1. *Accessible luxury:* Macadamias are a premium ingredient, with Australia a known and prestigious origin.
2. *A more indulgent experience:* While many consumers use chocolate to indulge, when macadamias are added, it takes the experience to new heights.
3. *Novelty and intrigue:* Of the 13,246 chocolate products launched globally in the last year, 1,864 featured hazelnuts, 577 featured peanuts, while just 72 featured macadamia nuts[1]. Their relative rarity makes them a more exciting and less expected inclusion in chocolate.
4. *Preferable flavour profile:* The buttery smooth flavour of macadamias is well suited to chocolate and less expected than other nuts.

The desire to eat well versus the temptation to indulge

When considering a chocolate purchase, consumers wrestle with the desire to eat healthy, wholesome food because 'health is wealth', and the temptation to indulge, because 'life is for living'.

This has created the demand for chocolate products that offer 'permissible indulgence'. Macadamias meet this demand perfectly, as their health benefits add a level of permissibility, while their status as a sophisticated ingredient answers the need for indulgence, more so than any other nut.

While consumers want permissible indulgence, they don't want it to involve compromise, so product innovation must deliver permissibility without detracting from the integral experience of chocolate.



Want to know more?

These findings are the latest in our series of consumer insights research exploring innovation opportunities for macadamias in the ice cream, bakery and snacking categories and form part of our industry's *Innovation Initiative*.

Innovation opportunities for macadamias in chocolate

The study identified four key innovation hotspots for macadamias in the chocolate category.

№1

Permissible indulgence: a healthier expression of chocolate focusing on quality, with additional ingredients that offer health benefits. Macadamias can add health associations via their protein and healthy fat content and cholesterol-reducing potential, alongside luxury cues that make them more special than other nuts.

№2

Novel creations: fun flavour and texture combinations that add surprise and joy to everyday chocolate. Macadamias can add textural intrigue via their unique eat journey that complements chocolate so well, and a sense of the 'extra-ordinary' as a more novel and less expected ingredient.

№3

Created with integrity: chocolate that has a craftsmanship story that speaks to consideration, attention and refinement. Macadamias can add natural and wholesome cues and a halo of integrity and high quality.

№4

Refined sophistication: premium chocolate that delights the adult palate. Macadamias are a sophisticated and luxury ingredient that lend themselves to gourmet flavour combinations. Their taste profile can bring sweetness to more bitter chocolate and also carry saltier, savoury flavours to balance out sweeter ingredients such as white chocolate.

To find out more, contact Lynne Ziehlke,
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The insights referred to in this story are from the research project Chocolate Confectionery Category and Macadamias: Western and Asian Consumer Insights conducted by independent research agency GALKAL, 2019.

[1] Mintel Global New Products Database, products released in past 12 months globally

WEAVING YOUR WAY THROUGH THE SUCCESSION DISCUSSION



Kim Lee, Rabobank Succession Planner, gives some guidance on how to approach succession planning with your family.

For the majority of farming families, providing a future for the next generation and ensuring the continuation of the business they have grown is generally the end goal.

Kim Lee, Rabobank Succession Planner said ultimately people want their family members to be happy with the arrangements on how the assets are divided. Unfortunately, how each family does this is often very different.

The overarching findings that Rabobank have made, in working with families in succession for the last 19 years, is that future viability is a priority, retirement security is important and that families negotiate around fairness.

"In over 95 per cent of family agreements we have helped to facilitate, the family have negotiated an outcome that is 'fair', as measured by family values, rather than equal", Kim said.

Farm succession planning is complex

In farming, planning for the next generation to succeed involves the complexity of the succession of the assets as well as succession into roles within the business. It is often difficult to separate the two and provide a viable business that can support more than one generation. As farming businesses are usually capital, rather than labour, intensive it can be the case that there are limited opportunities for working in the business for all family members.

While exceptions to this are found in industries where the business ownership/activities can be easily split and/or where risk can be easily managed, this is not the case for many of our agricultural industries.

Successive generations of farming families have found that growing the business, either through expansion or intensification and sometimes diversification of assets/investments, is the only way to ensure some of these goals are met.

Kim said the fact that there are only half the number of farming businesses in Australian agriculture compared with two generations ago is fair testament to this fact.

"Today, children are tending to return to family businesses later and partnering later, which has changed the succession environment for farming families. In intensive industries this trend does not appear to be as significant", she said.

"If families are to be happy with succession arrangements, it is really important that they discuss what their goals are, what the opportunities are, and what 'fairness' in treatment of family members might look like.

"This is not a one-off discussion – it needs to take place through the lives of the younger generation and is something that needs to be reviewed every time the family or business environment changes, such as new partners, a death or someone starting to work in the business (even if they have come home for a short time)."

Kim said it is important to understand that expectations are often set early and may be difficult to change as business conditions change. So flexibility, awareness and education are important for all family members. This involves a lot of quality communication and not just a lot of talking.

Understand your family's culture and goals

Opportunities that farm businesses present for family members and how each family views them are influenced by family culture (values) and history. However, most families are unaware of the cultural norms that influence the way they think and act. Differences in family culture express themselves in the way families view transparency of information flows (especially financial information), how money and how much money is spent, saved or borrowed; how female opportunities may be different to male inheritor/worker opportunities; and how work is viewed relative to leisure.

"These are just a few. Of course there are generational differences, as well as family differences, that have to be taken into account", Kim said.

"It's essential to understand family culture and how it influences family and business goals. Unless you know what is driving you, it's difficult to work out what the goals are."

Goal setting is an exercise that can be complex. It requires discussion and an understanding of how each family member views things like:

- independence
- transfer of assets now, compared to in a will

- what is sacred, in terms of the value of place and legacy
- what an opportunity to farm delivers compared to an opportunity to invest
- whether it's important to earn, or be given assets etc.

"Families that start early and manage to effectively explore and communicate values, work to set and constantly review goals, are transparent in their approach to finances and are inclusive of all members, have more options open to them", Kim said.

"This gives them the greatest chance of success in the long run, because if all family members are included, solutions are often more creative and relationships strengthened.

"I don't know how many times I have heard people in the farming community express despair around a 'failed' succession and cited family member personalities, or adviser failings when the failure often lies with the family's approach to the process and their misunderstandings around differences in values and goals.

