AUSTRALIAN MACADAMIA SOCIETY

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NEWS BULLETIN

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Bachelor of Science (Geology,
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a Masters of Agribusiness Management.

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AUSTRALIAN MACADAMIA SOCIETY

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Front cover. There have been many lessons for Robbie Commens in developing Salt Spray Farms on the floodplain at East Wardell. Robbie (pictured with his pal, Charlie) describes his journey so far on page 15.

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Hort Innovation Strategic levy investment | MACADAMIA FUND

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Our Mission

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

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What's On

DATE	EVENT	LOCATION	CONTACT
MacGroups			
Wed 3 March 9am – 12.30pm 1pm – 4.30pm	Northern Rivers (Plateau)	Summerland House Farm, 253 Wardell Road, Alstonville	AMS: 1800 262 426 office@macadamias.org https://australianmacadamias.org/industry/events
Thurs 4 March 1pm – 4.30pm	Northern Rivers (Coastal)	Evans Head RSL Club, 11-13 McDonalds Place, Evans Head	
Fri 5 March 9am – 12.30pm	Mid North Coast	Nambucca Heads Island Golf Club, Stuart Island, Nambucca Heads	
Tues 9 March 9am – 12.30pm	Glass House Mountains	Glass House Mountains Community Hall, 8 Coonowrin Road, Glass House Mountains	
Wed 10 March 9am – 12.30pm	Gympie	Chatsworth Hall, 3 Allen Road, Chatsworth	
Thurs 11 March 9am – 12.30pm	Bundaberg	Bundaberg Multiplex, 1 Civic Avenue, Bundaberg	
Mon 1 March	Norm Greber Award nominations open		
Fri 30 April	Nominations close		
Mon 11 May	AMS Board meeting	TBA	AMS: 1800 262 426
Tues 12 May	Australian Macadamia Handlers Association (AMHA) meeting	Brisbane	Jacqui Price Marketing Manager 0424 107 731 jacqui.price@macadamias.org

CEO's report



Last year was one few of us will forget, however much we would like to. And yet in many ways, it was a good one for our industry. Thankfully, none of the growing regions were significantly affected by COVID infections and it is a great credit to all the processing facilities that despite a number of factories across Australia becoming hot spots of infection, macadamia processing plants remained free from cases and maintained their high food and employee safety records.

This year has also started well, with good rains in most regions leading to a crop that looks like it will at least equal that of 2020. Most growers in both NSW and Queensland are reporting a good crop with well sized nuts. Let's hope the forecast rain does not interfere with harvest.

However, there is no doubt that things remain uncertain with cases of the virus likely to appear from time to time at any location until widespread vaccination is complete. The market is certainly reflecting this uncertainty with some delays and interruptions in shipping and some market sectors associated with travel, food service and hospitality showing some softening. Ongoing uncertainty over trade with China is adding to the mix. It is likely that farm gate prices will reflect these circumstances.

If you have not been giving increased productivity your 100% focus, it is not too late with a number of excellent articles in this edition of the Bulletin. Raising productivity is the best way individual growers can manage the risk of uncertain prices and I am confident you will enjoy reading the many insights shared by Robbie Commens, Michael Jenvey, Johan Jacobs, Scott Allcott, Jason Klotz, Mike Cooper and Lance Emery in this issue. Our thanks to these growers for their willingness to share their knowledge and experience with our readers.

The AusMac conference has been rescheduled to November 2021. Thank you to all those delegates, sponsors and exhibitors who booked for 2020 and have retained their commitment. I am delighted to announce that through a business event grant from the Department of Industry, Science, Energy and Resources, many exhibitors, sponsors and farm businesses could be eligible for a 50% rebate on the costs of participation. The same great AusMac conference at half the price!

I am sure your patience and faith will be well rewarded with what is set to be a fantastic event back at Royal Pines on the Gold Coast, the venue for the very successful AusMac 2018.

Hopefully by the time you are reading this, your processor will have contacted you, seeking your support for the Maccelerate program and the voluntary marketing fund. This is one of the most important initiatives the AMS has launched and your participation is vital if the Australian industry is to enjoy sustainable pricing over the coming decade. It is never easy to part with hard-earned dollars, but this is one of the most important investments in protecting your income that you can make. Without global coordination and demand stimulation, the downward pressure on prices may be inevitable.

If you have not been approached by your processor, please contact me and the AMS can arrange for you to contribute and be part of a stronger future for our industry.

Jolyon Burnett, CEO

Reduced withholding period for Agri-Fos 600

Agrichem has announced that its class leading fungicide Agri-Fos 600 has been granted a reduced withholding period (WHP) for macadamia trees from 28 days down to 14 days.

This change gives macadamia growers greater flexibility when applying Agri-Fos 600 to Phytophthora affected trees.

Agrichem will be updating labels to display a 14-day WHP, under APVMA Approval No. 54430/126557.

Clarifying the Agri-Fos label

A number of growers have pointed out to both the AMS and Agrichem that the wording in the macadamia trunk application section of the Agri-Fos 600 label is causing confusion about the correct trunk application rate and correct method of trunk application.

Agrichem has confirmed:

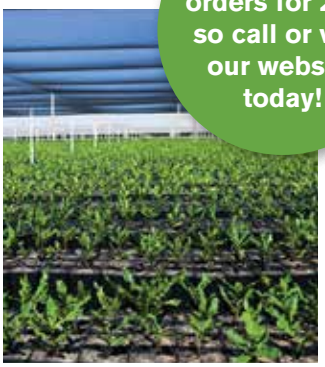
1. The correct dilution rate of Agri-Fos 600 for macadamia trunk application is:
   334 mL of Agri-Fos 600 mixed with 666 mL of water,
   or **1 part Agri-Fos 600 plus 2 parts water.**
2. In the Critical Comments section for macadamia trunk application, the comment "Trunk is to be wet at the time of application." is misleading. It is simply to reinforce the need to ensure that thorough coverage of the trunk occurs during application of the trunk spray solution. **The trunk DOES NOT need to be wet before applying the spray solution.**

To eliminate this confusion, Agrichem has indicated it will be applying to the APVMA for changes to wording in the macadamia trunk application section of the Agri-Fos 600 label.

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Australian industry proves resilient after challenging 12 months

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

Supply

The 2020 global crop finished at approximately 230,000 tonnes (in-shell, 3.5% moisture), marginally up on the 2019 season. The Australian macadamia crop finished at 46,900 tonnes in-shell at 3.5% moisture (50,300 tonnes in-shell at 10% moisture). Overall, Australian macadamia orchards weathered the drought conditions well, proving how naturally resilient these native trees are, and all growing regions performed better than anticipated.

At the time of writing and in advance of the official estimates for the 2021 season, indications in Australia are that weather conditions have been favourable and early estimates are for a crop in line with the 2020 season.

Macadamias South Africa (SAMAC) reported their 2020 season ended at 46,256 tonnes, 21.5% lower than 2019. However, reports are the 2021 season is looking promising despite some regions suffering adverse weather events. Industry sources estimate the 2021 South African crop will reach around 60-65,000 tonnes.

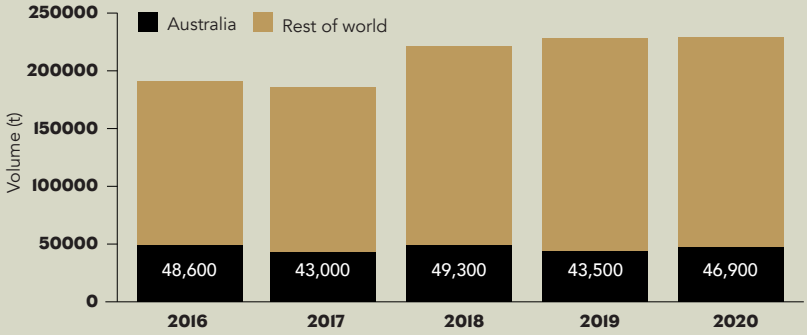


Figure 1.Global macadamia crop volumes 2016-2020 (tonnes).
Source: INC. All volumes are at 3.5% MC.

Demand

The effects of COVID-19 continue to be felt around the globe, with challenges around changing consumer behaviour and supply chain disruptions reflected in the latest import data. The ongoing impact on imports varies by country. US demand is being dampened by reduced out-of-home consumption and ongoing international travel restrictions have seen the Hawaiian crop consumed domestically as opposed to its traditional usage in the travel retail sector, contributing to increased price competition.

However, imports to Europe and several key Asian countries are improving. In shell imports to China increased 18% MAT and kernel imports are 5% ahead of the prior MAT period and up 36% for the July to November period versus prior year. Australia's market share in priority markets continues to hold, placing the industry in a strong position once the situation begins to normalise.

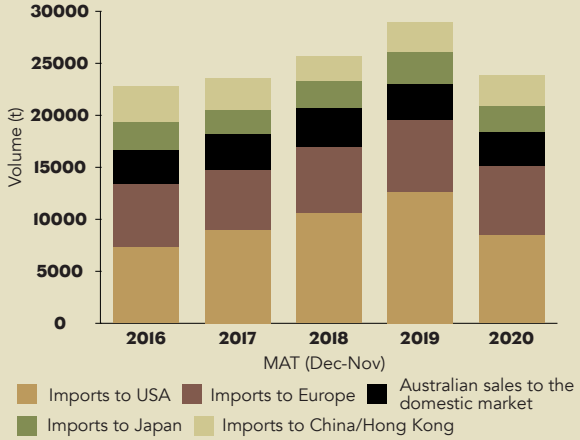


Figure 2. Macadamia kernel imports to top 5 markets (tonnes) MAT December to November.
Sources: USDA, Eurostat, Japan Customs, China Customs, Hong Kong Census & Statistics Department via HIS Markit Inc, AMHA.

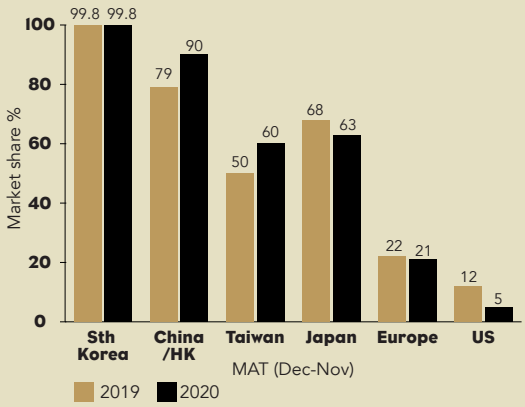


Figure 3. Australian market share of macadamia kernel imports (tonnes) MAT December to November.
Sources: USDA, Eurostat, Japan Customs, China Customs, Hong Kong Census & Statistics Department via HIS Markit Inc.

Australian sales

Overall, the Australian industry is proving resilient, as highlighted by the solid market share in key markets (Figure 3). Due to the quality standing of Australian macadamias and the strong commercial relationships in place, Australian kernel sales continue to improve in key markets. AMHA data indicates ongoing strong sales to China, a promising improvement in sales levels to the US market in Q4, and a slower return than anticipated in Japan.

Looking ahead in 2021, a key challenge for the Australian industry will be the weakening US dollar and a corresponding strengthening of the Australian dollar, which may lead to increased price competition in key export markets.

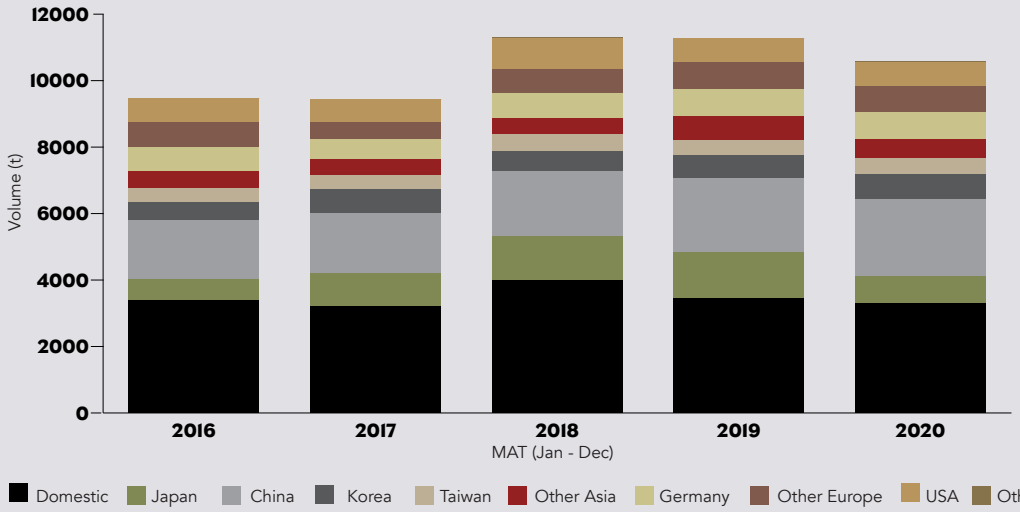


Figure 4. Australian macadamia kernel sales (tonnes) MAT (January - December). Source: AMHA. AMHA represents 97.5% production, sales are adjusted to represent non-AMHA members.

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Vale Edward Richard Davenport (Ted) 1932 – 2021

Ian McConachie



Ted Davenport was a larrikin, raconteur, friend, macadamia pioneer and gentleman.

Ted or Teddy Davenport was a larger than life macadamia champion who passed away on 18 January 2021. He was widely known and much respected by those of us who have been part of the global macadamia world for many years. He will always be remembered for his eloquent dress, his wit and wisdom, a twinkle in his eye, his friendship and his enormous contribution to macadamias.

Growing up in wartime England as a copy boy at Fleet Street, Ted at 18 boarded a ship for the adventure of his life as a five pound Pom. His mother's parting words as he left were 'beware of the wild women in Australia', a thought which sustained him on the long voyage. His first, very short job was in 1950 at Currumbin Creek where at the bottom end of a flying fox, he dropped the first two bunches of bananas. He then worked on soldier resettlement schemes in the Burdekin and the Atherton Tablelands and in other labouring jobs.

He studied at Gatton College, graduating as dux. His potential was recognised by the Colonial Sugar Refinery Company (CSR Limited) which supported him in obtaining a degree in agricultural science, a job in Fiji, and then in 1972, appointing him as Chief Sugar Agronomist for Fiji.

In 1963, when the 70 tonne annual NIS Australian macadamia industry was little more than a cottage industry, CSR started commercialising the industry by investing in research, establishing 80,000 trees at five orchards at Maleny, Mt Bauple and Baffle Creek and purchasing the Angus processing factory.

Ted transferred to the Macadamia Activity Division in 1971 and moved to Queensland in 1977 as Manager of all things macadamia. At CSR, Ted initiated and funded almost all early industry research, established a modern nursery, developed a largely unknown crop, and moved the processing factory to Sunshine Plantations at Woombye where it became MacFarms of Australia. He engaged and trained many people who became future leaders.

Ted served on the Australian Macadamia Society Board for 23 years, led coordinated marketing proposals and twice successfully represented the industry against allegations of 'dumping' by the International Trade Commission of the USA.

In 1983 he hosted Prince Charles and Princess Diana over MacFarms on the nutmobile. He also was the creative handicapper at AMS golf days.

When CSR sold its macadamia business, Ted resigned and on the death of Frank Rivers, the Australian Macadamia Society Secretary became Executive Officer and with his wife Anne handled management and administration. Ted became the public face of the AMS and its spokesperson.

He was made an Honorary Life Member in 1994, was awarded the Graham Gregory Medal for contributions to horticulture and was on the Board of the Horticulture Research and Development Corporation, the predecessor of Horticulture Innovation Australia. He was the longest serving member on the Governing Council of the University of Queensland at its Gatton campus.

In his spare time, Ted was a member of Rotary for 50 years, Vice Commodore of the Moreton Bay Yacht Club, knew every mud bank in the bay and was an avid caravanner and lover of life.

He was doubly lucky in marriage and on the passing of the much loved Anne, later enjoyed a new chapter with Kerry for 22 years. He is survived by Kerry, his daughter Jennifer and stepchildren Tony and Helen.

Ted's life story is filled with legends. He was never without his bow tie even at his funeral, where almost all the men were sporting one. His coffin was decorated with macadamias branches. He dressed with casual, elegant, sartorial splendour. He was a raconteur extraordinaire, a visionary and friend to so many.

His gift for words started in childhood where he created the family catchphrase when things went wrong of 'Bugger Hitler'. Later, he would say 'Can we order the wine with a great sense of urgency?', 'Just a little drop more', and 'We probably won't get out of this world alive'. He was often punished at Rotary by having to sit in the 'grumpy chair' and claiming his penance as 'outrageous'.



Ted Davenport was never without his bow tie, even at his funeral.

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Leoni's orchard rounds

Leoni Kojetin Industry Development Manager, AMS **M:** 0433 007 925 **E:** leoni.kojetin@macadamias.org

The first harvests of 2021 are off to a promising start, even though flowering and nutset at the start of the season can be described as variable. Many regions have received good rainfall and favourable growing conditions as we emerge from the dry 2020 season. Unfortunately, this is not the case for everyone, with Central Queensland remaining relatively dry and receiving significantly less rain than South East Queensland. In contrast, the NSW Mid North Coast and some parts of the Northern Rivers have experienced deluges over oil accumulation.

Comparing macadamia growing regions, the total yearly rainfall for one farm south of Bundaberg was 599 mm in 2020, while another farm near Nambucca Heads recorded well in excess of that over two days in December 2020 and an annual total of 2035 mm. With a La Niña year predicted for 2021, this will surely play out very differently over our growing regions. (Read more about this weather prediction and what it means in an article by Dr Chelsea Jarvis on page 48).

In preparation for a successful harvest season, many growers are adopting new systems to better understand yield and quantify crop loss. There has been an expansion in the use of technologies that assist with yield monitoring, mostly harvester-based tracking systems which give an accurate picture of block or row yield with some pinpointing crop down to individual trees.

Another aspect of the bigger picture is quantifying where crop was lost over the season and I encourage growers to engage with their grower liaison officers to decide which crop loss protocol they will be using and implement this at the start of the season. The most basic form is a review of consignment reports, but this is only a small part of the overall loss. Being part of the benchmarking project provides an individual farm report and small group discussion that many growers find valuable.

True losses mean that nut won't even make it to the shed, let alone through to the factory. The holy grail is obviously a system that quantifies potential crop not even set due to in-field factors and losses during the growing season all the way to post harvest quality deterioration, but as a young industry, we are still formulating this concept.

One system growers find useful is a simple classification of rejects. Researcher Neil Trevverow developed three protocols as part of a 2003 project "Establishing crop loss assessment protocols". The shed-based 100 nut sample from the reject bin is a quick way to quantify each loss down to a dollar figure per tonne.

The reject nut monitoring board (pictured top right) shows a number of in-field losses which never make it to the factory. Losses such as rat eaten nuts, which account for five out of 100 nuts (5%) from the reject bin in the example below, represent at least two to five times as many nuts lost in the orchard according to research. At a price of $5.00/kg, this 5% equates to losses of $250 per tonne and is obviously much higher when taking the orchard losses into account.



This is the reject nut monitoring board used by Gympie growers, Aimee and James Thomas.

Many lightweight defects which are blown or swept away or are unable to be picked up are difficult to quantify. Taking immaturity as an example, true levels are skewed by their factory reported unformed/shrivelled weight which is a fraction of saleable kernel weight.

To assist growers with their own crop loss protocols, the AMS has developed a fact sheet which can be downloaded from our website. The table (opposite) is a snapshot from the full version.

On page 49 you will find part one of a series of articles on understanding the nature of macadamia and how that informs management. This will also be a theme at our upcoming MacGroups in March where I look forward to seeing you.

Leoni

Visual	Defect	Distinguishing features	Evaluation	Control
Large holes in nuts 	**Rats**	Empty shell, large hole with distinct bevelled edges and teeth marks can be present	1 nut in the shed represents roughly 2 to 5 in the orchard	Rat management program with baiting/ orchard clean up and targeting hotspots
Medium to large holes in nuts 	**FSB/BSB** Damage before shell hardening	Large mark/hole often with black membrane Soft sunken area - weak spot can be further damaged mechanically	Pre shell hardening damage can be indicative of large in field losses that don't make it to shed	Occurs Oct to Dec In consultation with pest consultant check calibration, spray coverage and timing. Hotspot monitoring
Small holes in nuts 	Damage after shell hardening	Smaller holes, hard to see Small light brown pinpoint marks	Damage after hardening often difficult to see in shed but will be apparent in factory results (Damage can look like Leptocoris/ GVB)	Dec onwards through to harvest in thin shelled cultivars. If you must spray, be mindful of withholding periods during harvest. Worse in dark, overcrowded, tall orchards
Small holes in nuts 	**MNB**	Round, 2-3mm uniform holes with clean straight edges, usually only one	Potentially more damage in the field than seen in shed. Secondary damage such as mould can occur if left in orchard	With pest consultant check calibration, coverage and timing. Implement bio controls. Put Mactrix cards out from pea size regularly/uniformly and around boundaries Worse in dark/overcrowded/orchard
Pinholes in nuts 	**Boring beetles**	One but often many small pinholes	Potentially more damage in the field Secondary damage such as mould can occur if left in orchard	With pest consultant discuss IPM cultural control measures Remove and burn/finely chip dead or infested trees
Holes on one end of nut 	**Open micropyle**	Physiological defect seen as singular round to oval hole at one end of nut often with a distinct white margin	Secondary damage such as mould can occur if left in orchard Allows entry of pests such as MNB/kernel grub/beetles	More prone in cultivars such as 246 and H2 More frequent/rapid harvesting reduces potential for secondary damage
Cracks/holes in nuts/shell remnants 	**Mechanical damage**	Jagged edges, non-uniform damage	When seen stop equipment in field and shed, look for white kernel/shells in field	Can be worse in some seasons due to varying shell thickness Audit machinery, checking augers/cages/ dehuskers
Cracks in nuts/ shell remnants 	**Pigs**	Half shells or broken pieces	Often not picked up by fingerwheels or blown out in field	Implement monitoring program Look for broken white nut/shells and obvious pig damage to orchard floor Control could include fencing/baiting/ trapping
Cracks in nuts/ shell remnants 	**Cockatoos**	Often half shells broken along suture line	Often not picked up by fingerwheels or blown out in field	Scare techniques A permit is required to shoot cockatoos
Cracks in nuts 	**Germination**	Cracks in shell along suture line	Secondary damage such as mould can occur if left in orchard Germination can progress to roots/shoots developing	Seasonal variability, some cultivars prone such as 660 More frequent harvesting reduces germination potential Worse in dark/wet/overcrowded orchards
Pale shells and small nuts 	**Immature**	Pale light brown shells/ smaller nuts	Often lightweight and blown away in field Factory report levels often indicate only a fraction of actual loss Can be due to dry conditions/out-of-season flowering/fungal diseases such as husk spot/husk rot	Seasonal variable, reduce water stress Improve irrigation/soil health/increase organic matter Consider tree shaking for sticktight/husk spot control Some cultivars more prone to out-of-season flowering/sticktights/ husk spot/husk rot
Tan brown/ oily nuts 	**Older nuts**	Tan brown/oily feel on handling	Usually late season nuts where kernel begins to breakdown	Consider tree shaking/remove sticktights
Dark brown to black nuts 	**Old nuts**	Older nuts dull and black with newer nuts dark brown Often cracks along suture lines	Potentially out of season nuts Last seasons nuts pushed into ground/left behind Significant pathogen risk, such as mould and Salmonella	Improve orchard hygiene Consider tree shaking/remove sticktights Improve harvest pickup - check fingerwheels for wear/damage Upgrade orchard floor incl. exposed roots/ uneven surfaces. See the IOM book. Worse in dark/wet/overcrowded orchards

Tips for effective ethephon use

As more macadamia growers start to use ethephon to speed up the natural process of nut drop and make harvesting more efficient, it is timely to review how it works and is best managed variety by variety. For more detailed information and advice, turn to the AMS website for our fact sheet, 'Using ethephon in macadamias'.