"Succession discussions are uncomfortable. It's usually emotional and understandably succession agreements get put to one side, or are undertaken when an emotional event forces decision-making. None of this makes for a great environment for making considered rational decisions."

It's also confusing – where to start, who to involve and what advice to get – because it's multifaceted and multidisciplinary. But Kim believes often it doesn't really matter how it's approached just as long as you keep at it, keep asking questions and keep everyone involved.

"You may find you can be taking one step forward and two back at times. You may hear confusing messages, but make sure you are able to articulate your goals well before you go to advisers as they can't help your family until you are clear as to what you wish to achieve."

An encouraging factor that Rabobank has found is that today more families are approaching succession or family business continuity discussions as an important investment in the family's future.

"It's no longer a taboo subject or viewed as presumptuous on behalf of the younger generation. Family business negotiations and resultant agreements and reviews, are now being viewed as a very normal part of best practice in family business", Kim said.

Information
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Aspirators are often used to remove lightweight debris. They can also be used to grade nuts using their relative weight-to-volume.



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THE MACADAMIA PLANTING SYSTEMS TRIAL 5 YEARS AFTER PLANTING

John Wilkie, Helen Hofman, Jarrad Griffin and Carola Parfitt (Department of Agriculture and Fisheries, Queensland), Hanna Toegel and Benjamin Toft (Queensland Alliance for Agriculture and Food Innovation, The University of Queensland)

Project snapshot

Intensively managed orchard systems have delivered significant productivity improvements in the apple industry in recent decades. These intensive apple orchards are planted at high densities using dwarfing rootstocks, have detailed tree training techniques applied to them and relatively precise crop load management regimes.

One of the main aims of our work in the *Small Tree – High Productivity Initiative* is to translate these principles of orchard intensification to macadamia growing, in an attempt to improve macadamia orchard productivity. Another of our aims is to understand the factors affecting productivity of macadamia orchards.

Our first hypothesis is that increased tree densities lead to greater yield per hectare early in the life of the orchard (i.e. more crop earlier).

We have been able to confirm this, however, there are very large differences between the two cultivars we trialed and at 5 years after planting the NIS yield/hectare of the low density A203 is significantly greater than the high density 741 treatments in the main trial. This means that cultivar selection for high density plantings is extremely important if high early yields are to be achieved.

Our second hypothesis is that planting at higher tree densities leads to greater maximum yields at canopy maturity. It will likely be several more years before the low density treatments reach canopy maturity, so we cannot yet address this hypothesis.

Orchard system components

A system is a group of interrelated parts working together to make a complex whole. Our orchards are systems. To achieve high yields, we know that we need to have the components of the system working together. For example, if we have excellent tree health and nutrition, we may still achieve poor yields if our pest management is lacking.

From a tree physiology perspective, our project has identified four key components of orchard systems that we believe need to be better understood and managed in an integrated way to improve productivity. These orchard system components are:

- the orchard light environment
- tree vigour
- crop load
- tree architecture.

Intensive orchard systems have been the central element of productivity improvements achieved by the apple industry in recent decades. Modern intensive apple orchards are planted at high density using dwarfing rootstocks, detailed tree training techniques and relatively precise crop load management regimes.

Compared to traditional low density, large tree orchards, these intensive orchard systems tend to have increased yields early in the life of the orchard due to increased early canopy volume and light interception. At maturity, these systems tend to have higher maximum yields and improved fruit quality due to the combined effects of the improved light distribution, crop load management and tree architecture.

The trials

To achieve our aims and answer our hypotheses, we set up a Planting Systems Trial, which we planted at

the Bundaberg Research Facility in early 2014. We are comparing the effects of tree density, tree training system and scion cultivar on productivity. We refer to this as the 'main trial'.

We are comparing two commonly planted cultivars, both grafted onto seedling H2 rootstock:

- A203, as a precocious, spreading tree capable of flowering on young shoots.
- 741, as a non-precocious, upright tree that tends to flower on older shoots further away from the canopy surface.

The three tree densities being trialled are:

- low density (Bundaberg conventional spacing) – 8 x 4 m, 313 trees/ha
- medium density – 6 x 3 m, 556 trees/ha
- high density – 5 x 2 m, 1,000 trees/ha.w

The two tree training strategies being compared are:

The 'Bundaberg conventional' tree training technique

- This is essentially the industry standard for the region and is being tested at all three tree densities. It is an early tree training technique developed in the high-wind environments around Bundaberg and involves repeated mechanical hedging of the canopy. The aim is to create a stout, balanced, wind-resistant tree with a complex canopy (high shoot density) for improved early flowering.

Central leader tree training techniques at the medium and high densities, which are slightly different for the two densities.

- For the medium density central leader trees, we undertook minimal pruning to maintain a dominant central leader with frequent lateral branches. Unbranched central leaders greater than 40 cm in length were tip-pruned to induce branching.
- For the high density central leader trees, a dominant central leader was maintained by bending any vertically oriented lateral limbs arising from the central leader down to at or below the horizontal and tying them with string. Unbranched central leaders greater than 40 cm in length were tip-pruned to induce branching. Vigorous vertical shoots that have grown from bent lateral limbs were generally removed.

We also planted a small extra high density plot (4.5 x 1.5 m; 1,481 trees/ha) trained to a vertical trellis which includes both cultivars (A203 and 741). Up until 4 years after planting the trees were trained to a central leader, but this has since been abandoned. This is called our 'trellised plot'. Unfortunately, because this is a single plot planted outside the main trial, the results from the trellised plot cannot be statistically compared with the main trial.

For all treatment combinations in both the main trial and trellised plot, tree dimensions are being maintained by pruning to a predetermined maximum canopy height and canopy width (minimum alley way). The control of tree height and width has commenced in the trellis, high and medium densities. So far there has been no need to control the height or width of the low density trees.

Canopy development and total light interception

Canopy volume/hectare increased strongly in the 5 years following planting (see Figure 1) and increased faster with the higher tree density treatments. At this point in the trial, the canopy volume/hectare of the high density treatments is greater than the medium density treatments, which is in turn greater than the low density treatments. Although not directly comparable statistically, the trellis appears to have a greater canopy volume/hectare than all treatments in the main trial.