Ethephon is a plant growth regulator that breaks down in plants to produce ethylene, a naturally occurring plant hormone that promotes ripening and speeds up the process of nut drop. Ethephon is the active ingredient in the commercial product, Ethrel.

Macadamia growers can use it to shorten the length of the harvest season and protect nut quality by reducing the amount of time that mature nuts are in the trees and exposed to the elements.

Using ethephon can also be useful from a whole farm management perspective. It allows a break between nut drop and flowering of the next crop, which may reduce the potential to carry over insect and disease problems. It can be a useful tool for canopy management too, as a defoliant in dense varieties.

For these benefits to be realised, growers need to be able to carefully plan, schedule and manage their pre-harvest preparations, the harvest itself and post-harvest storage.

Using ethephon can take late season harvest from many rounds over many months to one major round. But it is important to consider whether growers have enough capacity to harvest, manage, store and deliver nuts over this shorter period. Split applications of ethephon in different blocks or by different varieties is an option.

Timing of application

Ethephon must be applied when the nuts are mature and natural nut drop has started. It is a good idea to have nuts tested for maturity first – 72% oil is the recommended benchmark.

At the same time, air and soil temperatures are important, with cooler weather and soil temperatures reducing effectiveness. Check the weather forecast for the coming fortnight, as wet weather and cold fronts will inhibit the action of ethephon. It is best applied in the morning, when soil and air temperatures are warmer and going to remain so during the day.

Ethephon can be applied from late March to May, depending on the region and macadamia variety. The ethephon permit states that it should be applied before the end of May. Applying ethephon too late can inhibit flowering.

There is a seven-day withholding period, so it is best to plan a pass to pick up all fallen nuts before the ethephon is applied to minimise any quality problems from having nuts left on the orchard floor too long.

Varietal considerations

Macadamia varieties which respond best to ethephon are those which have a high natural nut drop rate e.g. 344, 741 and 246. Results can be variable with 814, 816 and 842 and ethephon rates need to be increased to work well on A16. Ethephon cannot be used to manage sticktights, as it has no effect on them.

Applying ethephon to the trees

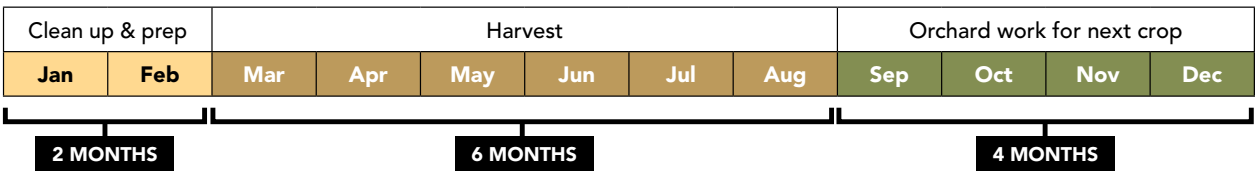
Before using Ethrel, growers should read the product label and follow its instructions.

Most macadamia growers use the 480 g/L formulation at application rates which vary depending on variety. (See Table 1.) Knowing the active, varietal responsiveness and individual orchard tree health is essential to accurately calculating spray volumes.

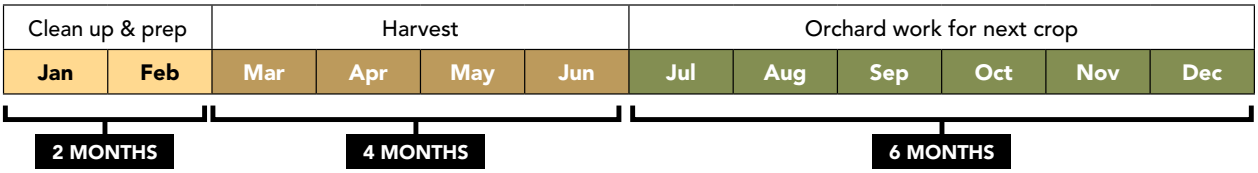
Ethrel is used as a foliar, sprayed at high volumes with the aim of achieving thorough coverage of trees, including the insides and tops, to the point of run off. This is important because ethephon does not translocate very far from where it lands. Efficacy is aided by the use of a non-ionic wetter.

After application, it generally takes between two and four weeks for most of the crop to drop, depending

Orchard management cycle where no ethephon used



Orchard management cycle where ethephon is used



Variety	Suggested Dosage Range (mls active/100L water)			Nut Drop (Compared to unsprayed control)		Leaf Drop Scale (1= Excessive 5=Moderate 10=Low)	Comments
	480g/L active	720g/L active	900g /L active	14 days	21 days		
A16	180 - 250	120 - 166.6	96 - 133.3	45%	75%	7	Not very responsive and higher rate generally required
A38	80 - 125	53.3 - 83.3	42.6 - 66.6	64%	94%	7	Effective with high percentage nut drop
A4	80 - 125	53.3 - 83.3	42.6 - 66.6	59%	93%	8	Effective with high percentage nut drop and little leaf loss
849	125	83.3	66.6	66%	92%	7	Effective with high percentage nut drop
246	125	83.3	66.6	57%	80%	5	Effective, but naturally good nut drop variety, shortens harvest
344	80 - 125	53.3 - 83.3	42.6 - 66.6	63%	96%	4	Effective, but naturally good nut drop variety, shortens harvest
741	80 - 125	53.3 - 83.3	42.6 - 66.6	63%	96%	4	Effective, but naturally good nut drop variety, shortens harvest
814	80 - 125	53.3 - 83.3	42.6 - 66.6	60%	70%	9	Very sensitive variety, start with lower rate
842	80 - 100	53.3 - 66.6	42.6 - 53.3	50%	83%	8	Very sensitive variety, start with lower rate

Table 1: Guide to responsiveness and drop patterns from ethephon by variety
Source: Fact sheet: Using ethephon in macadamias, Australian Macadamia Society, April 2020

on variety, rate and weather conditions. Ethephon can also result in increased leaf drop, especially older leaves. Splitting orchard applications can assist with the management of increased nut drop.

First time users are encouraged to seek expert advice and consider testing ethephon in a small area first to assess its potential effects as it can have a negative impact on stressed trees.

Ethrel gives good results for large grower

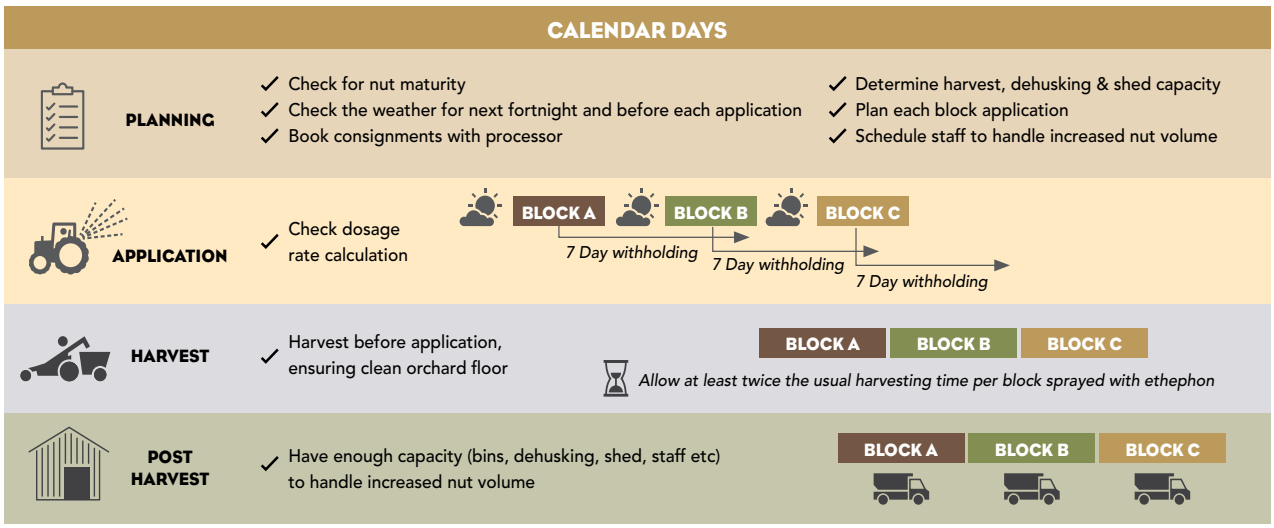


Scott Allcott from Macadamia Farm Management in Bundaberg uses Ethrel extensively in the orchards he manages.

"For us, Ethrel is essential. It presses the reset button on the tree and helps it move on to the next season.

"Of course, the correct use of Ethrel is variety dependent, with regard to timing and application rates. There are many things to balance when using Ethrel and each variety brings a new balancing act, so a good knowledge of your orchard is essential to getting good results. You also need to ensure adequate coverage, which encompasses spray volumes and management.

"We would be lost without Ethrel in our setting and our overall productivity would be lower."



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Three years on shows the benefit of careful planning and flexibility

Anne Currey, AMS Communications

Robbie Commens is looking forward to applying the lessons learnt from developing Salt Spray Farms.

Robbie Commens is no stranger to the macadamia industry. He worked with the AMS for more than seven years as its Productivity Development Manager before taking on a new challenge in 2017, establishing a 200 ha orchard on the northern NSW floodplain (Salt Spray Farms) at East Wardell, just south of Ballina. We caught up with Robbie in December 2020 to see how things are progressing after two years of getting his hands dirty on the farm.

Together with Matthew Durack, Robbie Commens is a joint owner of 2te, a macadamia management and development company, and they both have been busy planning, planting and establishing trees on the farm. Along the way they have developed innovative practices to suit this new macadamia growing environment.

In 2018, Robbie gave a presentation at the Macadamia Conference where he outlined plans for establishing the orchard.

The view from 2018

In his presentation Robbie outlined the strategic goals that would guide the farm's development - to produce 2 t/ha of saleable kernel when the orchard is mature and to have a reputation as innovative managers of premium value orchards. Crucially, underpinning these goals was a value that people come first. And Robbie emphasised the importance of accessing the huge depth of experience and knowledge that existed in the industry.

After doing a lot of research and constantly asking themselves why they were making each decision, a plan was put together to develop the orchard in two stages, with the first stage being 65 ha and the second, 135 ha.

The orchard was designed, again after much research, and Robbie and Matthew settled on a layout that was not industry standard. Rows were 9 m with trees spaced 2.7 m within the row, which means there are 411 trees/ha.