Early in the life of the trial, there were also significant effects of tree training treatment on canopy volume per tree, with the central leader trained trees tending to be larger than conventionally trained trees (Wilkie et al. 2017). For example, at 2 years after planting the high density central leader trees had approximately twice the canopy volume of the high density conventionally trained trees. In 2019, 5 years after planting, the differences are still statistically significant but not as extreme, with the high density central leader trained trees approximately 16% larger than the conventionally trained high density trees (data not shown).

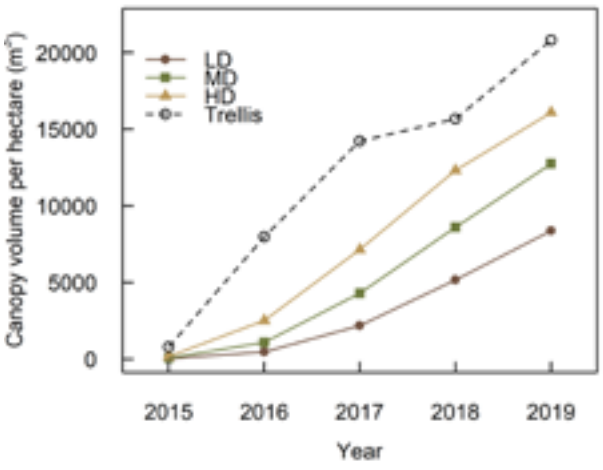


Figure 1. *Canopy volume/hectare over time in the Planting Systems Trial, averaged across 741 and A203. For the main trial, significant effects included cultivar, year, density and their interactions, and also the interaction between density and tree training treatment. For the trellised plot, there was a significant effect of year. Tree density treatments in the main trial are high density (HD), medium density (MD) and low density (LD).*

These differences in canopy volume have led to differences in total light interception between the tree density treatments (see Figure 2). Total light interception refers to the percentage of all light that is absorbed by the trees as opposed to what falls on the ground between the trees. Throughout the life of our trial so far, the high density has had greater total light interception than the medium density, which in turn has had greater total light interception than the low density. Although again not directly comparable statistically, the trellis appears to have greater total light interception than all treatments in the main trial.

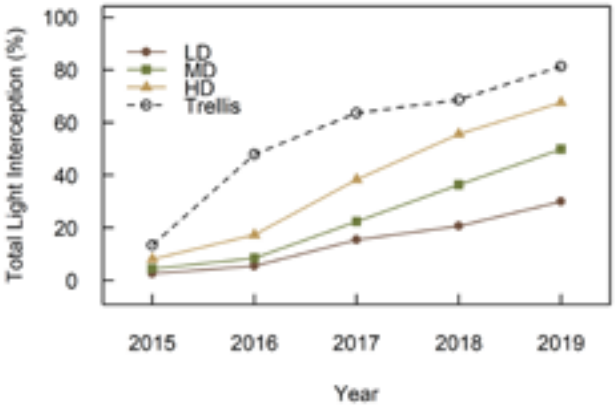


Figure 2. *Total light interception over time in the Planting Systems Trial, averaged across 741 and A203. For the main trial, significant effects included cultivar, year, density and their interactions, and also the interaction between density and tree training treatment. For the trellised plot, there was a significant effect of year. Tree density treatments in the main trial are high density (HD), medium density (MD) and low density (LD).*

Yield varies with age, density and cultivar

Nut-in-shell (NIS) yield/hectare over the 5 years of the trial is presented in Figure 3. There are three variables that have had significant effects on NIS yield/hectare: year, planting density and cultivar.

First, NIS yield/hectare has increased over time as the orchard has developed from planting. The first flowering of A203 was in the second year after planting and the first flowering of 741 was in the third years after planting, resulting in a very modest crop 2 and 3 years after planting for A203 and 741, respectively. The first commercially relevant yield was for 3 years after planting (2017) for A203 with approximately 2.3 tonnes NIS/hectare for the high density increasing to 4.9 tonnes NIS/hectare 5 years after planting.

Second, there have been strong significant effects of planting density on NIS yield/hectare. The higher density treatments for both cultivars have tended to have greater yield/hectare than the lower density treatments. For example in 2019, the high density 741 plots produced approximately 2 tonnes NIS/hectare compared with 1.1 tonnes NIS/hectare for the low density plots, and the high density A203 produced 4.9 tonnes NIS/hectare compared with 2.9 tonnes NIS/ha for the low density.

The trellised plot, although not directly comparable to the main trial, showed both earlier yields and higher yields than the high density plots in the main trial. We hypothesise that this not only due to higher planting density, but also because the support of the trellis stimulated earlier growth and means trees expended less resources on support structures. The narrower canopies of the trees in the trellised plot may also have meant better light distribution within the canopy.

Third, the yield of A203 has generally been greater than for 741. For example, in 2018, the yield/hectare of A203 ranged from 1.6 to 2.9 tonnes NIS/hectare in the main trial and for 741 between approximately 0.5 and 1.5 tonnes NIS/hectare. The difference in yields for each density to date has been more dramatic for A203 than for 741.

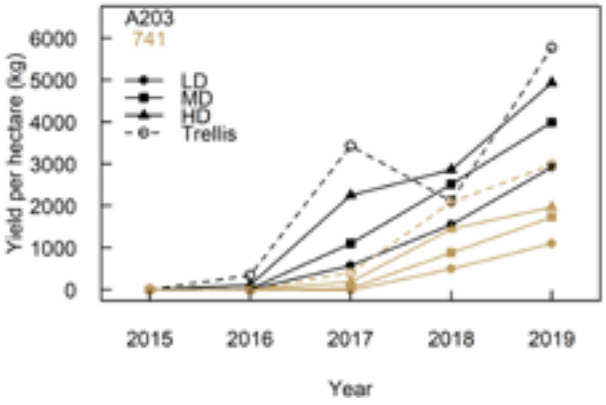


Figure 3. *NIS yield/hectare over time for the Macadamia Planting Systems Trial. Complete lines and solid symbols represent the main trial and dashed lines and open symbols represent the trellised plot. For the main trial, significant effects included cultivar, density, year and their interactions. For the trellised plot there were significant effects of cultivar, year and the interaction. Tree density treatments in the main trial are high density (HD), medium density (MD) and low density (LD).*

Drivers of early yield in macadamia orchard systems

Total light interception has been shown to be related to yield/hectare in a range of tree crops. In macadamia, yield/hectare has been shown to increase as total light interception increases from low up to moderate levels. At the highest levels of total light interception (above 90%), when orchard canopies have crowded, macadamia yield can decline (McFadyen et al. 2004).