One of 2te's smaller farms, Carneys North Farm, has 12,700 trees on 31 hectares.This shot highlights how close it is to the Pacific Ocean (top right) and the Richmond River.

Varieties planted were 344 (70%), 246, which were the pollinators (15%), and A38 and A203 (7.5% each). Being on the floodplain, much attention was paid to drainage and to mounding (to a height of 400 mm).

With this being the first macadamia development near East Wardell, Robbie knew there would be issues unrelated to the physical development of the orchard, including that of social licence.

Social licence is something many agricultural enterprises increasingly are required to deal with because of the implementation of environmental regulations and as neighbours, the community and regulatory bodies become more vigilant. The macadamia industry has not been immune to these pressures, especially in areas where settlement is more concentrated such as in the Northern Rivers.

Robbie explained that it was important to establish relationships with neighbours, keep them informed about developments and demonstrate that the management and staff of Salt Spray Farms were not 'cowboys'.

Progress so far

By the end of 2020, more than 72,000 trees had been planted across 175 ha, with one small 9 ha block to be planted in autumn 2021. At that stage, the orchard will be completely developed, and the focus will switch to managing trees and growing nuts.

Looking back to his 2018 presentation, we asked Robbie whether his plans had changed much.

"The strategic aspects of our plan have stood the test of time. We made confident decisions on our row widths, mound heights, within row tree widths, varieties and our drainage systems and we have formal, documented plans that we have shared with regulatory bodies and the wider community," he said.

The plan implemented for the orchard means that rows are all the same width, within-row widths are all the same and varieties are strategically laid out across the property.

"We believe that this groundwork will continue to deliver value to the orchard and the management company through lower operating costs because we can complete tasks with larger scale machinery in a single pass, attract a premium capital value and position ourselves to optimise profitability and production in the long term," Robbie said.

Investment in machinery and people pays off

According to Robbie, he did a lot of research into tractors before the decision to buy 6R series 120 hp John Deere tractors with IVT transmissions. His enthusiasm was obvious as he explained that the tractors are built in Germany, 'where the concept of near enough is good enough is unknown'. They are simple to operate, are light weight for their horsepower, have strong towing and lifting capacity and can easily be autosteer-ready (GPS guidance).

"Our tractors continue to impress us, both with their ease of operation and ability to perform above expectations," Robbie said.

The other great success has been with people, both their employees and the contractors they have hired.

"Our focus was to invest in obtaining people based on character and attitude over ability (sometimes they came with all three qualities). This has meant we have been able to develop a team that is committed to the outcome, enjoys work and has a thirst to keep improving. I believe that a happy worker is a hard worker!" he said.

One of the key innovations Robbie and his team are proud of is their in-house task tracking system that helps them track costs in a transparent manner across their cost centres, in real time. The system uses Microsoft Teams software.

"Our staff and contractors fill out a quick two-minute survey daily, and that feeds into our management dashboards and financial tools," he explained.



Trees on Salt Spray Farm made it through the drought and are now growing strongly (photo taken in September 2020).



To water the young trees during the drought, a 5000 L trailer was towed behind each of two GPS-guided tractors, while the Trimble system on the tractor automatically triggered the trailer to apply a precise amount of water to each tree.

They are now helping set up the same system across other businesses.

"Being Microsoft based, it is flexible and easy to use, two issues that I felt off-the-shelf apps and software programs didn't always deliver," he said.

Plans change

Inevitably, some plans have evolved and have been adjusted as a result of changing circumstances.

One of the key drivers of this evolution was the weather, which included two historic droughts in the first three years of the farm. Robbie's focus quickly changed from getting water off the farm to getting it on the young trees.

"It also meant we needed to find enough water that was also useable," Robbie explained. "We have monitored water quality across the property since we started developing it and were able to identify when and where water was suitable."

Despite this, during the peak of the drought in the 2019-20 summer they had to revert to buying town water.

"We were able to do this as economically as possible by driving our tractors and water trailers through town and filling up directly. This took transport costs out of the equation," he said.

With water availability an issue, it had to be used as efficiently as possible when irrigating the young trees. The innovative solution arrived at was to tow a 5000 L trailer behind each of the farm's two GPS-guided tractors. The Trimble system on the tractor automatically triggers the trailer to apply an amount of water adjustable between 2 and 10 L/tree.

"Using two tractors and applying 8 L/tree, we can water more than 50,000 trees (120 ha) in less than three days, at a cost of less than $40/ha," Robbie said.

While they know this amount of water is valuable to a young tree, it will not be enough for an older tree (>5 years). To prepare for this, they are currently establishing a 30 ha irrigation trial where they will monitor and assess any difference that irrigation may make on the floodplain.



The environment on the farm is supporting the growth of healthy trees, beneficial insects and Robbie's boys, Tate and Corey.

"We will keep you posted on the results," Robbie promised.

The approach to contractors has also changed over time. Initially the plan was to be 100% reliant on contractors and for 2te to be the project development manager. Faced with the reality, however, where the timeliness risk or opportunity to get tasks done on the floodplain is often measured in hours, not days, because of the average of over 200 rainy days per year, a hybrid had to be created where some key machinery was bought for the farm.

"This enabled a greater influence on the timing of key operations, as well as allowing us to maximise the contractors' efficiency and to reduce the costs of development," Robbie said.

Social licence under the microscope

With Salt Spray Farms being the first macadamia development around east Wardell, as well as its size and the fact that it was on a main road so very visible, Robbie knew that almost every move would be scrutinised by the local community.

Robbie and Matthew decided to be proactive and host an open day to explain their plans and show interested participants around the farm.

Robbie credits this decision as being a great success. Importantly they were very transparent with all information and the day built positive relationships and established goodwill with both the local community and regional regulatory bodies.

While the open day was a positive initial step, Robbie and Matthew have continued to invest in maintaining the communication with their neighbours and the local community.

"We do this through supporting local events and local businesses, employing local people, getting involved with local associations and making regular direct contact with our immediate neighbours," Robbie explained. "I would like to think we are now seen as positive members of our local community."

Next steps

Having established the value of the planning process, Robbie said that they will continue to follow this structured approach, with a focus on why they would undertake an action before actually going ahead.

"We have not implemented anything here because that is what the industry does or because that is what the neighbours do, rather we have reviewed and calculated each decision," he explained.

Robbie was also clear that while he is comfortable with the decisions made for Salt Spray Farms, this should not be a model for other growers, recommending that they go through a similar rigorous decision-making process.

"We focused on identifying our key limiting factors and developed strategies to manage them. I hope that all growers and managers would undertake that same process," he said.

With his reputation as a glass-half-full person, we asked Robbie whether he had managed to maintain his positive outlook. He admitted that he had been tested over the last three years, saying that there had been some challenging times.

"We have gone through two consecutive one-in-25-year droughts. We expected to receive close to 2,000 mm of rain a year, and instead received 1,330 mm (in 2018) and then 922 mm (in 2019), which meant we were establishing a large-scale orchard with 66 per cent and then 44 per cent of the area's average annual rain with no irrigation," he said.

The effects of this dry time are still being felt in the local landscape, which is showing signs of not having yet recovered.

"What doesn't break you, makes you stranger – I mean stronger!" added Robbie in inimitable fashion.

In summing up his experiences in the last three years, Robbie explained that it had not been easy, but that anything that is easy is rarely worth doing.

"While I still have a positive outlook, I also have some broader and slightly heavier shoulders to help me carry the extra baggage I have accumulated along the way," he said.

According to Robbie, this 'baggage' will deliver a strong return over time.

"I am sure it will help me and my team navigate through the difficult and unpredictable times when they occur again because, if anything is true in farming, it is that the unpredictable can and does happen," he said. "Onward and upward!"

Robbie's take-home message

As a way of summing up, Robbie said he is looking forward to undertaking the next development on the floodplain, to apply the lessons learnt from the Salt Spray Farms development and continuing to work with like-minded people to help them achieve their investment goals.

And it would not be a Robbie article without a quote or two.

"There are no straight lines in farming." (Matthew Durack)

"Doing the same thing but expecting a different result is the definition of insanity." (Albert Einstein)

A different approach to pollination

Pollination has been an issue in the industry, where there have been no hard and fast rules.

The approach taken at Salt Spray Farms has been different in that they have adopted a practice used in the almond industry where a pollinator variety (246) is planted in every third row, which also contains the major variety (344) as shown in the figure. The result is that the orchard consists of 15%, 246 and 70%, 344 (the other 15% are A38 and A203).

How much of a gamble has this been and why did Robbie Commens decide to do this? Robbie explains.

"While it was a gamble, it was a measured and calculated one. We first spoke with Dr Brad Howlett from PFRNZ, who had just finished his initial macadamia research into pollination, and we were able to spend time with him on our orchard before we planted any trees. His assessment was that a significant increase to yield due to cross-pollination of between 20 and 30% was likely. His other major point was that most current orchard designs (variety layout) did not encourage cross pollination, because pollinators service an area, not row by row by row.

"We reviewed the potential rewards (increased yield), the risks (disease, insect, management challenges, harvesting, crop protection, nutrition etc), the varieties commercially available (new and existing) and decided it was worthwhile investing in planting our orchard to encourage cross-pollination.

"Time will tell as we have established some comparison areas where we have planted whole rows of single varieties instead of our mixed variety rows on every third row. Give us a decade or so, and we should be able to confidently answer the question of whether cross-pollination increases yields on northern NSW coastal floodplain orchards."

Note that the orchard is not irrigated, reducing the restriction of variety specific irrigation systems.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	O	X	X	O	X	X	O	X	X	O	X	X	O	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	O	X	X	O	X	X	O	X	X	O	X	X	O	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	O	X	X	O	X	X	O	X	X	O	X	X	O	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	O	X	X	O	X	X	O	X	X	O	X	X	O	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

X = 344 O = 246

Orchard layout

For more information, contact Robbie Commens, 2 Tonne Enterprises, on mobile 0429 553 659 or email robbie@2te.com.au

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Harnessing technology creates new opportunities at Dungarubba

Samantha Elley, AMS Communications

Orchard: Stibbards Creek Macadamias Pty Ltd

Owner: Johan Jacobs, CEO and majority shareholder

Location: Stibbards Lane, Dungarubba, New South Wales

Total size: Five farms in Dungarubba, adding up to 360 hectares. There are currently 40,000 young trees planted with another 40,000 planned for the year ahead. The total, when finished, will be 120,000 trees.

Cultivars: 344, 849, G, MCT1, A203 and A38 planted at 9 x 3.5m spacing

Soils: Predominantly sandy loam and loamy soil. Land is flat.



Johan Jacobs with his newly planted macadamia trees at Dungarubba.

Johan Jacobs is 50 years old and has a long history in fruit orchard management, broadacre farming and running cattle across three continents, having farmed in South Africa, Canada and now Australia.

Born in South Africa, Johan has a BSc Degree in Agricultural Economics and the gift of bringing together all he has learnt from his time in other countries to establish and pioneer the establishment of macadamia orchards in areas that were previously reserved for cane farms.

As a unit manager for a large agricultural co-op back in South Africa, he ran a large packing shed for citrus and pecans and went on to develop his own farm with stone fruit. He did this for six years before moving to Canada.

This was a completely different experience for Johan who was suddenly faced with working in minus 40°C temperatures for six months of the year.

"I couldn't farm, so I started a cattle farm and later on extended to about a 2,000 hectare grain farm with some cattle on it," he said.

By 2018 Johan and his family arrived in Australia where he decided he wanted to grow macadamias. They went from Alstonville all the way up to Bundaberg in search of the right property.

Johan liked the climate and the steady rainfall of the Northern Rivers, particularly Alstonville, where he bought a share farm. After talks with Jolyon Burnett at the Australian Macadamia Society and other growers including Kim Wilson, John Pretorius and Ken Dorey, he started looking at land to develop in the East Coraki area.

"Because of limited funds, it wasn't an option for me to buy trees up on the hill where the land was about $100,000 a hectare then, so we had to start a new orchard," Johan said.

New beginnings

After more research with the Department of Primary Industries, looking at elevation maps to find the highest suitable area above sea level, and seeing what the Dorey family had done with converting flood plains to macadamias at Newrybar, Johan decided to re-establish several cane farms around the Dungarubba area near Lismore, calling his business Stibbards Creek Macadamias.

The process of establishing the old cane farms to take on macadamia trees has been broken down into various steps by Johan and his team.

When they first started the process, the cane was allowed to grow to about four or five metres high before it was mulched and incorporated back into the soil to provide organic matter to replace what had been lost from years of burning.

Now they use a combination of mulch and manure that is broadcast with lime and incorporated into the soil prior to forming mounds.

"About 85% of the soil here is sandy loam and the pH was already 5.8, so we corrected it to about 6.1," Johan said.

When it came to choosing the trees for the farm, Johan said they started off with the older varieties like 344 and 849 due to their good track record.

They are now planting many of the newer varieties including G and MCT1 with a little bit of A203 and A38.

Each of the five farms is set out in the same north-south orientation and the trees were GPS planted in preparation for automated orchard operations on the farm.

"In the future we are thinking of doing automated mowing, all on GPS," Johan said.

"Then it's easier to program the machinery to go down the rows rather than in all different directions for different blocks.

"That also helps us to spray, because all our sprays are GPS tracked."

For efficiency when spraying, Johan said the tractor goes down the row and as the tree is marked out on the farm via GPS, it will only spray where there is a tree.

Therefore, newly planted trees will only need 10% of the spray. As the tree grows, the percentage goes up until the trees touch and 100% of the orchard needs to be sprayed.

"It only sprays when it detects a tree," Johan said.

With his neighbour at Alstonville, Kerry Sparke, who is working on the development of an 850 ha macadamia orchard in the Clarence Valley, Johan said they investigated mounding heights on numerous farms in Bundaberg.

Johan said that the farm Kerry is developing has a good slope so only requires small mounds as the biggest problem is retaining water.

"Our biggest problem is to get water off the farm quick enough," Johan said.

"I had to create slope, so had to laser level the land and then form mounds."

The mounds lift the trees up above the high-water table and they direct water into the interrow and down drainage lines to catchment areas.



The three year old trees are already bearing fruit.



The irrigation pipes being laid around the Dungarubba farm.

Irrigation

To fully irrigate a farm is forward thinking in the Northern Rivers. Johan was mindful of the drought of the last few years and wanted to mitigate against a lack of water for his trees.

"It was the saddest day of my life when I discovered that we had had two of the driest summers in the area for, I don't know, 100 years," Johan said.

"Last year was the driest year in 160 years, so the idea of planting without irrigation was not going to happen."

Johan has a water allocation of 400 megalitres and has laid irrigation throughout his farm.

At this stage he is using supplementary irrigation to establish the new trees to then provide complete irrigation and fertigation for the future.

The irrigation scheduling is assisted by multi sensor probes in every block.

"The sensors are Stoock by Agroop probes installed to 60 cm and they measure soil moisture at multiple depths, ambient temperature, soil temperature, solar radiation, evapo-transpiration and many more features," Johan said.

"We install the probes on different soil types for precise monitoring and use them to schedule irrigation including prioritising certain blocks with available water.

"Either newly planted orchards with small root systems or the older orchard with the first crop on it will be prioritised."

He also plans to increase his water allocation in the future as water licences become available.

"We are currently using less than 0.5 megalitres per hectare," Johan said.

Drainage management

One of the issues the orchard faces and has been a consideration all through development is the high-water table in Dungarubba.

"That's the main reason why we make mounds," Johan said.

"This dries out at least 45 cm of the topsoil. If the water table is not above the ground, then we know there's still room for the roots to breathe and grow.

"Laser leveling is a must and that's another way to get the water off quicker."

Maintaining clean drains and being able to pump excess water into the dam helps protect the roots of the trees as they don't sit in water for extended periods.

"Our main problem is getting the water off in some months and then applying the water back in the others," Johan said.

Efficiencies

With the size of Johan's orchard, efficiency is the key to success and Johan said one of the areas this can be achieved is in the spraying, as mentioned previously.

The longer rows mean less turning time and blocks have varieties in distinct sections so harvesting can be done by variety.

The establishment of the farm means more money is going out than coming in, which in the life cycle of the macadamia tree, will continue for another few years yet. To ensure cash flow and offset his costs, Johan and his team run a tree planting business and establish orchards for other people.

With his experience in broadacre and fruit orchard farming, Johan has brought his knowledge together to build an efficient tree planter for his farm and orchards he has established for his clients. (See breakout story)

"We are developing 400 hectares for other people, doing everything from irrigation to planting trees to looking after them," Johan said.

"Normally you contract for four years and then after that, there'll be a new contract as the tree grows from vegetative growth into productive, and they may then contract us to do the harvesting and dehusking for them."

Johan has six people working on his farm with two in the nursery and two contract grafters.

He believes in looking after his staff and is keen to see them upskill, making them not only more valuable to the farm, but also to extend their experience and value.

"If I have a worker who hasn't done a course on spray management, I can't send them to another farm to spray their trees, so I want everyone to be as skilled as possible," Johan said.

Lessons learnt

Challenges are never few or far away when taking on the establishment of a new orchard.

For Johan, getting all his irrigation licences in place has been a major challenge, along with the price of water and normal bureaucracy.

"I found all the legal requirements around farming in Australia very burdensome and takes up valuable time," he said.

Johan's words of advice include making sure you buy your land in the correct location.



The modified tree sprayer used at the Dungarubba farm.

"If you buy your land in the wrong place, there is no future for you," he said.

"It's better to spend more money and buy the productive land you need for macadamia orchard development."

Another important lesson is to not compromise on nursery tree quality.

"Wait a year and plant the right tree," Johan said.

"If you've got irrigation, plant early as you will get a whole year's growth if you plant in September versus planting in February or March the following year.

"After one year, the tree planted in September will already be a good established tree and not needing any supplementary water, whereas the later planted tree will still need management, especially if there is no rain.

"It is also important to find the knowledge and orchard principles that suit your farm personally, among the advice you get from all the people in the industry."

Orchard trials

Johan's international experience with orchards means he is not shy in challenging the normal processes while establishing Stibbards Creek Macadamias.

While it is uncommon to find a farm that does not stake the trees when they are young in the Northern Rivers, Johan has set up several trials, inspired by what he saw in Bundaberg, which involved staking vs not staking trees.

"It is another reason why we went a little bit further away from the coast, to get away from the coastal winds," Johan said.

"We staked 25 trees in a row in two different rows of the same variety.

"We did this for two years and now only leaning trees get staked.

"The trees that weren't staked had the tops trimmed out with a hedger."

Results that followed showed the trees that were not staked had a 17% thicker trunk.

"We believe that because there's more movement in the unstaked tree, it knows it has to support itself and develops a thicker trunk quicker," Johan said.

Another trial Johan has been doing is with pre-emergent herbicides. Depending on the types of weeds on the farm, with the hard to kill varieties such as purpletop they perform a pre-emergent spray program.

Future steps

At first, Johan's biggest concern for the farm at Dungarubba was frost, but after three seasons where he could see the effects on the trees, his main concern now is preparation for the one in 100 year flood.

"I talked to the previous owners and in 1954 during their biggest flood, there was only about 60 cms of water here for a short while," Johan said.

"While other people closer to the river plant on land about 0.5 to 1.5 metres above sea level, Stibbards Creek Orchard is three metres above sea level, so while we might see 50 cm of water, they might see 2.5 metres on their farms."

Johan admits there is nothing to mitigate against flooding, except possibly prayer.

Modify machinery to lift efficiency

Every farm is unique and when time and efficiency is a priority, Johan Jacobs looked at his machinery to see how he could expedite the work that needed to be done. It also means the GPS operations on the farm are extremely important to reach this efficiency goal.

"When the trees are small, most of the machines can only spray one row at a time," Johan said.

"Most of the modifications we've done are to get more trees sprayed quicker."

As the farm has been planted and mapped out using the GPS system, Johan said they know where every tree is to the closest 2.5 cm. Therefore all spraying can be done by the tractor's GPS unit. The same goes for the watering and fertilising.

"My business partner Braam Fourie is an electronics engineer, so everything I can think of, he does for me," Johan said.

These have included Johan's tree planter, his herbicide sprayer and his pesticide sprayer.

"Our tree planter is built to what we wanted," Johan said.

While visiting several growers in Bundaberg including Darryl Wake, Jason Klotz, Scott Allcott and Dave Harris, Johan saw the use of modified cane planters.

From there, Johan decided they were going to build a purpose-designed tree planter, so all they needed was to see how the GPS system could guide the planter.

"After that it was a matter of welding steel together, nothing special. The GPS is the difficult part and to build the controls for the time delays," Johan said.

The tree planter sits behind the tractor which goes wide legged across the tree row and the trees are planted from behind. When the GPS system indicates the spot, a plate drops (likened to the platform under a hangman's noose), the tree goes into the hole, the tree roots are covered with soil, and wheels at the back compact the soil around the tree. Finally, a dripper line is rolled out.

Johan's best day planting trees was 4,500, but he can plant 3,000 trees per day consistently with the tree planter.

"It all depends on how close the trees are together and how long the rows are," Johan said.

"I built it for my farm, never as a business. Now it's probably one of our main sub-businesses."

Modifications made to the weed sprayer came through ideas from people in South Africa, Bundaberg and even new orchards in California.

"If I can get one person and a machine to spray 20,000 trees in a day, instead of five people doing two and a half thousand a day, that's what I'm after," Johan said.

Johan extended the back arms of the tree sprayer to stretch across the rows, reaching two rows at once in each pass.



Right: Inside the tree planter showing where the tree is set into the ground and the tyres that pack the soil down.

Below: Johan's tree planter.





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Floodplain macadamias: learning what works (and doesn't)

Anne Currey, AMS Communications

Grower: Michael and John Jenvey

Farm: Jenvey Brothers Plantation, Mororo, Clarence Valley NSW

Size: 65 ha over two neighbouring blocks, one of 40 ha and one of 25 ha. Managed by two staff

Orchard: 11,000 trees between 8 and 12 years old, on 6 x 5 m, 8 x 4 m and 9 x 5 m spacings. Varieties include A4, A16, A29, A38, A268, A203, A268, Daddow, 842, 849 and 344

Topography and soils: Mostly flat with some slightly undulated areas. Soils are mainly heavy loams with some sandy areas

Production: 65 t (2018), falling to 25 t (2019) and 10 t (2020) because of drought. Looking at 60+ t/ha in 2021

Irrigation: Supplementary drip from on-farm storage to 6000 trees



Access for machinery, adequate light for the canopy and drainage to get water out of the interrow were all important considerations when establishing trees and deciding on row spacings.

When Michael Jenvey and twin brother John bought a 40 ha sugar cane block at Mororo in 2006, planting macadamias was regarded as something of a novelty. Now the surrounding area, which includes Chatsworth and Palmers island, is one of the 'hot spots' for macadamia development in NSW.