In the Planting Systems Trial in 2019, NIS yield/hectare increased with total light interception up to the maximum recorded of 70–80 % (Figure 4). Higher tree density led to greater canopy volume/hectare early in the life of the orchard (Figure 1), which in turn led to greater total light interception and NIS yield/hectare.

Total light interception, however, is not the only consideration. For any given level of total light interception, the yield/hectare for A203 was greater than for 741. Part of the reason for this is that the raceme densities (racemes/canopy volume) were greater on the A203 trees and yield efficiency (NIS yield/canopy volume) increased with raceme density (see Figure 5). That is, the yield of some trees of both cultivars was still limited by raceme production.

For the same level of raceme density, the yield efficiency of A203 was greater than for 741 (see Figure 5). This indicates that A203 was either able to retain more nuts per raceme, the nuts it retained were larger, or both. The reasons for this are unclear.

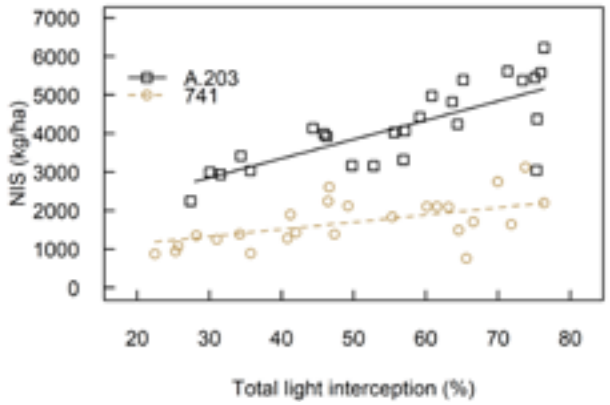


Figure 4. *The relationship between total light interception and NIS yield/hectare in the macadamia Planting Systems Trial in 2019. Each symbol represents one plot and all planting densities are included. There were significant effects of total light interception, variety and their interaction.*

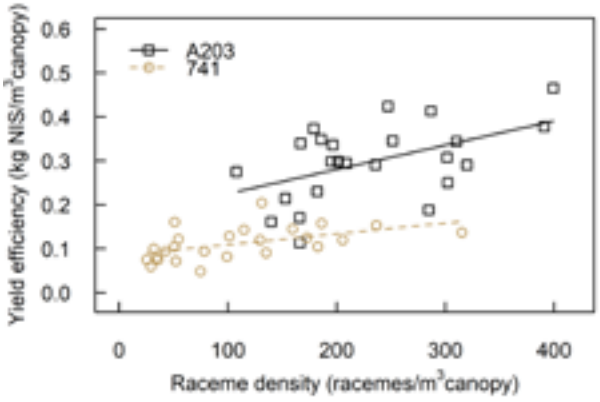


Figure 5. *The relationship between raceme density and yield efficiency in the macadamia Planting Systems Trial in 2018/19 cropping season. Each symbol represents one tree per plot and all planting densities are included. There were significant effects of raceme density and variety.*

Conclusions

We have been able to confirm our first hypothesis that high density macadamia plantings will lead to higher early yields. However, there are very large differences between the two cultivars and at 5 years after planting the NIS yield/hectare of the low density A203 is significantly greater than the high density 741 treatments in the main trial. This means that cultivar selection for high density plantings is extremely important if high early yields are to be achieved.

It will likely be several more years before the low density treatments reach canopy maturity, so we cannot yet address our second hypothesis on the effect of plant density on maximum macadamia yields.

At 5 years after planting we are still relatively early in the life of a macadamia orchard and so these results are still preliminary. Our major challenge over the coming years will be to manage the canopy crowding of the high density treatments and maintain the maximum yields once they are achieved. It remains to be seen how the more intensive systems will perform in later years.

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Wilkie JD, Hofman H, Griffin J, Parfitt C and Toegel H 2017, 'Early canopy development and yield in the macadamia planting systems trial', *Australian Macadamia Society News Bulletin:* 45 (3), 55–59.

Information

The *Small Tree – High Productivity Initiative* is an initiative of the Queensland Government. Major partners include the Department of Agriculture and Fisheries (DAF), DAF's research alliance with The University of Queensland (Queensland Alliance for Agriculture and Food Innovation), and the NSW Department of Primary Industries.

A key element of this initiative has been co-funded by Hort Innovation using the across horticulture levy and voluntary contributions from DAF and matching funds from the Australian Government through the Hort Innovation project *Transforming tropical/subtropical tree crop productivity.* We are especially grateful to Hort Innovation and the various associated industries and horticultural businesses for their support for this initiative.

Acknowledgements
We would also like to acknowledge the macadamia Planting Systems Trial advisory group: Kevin Steinhardt, Clayton Mattiazzi, Ray Norris, Kim Wilson, Scott Alcott and Dr Chris Searle.

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LIMB BENDING AND LIMB ANGLE

Dr Benjamin Toft, Dr Mobashwer Alam and A/Prof Bruce Topp (Centre for Horticultural Science, Queensland Alliance for Agriculture and Food Innovation, The University of Queensland) and Dr John Wilkie (Department of Agriculture and Fisheries, Queensland)

Project snapshot

We have been studying a number of macadamia trials in Bundaberg and the Sunshine Coast to better understand the responses of canopy growth, flowering and yield to natural limb and shoot angle and to limb bending, one method to manipulate shoot angles.

The relationships between limb angle and growth, flowering and productivity were promising. Manipulating limb angle through bending has limited benefits and is probably impractical for macadamia growers. However, manipulating limb angle through breeding should be possible and the potential for selective pruning techniques to produce more desirable shoot and limb angles should be investigated.



Tree structure and limb angle

Tree structures tend to be highly managed in intensively grown temperate tree crops. The purpose is to create an efficient canopy with optimal light distribution, sufficient fruiting sites to carry a high crop load and a low vigour canopy that will partition more resources to the fruit as opposed to shoot growth. Limb angle is an important consideration as part of the tree structure. In apple, for example, horizontal limbs tend to have reduced vegetative growth and increased flowering. Limb bending is one method used by apple growers to manipulate limb angle. Selected limbs are tied to the horizontal to create regular scaffold branches and the resulting upright lateral growth is pruned to provide an efficient canopy structure.

Macadamia growers have long been reporting that the horizontal limbs seem to carry more nuts than the upright limbs. This suggests that similar mechanisms to that in temperate tree crops might be at play in macadamia. These observations, in addition to the importance of limb angle in temperate tree crops, led us to set up experiments to observe the effect of natural limb and shoot angle on productivity and growth.

Limb bending trials

We set up experiments at Maroochy Research Facility and Bundaberg Research Stations to see if manipulating limb angle using techniques such as limb bending affected flowering and shoot growth. This work aimed to improve our understanding of the effect of limb and shoot angle on vegetative growth, fruiting, early flowering in young trees (precocity) and flowering in older trees. We also wanted to assess limb bending as a useful and practical management tool for macadamia growers.

At the Maroochy Research Facility, we used one of the Macadamia Breeding and Conservation team's trials to study the effects of canopy architecture across varieties on vegetative growth, flowering and nut set. The trial included 15 genotypes from natural and breeding populations that showed a high level of diversity in canopy structure (see Figure 1), including limb angle (see Figure 2). One of the things our

Figure 1: *Some diversity in branching patterns and tree size in a large breeding trial at Maroochy Research Facility.*



Figure 2. *Natural limb angle diversity in macadamia: examples of weeping (left) and upright (right) canopies. Part of another breeding trial at Maroochy Research Facility.*

analysis showed, was that the cultivars with horizontal limbs were likely to produce more racemes, retain more nuts and have a greater yield than the cultivars with more vertical limbs. Our analysis also showed that the horizontal limbs tended to have less extension growth than the vertical limbs.

At the Bundaberg Research Facility, we used the Macadamia Planting Systems Trial to understand the effect of architecture at the individual shoot level (individual flushes) on flowering and nut set in 741 and A203 trees. We found shoots oriented horizontally or below were more likely to produce racemes, set and retain nuts than more vertically oriented shoots (see Figure 3).

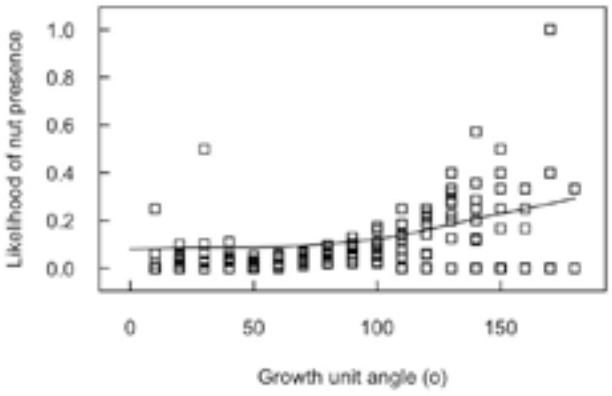


Figure 3. *Across the larger Planting Systems Trial at Bundaberg, the likelihood of a shoot having at least one raceme with at least one mature nut increased with the angle of the shoot from vertical in both cultivars A203 and 741. A growth unit is a section of a shoot formed from a single flushing event. An angle of 0° means the growth unit is oriented vertically up, an angle of 90° horizontal and an angle of 180° vertically down. A likelihood of 0 means the growth unit has no chance of producing a nut and a likelihood of 1 means the growth unit is almost certain to produce a nut.*

Manipulating limb angle

This research supports the relationships long recognised by growers, but how can we use them to improve our orchards?

In apple orchards, growers manipulate limb angle by physically bending limbs in the canopy, securing malleable branches to a trellis or to lower branches. Over recent years we have been trying to replicate this practice in our macadamia trials. In the extra high density (1,481 trees/ha) trellised plot of the Macadamia Planting Systems Trial, we looked at the effect of bending limbs in 741s and A203s on early flowering, yield and vegetative growth. On the young trees (1–2 years since planting), all main limbs from the trunk were tied to the horizontal. When limbs were bent, we found they grew less from the apex (less elongation of the limb) but there was more branching compared with the unbent limbs (Figure 4). However, over the first 2 years of flowering since planting,



Figure 4. *Branching along the shoot and reduced apical growth in response to limb bending. From the extra high density trellised portion of the macadamia Planting Systems Trial in Bundaberg where we looked at limb bending in young trees.*

the whole-tree raceme count and yield were not significantly influenced by limb bending treatments. Without pruning, the new branching from the bent limbs quickly became complex and overgrown, due to vigorous multiple flushing each year. It is possible that the stimulation of vigorous branching by bending may have obscured any beneficial effect on flowering and yield.

Timing of limb bending

In a separate study, we looked at the timing of limb bending. In this study we compared bending single limbs within mature A4 tree canopies (6 years since planting), at different times on flowering and vegetative growth. We found that when we bent limbs around the time of floral initiation (late May), those limbs produced double the number of racemes compared with unbent limbs or limbs bent in February.

Limb bending increased flowering only when bending occurred around the time of floral initiation. Therefore, the response to limb bending is dependent on the timing. It is possible that we may have been able to increase precocious flowering in the macadamia trellis limb bending experiment, above, if we had bent the limbs at the correct time. It is also possible that in macadamia, properly timed limb bending can increase flowering in mature trees but cannot increase early flowering (precociousness) in young trees. The limb bending experiments suggested that some responses, which are exploited by growers of temperate trees to manage vigour and improve flowering, may also be present in macadamia. However, in terms of current cultivars and existing orchards, limb bending is likely to be an impractical management method with limited benefits. Another possible method to manipulate limb angle might be to use selective pruning techniques that favour horizontal limbs and gradually remove upright limbs to improve the relative number of horizontal limbs in the canopy, although this needs to be tested.

Conclusions

Our studies found that limb angle and other useful traits, such as raceme length, tend to have a relatively high heritability value, suggesting it should be possible to alter these characteristics through selective breeding. As breeders select for more horizontal canopy architecture, the varieties of the future may be more easily managed with less limb manipulation needed.