A few years later they increased their holding by buying a neighbouring 25 ha farm, which was already planted with 6,000 macadamia trees that were in a rundown state.

The 65 ha plantation currently has 11,000 trees, with plans to establish 1,000 more to bring the total up to 12,000. When it is in full production, the expectation is that total annual yield will be 130+ tonnes.



Michael Jenvey with his young helper, daughter Isabella.

Why floodplain macadamias?

Michael and John are no strangers to horticulture, having been brought up on the family farm at Nambucca Heads, where their father and older brother grew a variety of crops ranging from vegetables to macadamias. When they were looking for a block to buy, this experience shaped their search. The brothers didn't want to grow vegetables because they were 'all hard work' compared to macadamias, according to Michael, and they were looking for a larger, flat area that would allow for efficiency based on size.

"With our background at Nambucca where the country is steep, we thought the Clarence Valley property would be good to develop. Its size and flat topography lent itself to a larger scale of operation where we could have long rows and use bigger equipment that is not suitable for a steeper plantation, such as 4000 L sprayers," Michael explained.

Despite their farming background, the brothers are still learning lessons about what works and what doesn't with establishing and managing a floodplain orchard. Along the way they have also faced significant challenges in the form of the 2018-19 drought, bushfires in November 2019, wild pigs and the fact that they live off-farm so are not on-site full time.

Establishing the orchard

Underpinning all decisions made about the farm are the aims of efficiency (labour and time), having sufficient scale of operation and practicality.

Scale of operation was a motivation for adding to the farm by buying the neighbour's block, which was on narrow 6 m row spacing and lacked suitable drainage. With inter row spacing at 6 m, either the drains were not deep enough to get the water away, or the hilling up was so severe that only narrow machinery could fit between the rows. Michael and John decided to take out every second row, doubling row spacings to 12 m and they are halfway through this task.

For the original 40 ha block, Michael explained that the first challenge was to decide on varieties to plant, not an easy thing to do as there was very little information on what might best suit the area.

"Because we didn't know what would do best here, we decided to spread the risk and plant a range of varieties, beginning in 2008," he said.

About two-thirds of the area is planted to A varieties, all of which are doing reasonably well, particularly A38 and A29, and the rest to Hawaiian varieties, mainly for pollination. They have also recently planted A203 'to see how they go'.

With the establishment phase almost complete, other than for 1,000 trees to be planted, Michael identified that as well as difficulties finding information on varieties, another issue was preparing the rows for planting.

When they were developing the farm, they relied on their experience with steep country in Nambucca Heads, which resulted in them not hilling up enough.

"This was a mistake as it meant that we couldn't get the drainage water off well enough, so we had to buy a grader and redo them," he said.

Bushfires take their toll

Two of the most significant challenges recently have been the bushfires of November 2019 and the drought in 2018-19, which exposed a key vulnerability - access to a reliable water supply for the supplementary irrigation system.

The bushfires revealed the fact that one of the orchard's greatest advantages, that it is bounded on two sides by state forest, could also be a disadvantage.

"Having bush on two sides is fantastic for native bees, and the privacy means that we have no problems with neighbours," Michael said.

But it was also a trap during the hot, dry weather of summer 2019-20, when bushfires were raging around the area. Fortunately, Michael kept an eye on weather forecasts and the RFS website, so he knew several days in advance that they would need to prepare to protect the orchard.

"Being prepared definitely helped us as we had time to grade a wide strip of bare earth around our boundaries as a firebreak," he said.

"We also mowed the groundcovers as low as we could, removed dead timber from the plantation and got our tractors ready with water tanks that gave us the capacity to put out spot fires and close down any flare-ups."



While the fire scorched these trees, they did survive and are back to vigorous health 12 months later. The photo shows the firebreak graded to protect the orchard from fire coming from the state forest.



The bushfire burned right up to the farm boundary. Precautions taken such as grading firebreaks and mowing groundcover ensured that the orchard survived intact.

Even though more than 3 km of property boundary was on fire, their preparation and fast reaction to spot fires meant there was no significant damage to the plantation. Some irrigation dripline and underground poly pipe in one block had melted because of the heat of the fire.

"The only tree I lost was from falling debris that caused a spot fire in the mulch and crept up to ringbark the tree. It died a couple of days later," Michael said.

As a result of this initiation, Michael is investigating the option of installing perimeter overhead irrigation along the boundaries with the state forest so that he can flood trees in advance of a bushfire and provide more protection.

Wild pigs

Damage by wild pigs is a problem in several macadamia growing areas. According to Michael, wild pigs in the orchard were eating low hanging crop and making a huge mess of the rows, where they were digging for worms and grubs.

"They were making such a mess that we could not run a harvester over the ground. It was like harvesting mud," he said.

The solution, which has worked successfully, was to install a 900 mm high hinge-joint, mesh-wire exclusion fence around the entire property, with an electrified wire on the outside located 200 mm above the ground to discourage the pigs from lifting the mesh wire.

Access to water

Having a reliable water supply for bushfire control and irrigation is a problem that the Jenveys share with many of the newer growers on the floodplain. This has been especially critical in the last few years, most of which have been characterised by months that have been extremely dry, compared with long-term averages.

As an example, the long-term annual average rainfall for the area, measured at Harwood Island from 1915 to 2020 is 1301.5 mm, with the months from September to December being the driest (the lowest average is 0.8 mm for September 2017).

Table 1 below shows figures from September to December 2016 to 2020, compared to the long-term average.

	Total Sept to Dec (mm)	Annual total (mm)
Average 1915 to 2020	326.6	**1301.5**
2016	109.6	**959.1**
2017	403.0	**1962.6**
2018	390.7	**1107.2**
2019	101.9	**530.7**
2020	419.9	**1252.9**

Table 1. September to December rainfall totals and annual totals measured at Harwood Island (2016 to 2020) compared to the long-term average (1915 to 2020). Source: Bureau of Meteorology.

But these totals from September to December do not tell the whole story - in three of the five years, high rainfall in one or two months 'rescued' rainfall figures that were much lower than the long-term average.

The monthly totals show how desperate the situation was in 2016 and 2019, when there was no significant rain from September to November. As well, every month in 2019, except June, was very dry, resulting in an annual total that was less than half the long-term average.

Michael added that rain at the start of 2020 was too late for the 2020 crop as the damage from a dry 2019 was already done.

"The wet December in 2020 was just in time for this coming year as we had emptied the dam a couple of days before the rain started falling. Irrigating from September to November last year was key to the 2021 crop," he said.

This extreme variability in monthly and annual rainfall averages has implications for nut yield and quality on the plantation as the driest time coincides with the time when moisture availability is most critical for macadamias i.e. during nut set and oil accumulation.

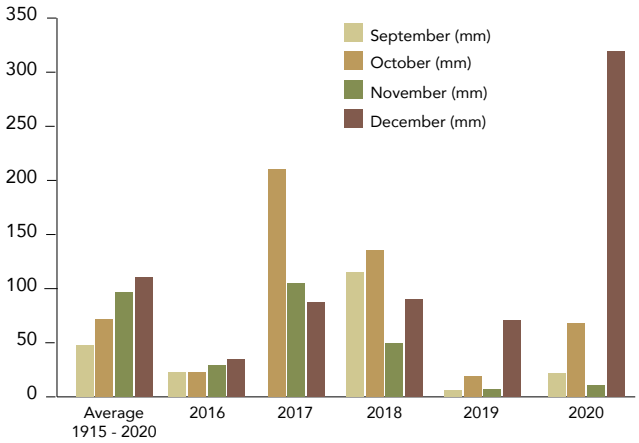


Figure 1. Rainfall at Harwood Island for the months from September to December (2106 to 2020) compared to the long-term average. Source: Bureau of Meteorology.

Currently the farm has two storages, one with a 5 ML capacity and the second with 1 ML. During the drought this helped with keeping trees alive, but Michael is aware that this is not enough supply for the orchard, and he is looking for secure options for the future.

Trying to understand water policy as it applies to coastal floodplain areas and getting approval for dams are proving to be significant hurdles, and Michael has identified this an area where floodplain growers need support. In particular, he would love a formal review or changes to water licencing to allow growers greater access to water.

Irrigation – learning by doing

Even before the drought, the plan was to install irrigation to provide supplementary irrigation to half the orchard. While having access to enough water to fully irrigate the orchard would be ideal, Michael is limited to a harvestable right, which means he can capture 10 per cent of the rain that falls on the farm.

Not having had any experience with developing a supplementary irrigation system and having received a quote for a system in mid-2019 that Michael felt was 'astronomically priced and over engineered', he and John took a step back and did a lot of research to learn about irrigation system components and the purpose of each one.

"We then installed a trial system on 1,000 trees using cheap drip tape, which was so successful we extended it to 5,000 trees in July 2019," Michael said.

The trial was important in that it revealed management issues to do with the high-flow-rate drippers and the size of the pump and mainlines. High flow drippers required so much water that they could only do small areas of 600 to 900 trees at a time, before it was necessary to switch gate valves to water a new area.

It also showed that the lower cost drip tape would split if the pressure was too high, it was prone to bird and rat attack, repair overheads were too high and the application rate was not uniform enough over long row lengths.



One rain event in December 2020 was more than enough to fill the dam.

"A larger diameter, lower flow, thicker tube with better pressure capability was what we wanted, so after trialling a couple of products we made our decision based on efficiency and price. We also trialled in-tree dripline and dripline laid on the ground and went with the latter as we had no significant issues with our harvester/sweeper moving it," Michael said.

The system they installed is based on what they learned, particularly matching dripper flow rate to pump capacity and ensuring that, while it is manually controlled, it is not management intensive.

"We decided that we didn't need a complicated system, with huge pumps or complex infrastructure, rather we have gone for a system that is easy to manage and supplies water uniformly along our 250-metre rows," Michael said.

Because of the issue with limited water supply, the aim is to provide supplementary water to the 6,000 trees that are irrigated. Even without providing full irrigation, Michael said that the difference between them and the unirrigated trees is like 'chalk and cheese'.

"The differences we have noticed include nut size, shedding by unirrigated trees and higher yield of irrigated trees," he said.

The manual system comprises two relatively small diesel pumps and dripline with very low flow, pressure-compensated drippers at 50 cm spacings. The low flow rate is important as it allows 60+ rows (3,500+ trees) to be watered uniformly at the one time, applying between 20 to 30 L a day.

"While we do have a couple of soil moisture sensors, our rule of thumb for scheduling irrigation events is to water every day if there hasn't been rain in the last 48 hours. What we do use the sensors for is to determine when to restart irrigating after rain events," Michael explained.

This schedule is implemented during the important nut set and oil accumulation stages, from September to mid-January.

While they are not using the system for fertigation, it is set up for uniform water delivery across the plantation so if a there is a good business case to move to fertigation, it will be an option in future.

If Michael had enough water, he would obviously be irrigating to meet crop water requirement and would thus be relying on the soil moisture sensing equipment to schedule irrigations. His rule of thumb approach is a logical one in the situation where he is providing supplementary water only.

On the drawing board for 2021

According to Michael, the orchard is still a work in progress. Priorities for this year, based on availability of resources, include:

- Trimming the largest A29 trees on the original farm block. These trees have grown very tall, making access difficult for machinery.
- Using ethephon on the A29s as a way of allowing time to manage trees and adjust their height.
- Replacing the manual filters on the irrigation system with automatic or semi-automatic filters.
- Mulching the orchard as this hasn't been done for a couple of years.
- Researching ways of extending the dam within the harvestable right allowance.

Michael's tips

Michael summed up his experience since 2006 by saying that one of the key things he has learned is that it is crucial to deal with the resources available, particularly time and money. While it would be great to have the best of everything, this is not possible, so he has concentrated on keeping things simple, managing efficiently and keeping costs down.

Aerator proves its worth in 2020

In 2020, the Jenveys decided that they would trial using an aerator, which they leased from McGregor Gourlay. They are so pleased with it that they will be buying their own machine.

Key benefits of using an aerator are improved soil health and structure as well improved moisture infiltration when it rains. While they sowed groundcover seed at the same time, it did not germinate because the inter rows were so dry and there was no rain at all after sowing. Michael thinks it worth giving another try if the soil moisture is available to promote germination.

A consideration when deciding whether to use an aerator is tractor size and power. Michael used a 46 hp tractor with the aerator. He believes that this is the smallest tractor that is possible to be used with the aerator, and that a 60+ hp would be ideal.

"You want to load weights onto the aerator to better penetrate the ground, which allows for faster ground speeds. However, the extra rear weights make a lighter tractor too bouncy to drive. While we did use the smaller tractor for a couple of thousand trees, we switched to an 85 hp which was a lot easier to drive," he said.

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Developing macadamia on floodplain soils

Macadamia growers are establishing successful orchards on floodplains, despite the challenges of the terrain. Apart from the risk of flooding, other issues such as soil acidity, acid sulfate soils and drainage constraints need to be considered and addressed. This is a brief overview for macadamia growers considering establishing orchards on floodplains. For more information and advice, see NSWDPI Primefact 1656, on which this article is based.

Acid sulfate soils

One of the most significant hurdles to consider is the risk of disturbing potential acid sulfate soils. It is essential to know where potential acid sulfate soils are located on the property and how deep below the surface they occur. They are generally located in coastal areas below 5 m Australian Height Datum (AHD).

When potential acid sulfate soils are disturbed and exposed to oxygen, the resulting chemical reaction produces sulfuric acid and pyrite. The sulfuric acid will kill young macadamia seedlings and cause toxicities in the soil and water. It can also cause problems for fish and other aquatic wildlife downstream. The pyrite released can cause problems later by contributing acid salts to the soil.

Disturbing potential acid sulphate soils requires development consent and in both NSW and Qld an Acid Sulphate Soils Risk Assessment and Management Plan is required prior to any works. Growers are encouraged to seek council advice in this area as the regulations can be different in each local government area.

'Disturbing' soils includes activities to lower the water table, laser levelling, mounding, drainage construction, redesign or maintenance. Growers are likely to need comprehensive soil testing.

Flooding risk

Understanding the elevation of the property is essential because this controls drainage during floods or heavy rain. Growers can use satellite digital elevation modelling or actual measured relative heights to obtain this information.

Land lower than 1.5m AHD (above sea level) poses challenges for growing macadamia.

In some cases, only part of the property will be suitable for macadamia. Consider establishing other native plants on the low-lying areas to complement the farm.

Soil acidity

Macadamia prefer soil with a pH of 5.5-6.0 (water), but where soils are more acidic they can have high levels of aluminium which is toxic to macadamia trees.

To protect the trees, many growers plant on mounds above the natural soil surface. The height varies according to soil type, ability to drain and the presence of potential acid sulfate soils.

Acidic soils should also be limed regularly to manage the pH of the soil in these mounds and the water moving through the soil profile.

Drainage constraints

Many floodplain properties have existing drainage systems and these can be the responsibility of the local flood mitigation authority (local council), a drainage union or the landowner. Growers should find out who is responsible for any existing drains and what level of drainage they provide.

Building new drainage systems on the floodplain is likely to trigger the need for development consent if potential acid sulfate soils will be disturbed or drained.

Last but not least, individual growers are responsible for understanding the constraints of the land they wish to purchase and grow macadamia trees on. Planning is the key to long-term success.

There is a wealth of information and advice for growers who want to know more about acid sulfate soils, where they are found and how to manage them.

Leoni Kojetin, Industry Development Manager at the Australian Macadamia Society, is encouraging growers who may be in affected areas to take a look at some of the many resources available online.

"It is worth remembering that the regulations vary in different states and local council areas," she says.

National:
Acid sulfate soils (waterquality.gov.au)

NSW:
Acid sulfate soils | NSW Environment, Energy and Science

Acid Sulfate Soils Remediation Guidelines for Coastal Floodplains in NSW | NSW Environment, Energy and Science

Acid Sulfate Soils Risk - Datasets | SEED (nsw.gov.au)

Queensland:
Acid sulfate soils | Environment, land and water Queensland Government (www.qld.gov.au)

Managing acid sulfate soils | Environment, land and water Queensland Government (www.qld.gov.au)

Guidance materials for acid sulfate soils | Environment, land and water | Queensland Government (www.qld.gov.au)

Mapping and sites | Environment, land and water Queensland Government (www.qld.gov.au)

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Update on Clean Coastal Catchments

Jeremy Bright Development Officer, Macadamia NSW DPI **M:** 0427 213 059 **E:** jeremy.bright@dpi.nsw.gov.au

The Clean Coastal Catchment (CCC) project is funded through the NSW Government's Marine Estate Management Strategy (MEMS) to improve water quality for our oceans, estuaries and coastal wetlands. CCC is working with the macadamia industry to understand and validate how sediment and nutrients such as nitrogen and phosphorus move through the system.

On-ground works

The first round of on-ground works funded by the Clean Coastal Catchment project has been completed. The aim was to develop a drainage plan for growers and install the drainage network to divert water throughout the farm over designated grassed water courses, ensuring the run-off from the farm was clean and free of nutrients.

A decision matrix was used to identify priority farms for project funding. This work was then facilitated through Kel Langfield from the North Coast Local Lands Service.

There are several case studies that growers can look at to see what was involved and the process of developing a drainage plan for the farm.

Some key points relating to the on-ground works are:

- funding for this project has allowed drainage management to occur on 50 farms across the Northern Rivers of NSW
- on-ground initiation works has led to a further spend of $650,000 by industry to ensure completion
- farms covering 300 hectares have addressed clean water run-off through integrated orchard management as a result of this project.

Work on crop replacement values for individual macadamia varieties is continuing to assist growers to make more accurate calculations of nutrients.



Jeremy Bright and his colleagues at NSW DPI and Southern Cross University installed fluxmeters between the rows to measure water infiltration into the soil at tree line, drip zone and centre of row. The water caught is also tested for nutrients.

Monitoring and demonstration sites

Two monitoring and demonstration sites have been set up and are being used to trace all pathways of nitrogen, phosphorus and sediment. One site is located on a typical Northern Rivers ferrosol soil type on moderate to steep slopes (>13%).

The second site has been set up on the NSW floodplains, reflecting the industry expansion into that area.

Both sites will allow us to collect data over the mid to long term period (depending on future funding allocations) and will provide credible data over multiple seasons.

These two sites will then have integrated orchard management interventions which will be designed to divert water across grassed water courses and have groundcover to allow nutrients to infiltrate the soil.

This is effectively what is occurring with the on-ground works project. It will provide a useful demonstration site to drive industry adoption of best practice water and nutrient management.



Left: Cleaning the sediment around the monitoring equipment after heavy rainfall is common. It is hoped once integrated orchard management is in place, cleaning will be less frequent.

Below: This drain forms part of the drainage works that have been set up to trace all pathways of nitrogen, phosphorus and sediment on two macadamia farms.



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You can't put icing on a cake when there's no cake

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Scott Allcott talks to the Australian Macadamia Society about some of the fundamentals involved in growing macadamia that he has gleaned over many years of managing farms. From getting the basics right to learning off farm, he shares his insights from a grower perspective.



Scott Allcott and his team from Macadamia Farm Management manage more than 600,000 macadamia trees in the Bundaberg, Maryborough and Gympie regions.

Scott Allcott is Managing Director of Macadamia Farm Management which manages several farms in the Bundaberg, Maryborough and Gympie regions. The business manages all aspects of operations on several existing orchards and is also actively involved in establishing new orchards, managing more than 600,000 trees.

In the AMS Awards for Excellence announced in 2020, Macadamia Farm Management won several awards for its outstanding performance in the 2019 season.

Central Queensland Best Productivity **Winner** (Small farms <50 ha)
Quamby - 1.45t/ha saleable kernel recovery
Central Queensland Best Productivity **Finalist** (Large farms >50 ha)
Banyula - 1.36t/ha saleable kernel recovery
Kona - 1.31t/ha saleable kernel recovery
Central Queensland Best Quality **Winner** (Small farms <50 ha)
Cambewarra – 0.89% reject kernel recovery
Central Queensland Best Quality **Finalist** (Small farms <50 ha)
Quamby – 1.24% reject kernel recovery
Central Queensland Best Quality **Winner** (Large farms >50 ha)
Burrawang – 1.08% reject kernel recovery
Central Queensland Best Quality **Finalist** (Large farms >50 ha)
Eldorado – 1.09% reject kernel recovery

These orchards are consistent winners and along with Classic Park, these older orchards are still performing very well. What are the tree ages and varieties?

Cambewarra and Quamby are 15 years old, with Banyula a mix of 15 and 20 year old trees. Kona, Burrawang and Classic Park are much older at 31 years. In the orchards, we have some higher kernel recovery varieties, namely A16, 816, 842 and Daddow, and some low kernel recovery varieties, 344 and 660.

816 hasn't been a great performer for us over the last five or so years. 816 does 3t/ha on the yield monitors and everything else does 5t/ha plus. Luckily, we don't have too many 816's, but it does hold us back to an extent in those orchards.

With so many orchards, soil types, varieties and ages, do you manage them vastly differently?

There are definitely different management protocols for each variety as well as for each tree age. We also closely track the soil conditions in each orchard. Two particular differences are the nutrition programs and canopy management.

We prune distinctly for different varieties, particularly with older upright growing Hawaiians. When it comes to nutrition, A16 and 816 certainly have higher inputs with 842 and Daddow getting less as an example. We find with the higher KR varieties naturally need more and if we don't supply that higher rate we end up with biennial bearing.

Do you think this will be the case with some newer higher producing and high kernel recovery varieties?

MCT1 falls in the same category of caution, producing more than standard varieties. If you don't allow for that good kernel per hectare, it's going to burn out if you don't replenish the trees.

How have some of your canopy management strategies for different varieties and tree spacing changed?

With any of the Hawaiian varieties that are big in nature, vertical growing and on tighter spacing we are hedging less, selectively removing limbs and if needed removing rows.

We haven't done selective limb removal early enough on some of the 30 plus year old orchards. In some orchards with narrower spaced 7 metre rows, we removed some rows about a year ago, removing every second row of 816 in particular, because it is a very big tree and needs its space.

What about row removal on wider spacing such as 8 and 9 metre rows?

We are doing some row removal on 8 m rows if they are large growing varieties. We wouldn't remove a smaller A variety on 8 m spacing, but with a big Hawaiian variety that's 30 plus years old on reasonably good soils, it's a different story. The tree is becoming more and more vertical because of competition from overcrowding and worsened by hedging.

I think 9 m row removal, leaving an 18 m interrow for us is just too far. It's horses for courses when it comes to row removal and definitely variety and soil dependent. In these older orchards, if we could go back and prune differently, it would be a different story. Little canopy management was done in the past and now we're stuck with the results.