Future increases in orchard productivity will be dependent on improving the efficiency of orchard canopies (i.e. reduced growth, increased yield). Breeding for useful characteristics such as canopy architecture (including limb angle) and canopy vigour (low vigour scion and rootstock varieties) may be equally as important as developing improved management practices, and may lead to more efficient canopy management options.

Information
The Small Tree – High Productivity Initiative is an initiative of the Queensland Government. Major partners include the Department of Agriculture and Fisheries (DAF), DAF's research alliance with The University of Queensland (Queensland Alliance for Agriculture and Food Innovation), and the NSW Department of Primary Industries.

A key element of this initiative has been co-funded by Hort Innovation using the across horticulture levy and voluntary contributions from DAF and matching funds from the Australian Government through the Hort Innovation project Transforming tropical/subtropical tree crop productivity. We are especially grateful to Hort Innovation and the various associated industries and horticultural businesses for their support for this initiative.

Acknowledgements
We thank Carola Parfitt, Jarrad Griffin and Helen Hofman (DAF) and Hanna Toegel (QAAFI) for architectural assessments in the macadamia Planting Systems Trial. We also thank Dr Neil White (DAF) for developing tools and techniques for our architectural analysis. Associate Professor Jim Hanan and Dr Inigo Auzmendi (QAAFI) were advisors of the PhD.

Most of the work presented in this article was undertaken as part of Benjamin Toft's PhD studies. If you are interested to learn more, his thesis can be downloaded from: https://doi.org/10.14264/uql.2019.351 or email benjamintoft@icloud.com.



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PRUNING AND COMPETITION IN MACADAMIA

Hanna Toegel and Dr Jim Hanan (Centre for Horticultural Science, Queensland Alliance for Food and Agriculture Innovation, The University of Queensland), Dr John Wilkie (Department of Agriculture and Fisheries, Queensland) and Prof Phil Brown (Central Queensland University)

Project snapshot

As part of the *Small Tree – High Productivity Initiative,* two trials in Bundaberg looked at competition between shoots and nuts in macadamia trees and implications for the timing of hedging and other canopy management measures.

Different parts of a macadamia tree compete with one another for resources. Hanna and her team set out to see if they could increase the flow of resources towards nuts, rather than shoots. In particular, how the tree determines which part of the plant receives resources.

Their results suggest that it is indeed possible to influence the distribution of resources in macadamia trees using techniques like pruning. However, more research is needed to better understand how resources are allocated to shoots and nuts, to identify improved hedging and pruning times, and to understand other canopy management options.

Their work supports the current recommendations for hedging during November to December in northern New South Wales. Future work will compare results for late hedging with the current industry preference for winter hedging in the Bundaberg region.

It is an open secret that plant organs within a macadamia tree (such as a shoot or a nut) compete with each other for a limited amount of resources.

Usually, the tree determines the outcome of this competition, but is it possible to influence it through management practices? Can we tilt the balance in favour of an increased flow of resources towards nuts, rather than shoots?

This could potentially kill two birds with one stone: It could support nut development and thus increase yield, while reducing shoot growth, thereby addressing some of the issues that are associated with either a crowded orchard (such as reduced spray penetration) or traditional hedging (reduced yield).

The most important question we wanted to answer was how the tree determines which organ receives resources. We found clues in past research into the timing of hedging. McFadyen et al. (2012) found that hedging at certain times of the year had less impact on yield than at other times. That study was conducted in northern NSW and exact timings would be specific to that area. However, the overall conclusion was that trees performed better when the post-pruning flush emerged only as the early fruit drop period was coming to an end.

Our hypothesis centred around the timing of growth of one organ, relative to another. Both shoots and nuts generally grow slowly at the beginning, before reaching a phase of rapid growth. According to our hypothesis, a shoot or nut in this rapid growth phase is particularly successful at securing resources and can out-compete an organ in a slow growth phase. It was up to us to create different combinations of slow and rapid growth in nuts and shoots within individual trees and track the effects on shoot growth and nut development.

First trial: competition between shoots

Our first trial aimed to lay the groundwork by looking at competition between shoots on young 741 trees that had not yet commenced bearing. The majority of shoots on each tree were made to start growing simultaneously by tip-pruning around the entire canopy, leaving only two shoots intact. These two shoots were tip-pruned later and therefore started growing later, relative to the majority. In the different treatments, the interval between these two tip-

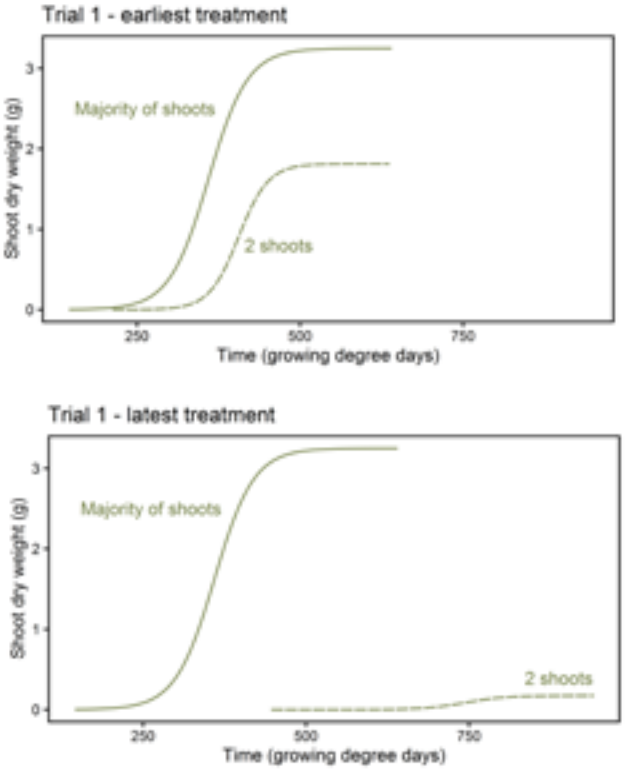


Figure 1: *Results from the earliest (top) and latest (bottom) treatments of the first trial. The development of shoot dry weight (converted from shoot length) over time, for the majority of shoots and the two shoots that were tip-pruned later.*

prunings varied, thus creating varying amounts of competition between the majority of shoots and the two later shoots. When comparing the earliest treatment (in which the two shoots were tip-pruned only 5 days after the majority) with the latest treatment (19 days between tip-prunings), the difference becomes obvious.

In the earliest treatment of this trial, the two shoots started growing just after the majority (see Figure 1). Their rapid growth phase was therefore only slightly delayed, and they grew to be almost as long as the majority of shoots. In the latest treatment, the majority had reached rapid growth by the time the two shoots were slowly starting to grow. Therefore, the two shoots had a competitive disadvantage and remained short. These results show that the competition between shoots can be influenced and the growth of individual shoots can be reduced through manipulation.

Second trial: competition between shoots and nuts

Based on these findings, we designed a second trial that focused on the competition between shoots and nuts on A203 trees. The setup was similar to the first trial, but this time the entire canopy of each tree was tip-pruned. A new round of trees was tip-pruned every two weeks, starting 4 weeks before, and ending four weeks after full bloom. In the earliest treatment, we saw rapid shoot growth coincide with early, slow nut growth (see Figure 2). In this case, shoots competed strongly and grew long. Nuts, on the other hand, dropped in large numbers, causing the trees in this treatment to have a relatively low yield. The effect we saw in the latest treatment was quite different. Nuts had reached rapid growth by the time shoots were slowly beginning to grow. Consequently, nuts competed strongly. They remained on the trees while shoot growth was reduced. The results from both treatments were consistent with our hypothesis and showed that it is indeed possible to influence the distribution of resources in macadamia trees.

Looking at yield adds another piece to the story. The difference in yield between trees of an unpruned control treatment and ones of the latest pruning treatment was statistically not significant. The yield of all other treatments was lower, with the lowest yield from the trees that were tip-pruned at full bloom (see Figure 3). In conclusion, trees of the latest treatment, which were tip-pruned in late October, produced a yield similar to unpruned trees, while at the same time showing reduced shoot growth, compared to the earlier treatments.

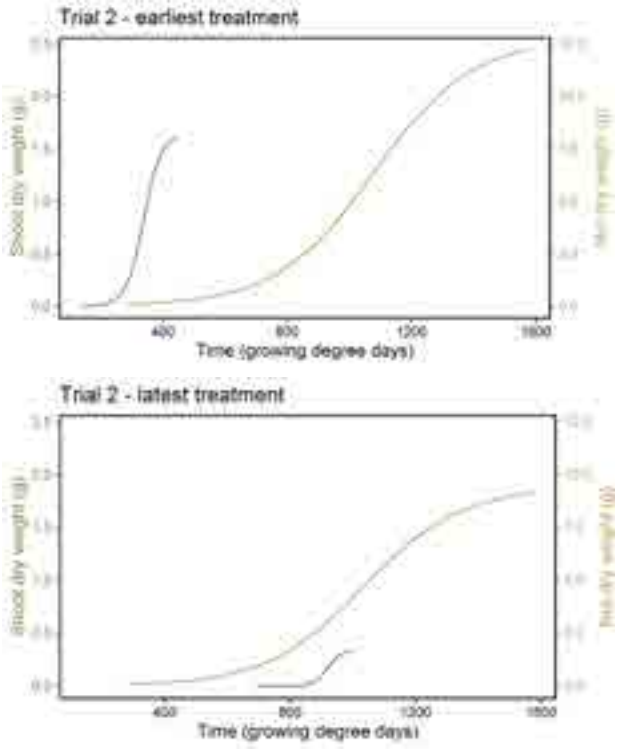


Figure 2: *Results from the earliest (top) and latest (bottom) treatments of the second trial. The development of shoot dry weight and nut dry weight over time.*

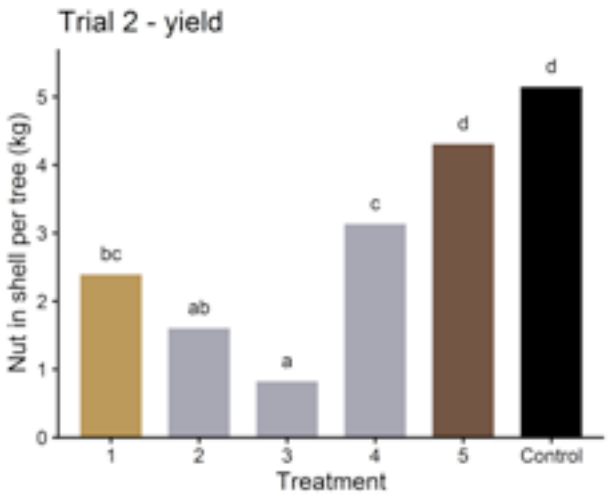


Figure 3: *Final NIS yield per tree for trial 2. The coloured bars represent the five treatments (1 being the earliest; 5 being the latest) and the control. The letters above the bars represent the statistical significances – if the letters are different, the difference between the means is statistically significant at the 95% confidence level.*

Informatiion
See the *Small Tree - High Productivity Initiative* information on page 68. Trial 2 was part of an honours project with Central Queensland University.

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Where to from here?

These studies have provided us with valuable insight into macadamia's physiology and showed that we can manipulate nut retention and yield through canopy management. However, more research is required before we can consider making any changes to existing recommendations for hedging times. For northern NSW, the conclusions from our work support the current recommendations for hedging during November or December. For Bundaberg, we have not yet compared this late hedging with the current industry preference for winter hedging. Other aspects, such as long-term effects, have yet to be investigated as well. We hope to continue working on this matter in order to even better understand how resources are allocated to shoots and nuts, to identify improved hedging times, and to understand implications for other canopy management options such as selective pruning and growth regulators.

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R&D PROJECTS : YOUR LEVIES AT WORK

The industry levy collected by the Levies Revenue Service (LRS) goes to: 1) the National Residue Survey (NRS) for residue testing, and 2) Hort Innovation. Hort Innovation administers the levy on behalf of the government according to our industry strategic plan. Currently the levy funds from Hort Innovation are channelled into: a) marketing and promotion, b) research and development (which is matched dollar-for-dollar by the Commonwealth Government).

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

Project no.	Project name	Delivery partner	Expected end date (subject to change)
Macadamia Fund investments: levy projects			
MCI3008	Biology, species and genetic diversity of macadamia lace bugs	University of New South Wales	May 2019
MCI4000	Macadamia second generation breeding and conservation	The University of Queensland	Dec 2019
MCI5004	Australian macadamia industry innovation and adoption program	Australian Macadamia Society	Feb 2021
MCI6000	Innovation rootstocks for the Australian macadamia industry	Qld Department of Agriculture and Fisheries	Dec 2021
MCI6002	Macadamia industry minor use program	Hort Innovation	Ongoing
MCI6004	IPM program for the Australian macadamia industry: NSW DPI	NSW Department of Primary Industries	Oct 2021
MCI6005	IPM program for the Australian macadamia industry: Qld DAF	Qld Department of Agriculture and Fisheries	Sep 2021
MCI6006	IPM program for the Australian macadamia industry: IPM Technologies	IPM Technologies	Oct 2021
MCI6007	IPM program for the Australian macadamia industry: University of Sunshine Coast	University of the Sunshine Coast	Jul 2021
MCI6008	IPM program for the Australian macadamia industry: BioResources	BioResources	Apr 2020
MCI6018	Macadamia integrated disease management	The University of Queensland	May 2022
MCI7001	Developing a macadamia industry tree stock standard	Nursery & Garden Industry Australia	Jun 2019
MCI7005	The effect of macadamia nuts on cardiometabolic risk factors and adiposity: a randomised intervention study	Loma Linda University	Jun 2020
MCI7006	Macadamia regional variety trials series 4	Qld Department of Agriculture and Fisheries	Aug 2026
MCI7007	Generation of pesticide data – *Sigastus weevil* [1]	Peracto	Jul 2019
MCI8000	Australian macadamia communication program	Australian Macadamia Society	Feb 2022
MCI8002	Benchmarking the macadamia industry 2019–2021	Qld Department of Agriculture and Fisheries	Mar 2022
MCI8003	Macadamia crop forecasting 2020–2022	Qld Department of Agriculture and Fisheries	Apr 2022
MT16005	Enhanced National Bee Pest Surveillance Program	Plant Health Australia	Dec 2021
MT17015	Consumer behavioural and retail data for fresh produce	Nielsen	Mar 2021
ST16006	Generation of residue, efficacy and crop safety data for pesticide applications in horticulture crops 2017	Eurofins Agrisearch	Feb 2020
Macadamia Fund investments: voluntary contribution projects			
MCI3014	Macadamia: propagation and precocity	Plant & Food Research Australia	Nov 2018
MCI5007	Still wild about macadamias: conserving a national icon	SEQ Catchments Limited	Apr 2019
MCI5008	Establishing an open-source platform for unravelling the genetics of macadamia: integration of linkage and genome maps	Southern Cross University	Apr 2019

[1] Now called macadamia seed weevil.

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

AUSTRALIAN MACADAMIA MINOR USE PERMITS

Current at November 2019

Chemical	Permit no.	Pest/Disease use	Application rate	Withholding period (days)
ABAMECTIN	PER87510	Thrips and flat or broad mites	Product containing 18 g/L abamectin: 750 mL product/ha plus 5 L summer spray oil/ha Product containing 36 g/L abamectin: 375 mL product/ha plus 5 L summer spray oil/ha	28
ACEPHATE	PER81463	Macadamia seed weevil	Product containing 970 g/kg acephate: 80 g/100 L Product containing 750 g/kg acephate: 100 g/100 L	Harvest Not required when used as directed
CHLORPYRIFOS AND 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: 1.4 or 1.9 L/ha Product containing 1,000 g/L maldison: 600 or 850 mL/ha Product containing 1,150 g/L maldison: 520 or 750 mL/ha	Chlorpyrifos: 30 Maldison: Not required when used as directed
DIAZINON	PER14276	Macadamia lace bug	Product containing 800 g/L diazinon: 120 mL product/100 L	14
ETHEPHON	PER11462	Promote nut fall after maturity reached	Product containing 480 g/L ethephon: 65–250 mL/100 L water	7
INDOXACARB	PER86827	Macadamia seed weevil	Product containing 150 g/L indoxacarb: 50 mL product/100 L Product containing 300 g/kg indoxacarb: 25 g product/100 L	42
METHOMYL	PER12796	Banana caterpillar	Product containing 225 g/L methomyl: 1.5– 2 L/ha Spraying ground mulch/soil surface up to treelines only	Not required when used as directed
PETROLEUM OIL	PER11635	Macadamia felted coccid	Product containing between 763 and 861 g/L petroleum oil: 1 L/100 L water	Not required when used as directed
TRICHLORFON	PER13689	Macadamia lace bug, fruit spotting bug, banana spotting bug and green vegetable bug	Product containing 500 g/L trichlorfon: 200 mL/100 L	2

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. This table is also available to download and print from the AMS website (Resources tab).

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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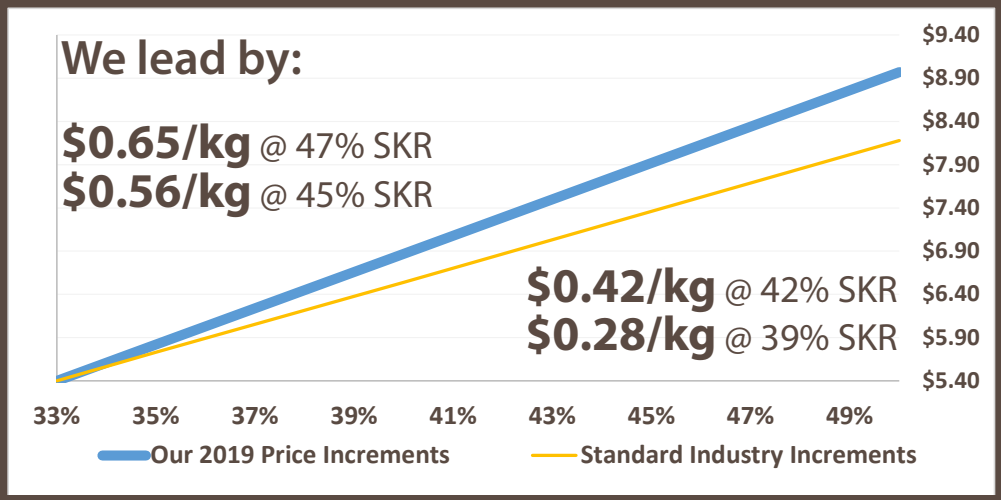
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CHAT WITH OUR TEAM TODAY:

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