Row removal isn't done cold turkey, it's a slow and phased process usually undertaken over two to three years. Depending on the age and variety, we look to hedge the row that's coming out, allowing the rows on either side that are remaining to relax into the space and grow more canopy over time.

This allows more light into the remaining trees as they grow and into the remaining wide interrow to establish essential groundcover.

A lot of what we plant now on 9 m row spacing are smaller varieties. With better varieties, cross pollination, early pruning, selective limb removal and higher early yields, canopies will be completely different. Pushing the tree early to get good vegetation and early production will ultimately hold tree size back.

Are you pruning small trees differently and pruning more proactively?

From year 5 onwards, we certainly start removing a limb from the middle of trees, a process we would only have started at year 10 before. Among other benefits, this rejuvenates the wood. A lot of the precocious varieties fruit on younger wood and when they get older and there is a lack of light, you end up with an empty heart to the trees.

In the past, the industry was nervous about the sheer cost of selective limb removal, but it's a cost that is covered and essential. If you don't do it, the cost will be far more.

In macadamia management, it has been easy to get stuck in our ways - stuck on not doing the necessary canopy management, the same fertiliser regimes, even stuck on planting the same varieties.

All of us in the industry are so busy and it is easy to look over the fence and copy practices, especially when we don't have the experience ourselves. In many ways though, this keeps us stuck on the little that we know about the trees.

You need fresh eyes to challenge and bring new life into old routines. Often those aren't even rocket science or a silver bullet but just practical new approaches.

We have also lowered our skirts over the years in a gradual process. Still high enough to have machinery access, but much lower than most orchards that skirt up to around shoulder height. We're skirting back to about hip height, around 900 mm off the ground.

We are obviously keeping skirts low for moisture retention, but particularly to gain more crop.





Macadamia Farm Management manages existing orchards of all ages as well as establishing new farms.

Lower limbs, if they are there, will definitely grow a good crop as long as there is sunlight available down to those parts of the tree.

Do you think good prices have confounded this nervousness to prune proactively?

We need to disregard the price of macadamia currently. It can make jelly in the heads of growers. Farming has ups and downs, but high or low, I try to focus on what we have control of.

We all obviously love a good price but if you farm for yield, what more can you do? By focusing on maximising sustainable production, which often isn't a cost saving or reductionist view in agriculture, the price then takes care of itself.

You have gone through a significant amount of orchard and tree rejuvenation in these orchards, but where do you start?

Orchard rejuvenation and tree rejuvenation are different and both steps are required. An orchard floor, with exposed roots where you clearly haven't got the fibrous feeder roots and a storage bank, will never be productive.

If I was walking into a 30 year old orchard that had been neglected, the first thing I would spend money on would be managing the irrigation properly, then organic matter, then synthetic fertilisers, then canopy management once you've improved tree health and the trees are putting on more new leaves. Older unproductive orchards lack leaf with symptoms like a skeleton top. Selective limb removal is a process that happens later on.

Some orchards require tree removal and it is a neutral cost exercise, when you take into account the cost and delivery of organic matter. We chip and then compost the removed trees to go back onto the orchard. We then grade the soil out of the interrow and over to the tree rows, adding about 12 to 15 cms of growing media onto the trees that remain.

It varies, but we get about 1.5 cubic metres of chip from a large 30 year old tree. Our method is to remove and then compost that chip on the headland. This allows crucial space to do the necessary earthworks and then we can also place it back more precisely rather than scattered, getting the most benefit. We are better off composting it, adding more chip if needed and applying it back the following year.

When I talk about increasing organic matter, it has to go hand in hand with orchard floor management. We bring in a good compost and then sweep the interrow which usually has an accumulation of grass, husk, leaf and soil. We throw that interrow material on top of the organic matter. The interrow is a great resource that is really under utilised. Everything migrates there over time and it has to be managed to get the best out of it.

What are some of the other basics that you prioritise each season?

Applying lime and gypsum has to be maintained. Because you apply it annually rather than in small amounts regularly, it can seem like a big cost. Growers shy away from big numbers. When you add up the cost of your regular nitrogen or potassium applications they are equally as expensive, but the cost is spread out.

A bill for lime that's thousands of dollars can seem too much. Crucially, these amendments are about getting the soil structure right. Soil health is completely reliant on soil structure and without it you cannot get the benefit of all the other inputs.

You need to have the soil structure right to have an ecosystem and living environment under your trees. It's fundamental and thinking we can save costs here is false economy.

On that topic, there must be a plethora of salespeople offering you the latest soil amendment or micro biological product. How do you balance trying new things with providing value for money for your investors?

It can be a minefield. We have multiple people listening, judging and analysing inputs we are being sold, so it's not just one person potentially being swept up. Reputation is important and we ask for evidence of product claims and where it has been used before. If we feel there is a gap in our program, we will do our own trial. It needs to be about the product not the salesperson.

Mentally though, one first needs to get the basics right. If you haven't got those basics right, don't jump to something amazing, which is a liquid in a bottle. Things like getting your pH right and soil health elements need to be in place first. Then you can start experimenting with different products once the fundamentals are correct, otherwise you are not likely to get the benefit from these fancy and often expensive products.

Much of what is being sold to improve productivity is high end. We call them the 1%, 2% or 3%'s, but we've already got the basics right. People have a desire and personal interest in finding the 1%'s, but they're adding that to a base of only 60%.

They are jumping ahead to what may be good if they had any food in the soil to begin with.

It can be like feeding concrete, it fails. So many products fail expensively on the back of not getting the basics right. You can't jump to your foliars when your roots are non-existent, for example. You're trying to put the icing on the cake but there's no cake there, or there's only a small amount of cake.

How long has this journey taken for you and your team?

This has not been an overnight journey, that's for sure. We are naturally impatient, me in particular. More than seven years ago, we started applying organic matter. It wasn't a finished compost but more of a melt compost that was an economical way to provide body. It was more of a 'bang for buck' soil food, while some people went out and bought expensive compost and applied small amounts because of the expense…three, four, five tonnes to the hectare and it blew away or got washed away like potting mix. Our hardwood chip, which was more of a mulch than a compost and had much more organic matter bulk, is still there today after three years. It's a build-up and nothing in this industry is overnight. It just simply isn't.

Return on investment can be false when you're trying to speed up the process. The goal often costs much more than you think and it's a process of spending and then waiting. The best investment is getting the foundations right.

The other thing we could do better is to put organic matter on young trees earlier. Many tend to wait until the trees are closer to producing and then start spending money. They have spent a heap and are licking their wounds.

You cannot put a tree in the ground and shut the gates, waiting until a nut comes down. You've actually got to be proactive.

You derive many benefits from the team you have built around you, both staff and advisors. For many growers, it's more like a one man/woman show. How would you approach management if you were on your own?

I would choose progressive like-minded growers in close proximity and form a small group that gets together, say every second month. Have a barbecue, have a beer, discuss and share what you're doing. In that way, you are creating your own grower micro-climate within your street or region.

I think getting off farm is particularly important. With your head down at home, growers are often not learning or challenging themselves, concentrating instead of doing the day to day.

Instead of looking over the fence, go through the gate and speak to the grower rather than copying from a distance and missing so much of the context of what they're doing. The bonus is it works both ways, the sharing actually assists both growers.

We are all proud, so we hide some things, avoiding adopting new ways because we're actually scared of exposing our misfortunes. But we are all out to improve and exposing your challenges is only going to help and give you a perspective you didn't have.

Getting off farm?

If you would like to take Scott's advice and be part of a "Getting Off Farm" program where the AMS will facilitate grower trips to experience growing practices and farm life in another region, expressions of interest can be sent to office@macadamias.org.au. Please include your name, organisation, email address and how many are interested in taking part.

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Harvest efficiency a key to success for Red Rock Macadamias

Maike Smit R&D coordinator and grower liaison, Macadamias Direct **P:** 0491 201 274 **E:** maike.smit@macnut.com.au

Orchard: Red Rock Macadamias

Owner: Jason and Fiona Klotz

Location: Bundaberg and Redridge, Queensland

Farm size: 80 ha of mature trees, 120 ha of 4-year-old trees

Varieties: 816, Daddow, A203, A4, 741

Years farming: 15 years



Jason Klotz has adopted a new finger wheel system which is increasing harvest efficiency at Red Rock Macadamias.

Red Rock Macadamias are consistently one of the best growers in the industry, winning the industry large grower of the year award multiple times as well as lowest unsound kernel/ha. Jason Klotz describes the new finger wheel system he has modified over the past three years to improve harvest efficiency and maintain nut quality.

As soon as macadamias reach maturity, the clock protecting kernel quality and shelf-life starts ticking. As a result, the priority for growers quickly turns to rapid and effective harvesting to maintain nut quality. However, with increasing hectares and often unfavourable conditions faced at harvest time, optimising harvesting rate and efficiency has become even more important.

Red Rock Macadamias has conceptualised and modified the finger wheel system to overcome some of the most dreaded challenges faced during harvesting. Frequent cleaning of finger wheels during harvesting takes up a significant amount of valuable time. Adding to the lost time lost is repairing and maintaining damaged finger wheels due to clogging. Harvesting tempo is ultimately impacted, reducing overall efficiency.

Jason explained some of the key modifications he has made to an existing system and how it has improved overall efficiency.

What were some of your key considerations when modifying the system?

Finding a flexible but durable material for the finger wheels was one of the key challenges, since this will ultimately affect how well the finger wheels can pick up and hold onto the nuts. Having a durable material further reduces the need for maintenance on the system, especially under harsh harvesting conditions.

Achieving optimum results with the modification required altering more than one component. Over or under designing one component may have ultimately impeded the functioning of the other, affecting the system's overall efficiency.

How often should you replace the finger wheels?

This will vary as the conditions under which it is used will affect its longevity. For example, our rear wheel packs in the grass can last up to two seasons. Front wheel packs under the tree line may have to be replaced seasonally to maintain optimum pick-up.

What is your harvesting frequency?

We do at least nine harvest rounds per season with one harvester, as well as a pre-season clean-up, with each round being about 200 km. During peak season we try to harvest every two weeks.

What pick-up percentage are you aiming for using the modified finger wheel system?

Of course, growers will always aim for a 100% pick-up, but we have managed to achieve at least 98% with this system, without compromising harvest speed.

Was it worth investing time to modify the finger wheel system? What benefits did you get from this?

Now entering our third season since investing in these modifications, there are plenty of rewards. Firstly, we have almost doubled our ground speed at harvest from an average of 5-6 kph to at least 8-10 kph at a 2-3 kg/tree pick-up.

The modifications also allow us to harvest in areas where tree shaking leaves high volumes of sticks and leaves on the orchard floor, without having frequent clogging up of the finger wheels.

The wheels are fully reversible, which enables easy de-clogging without the operator having to lift a finger! (no pun intended).

The bigger picture

Poor harvesting practices easily account for 10% of the crop lost each season across the industry when you factor in what doesn't get back to the shed, what gets thrown out at the shed, and what gets rejected at the factory.

At an industry average of 3 t/ha, this equates to 300 kg/ha worth $1,800/ha at current prices. Do the maths for your farm, it is a big number, so you should never hesitate to spend more money on new wheels and extractors for your harvester each season or upgrade your harvester to optimise your harvest pick-up.

What do other growers say?

Red Rock Macadamias have fitted their finger wheel packs to other growers' harvesters to get a better understanding of their ability in varying conditions.

Mitch Davis from Gympie simply describes them as 'the best pinwheel on the market and I have gone from pulling my hair out to nearly sleeping on the harvester'.

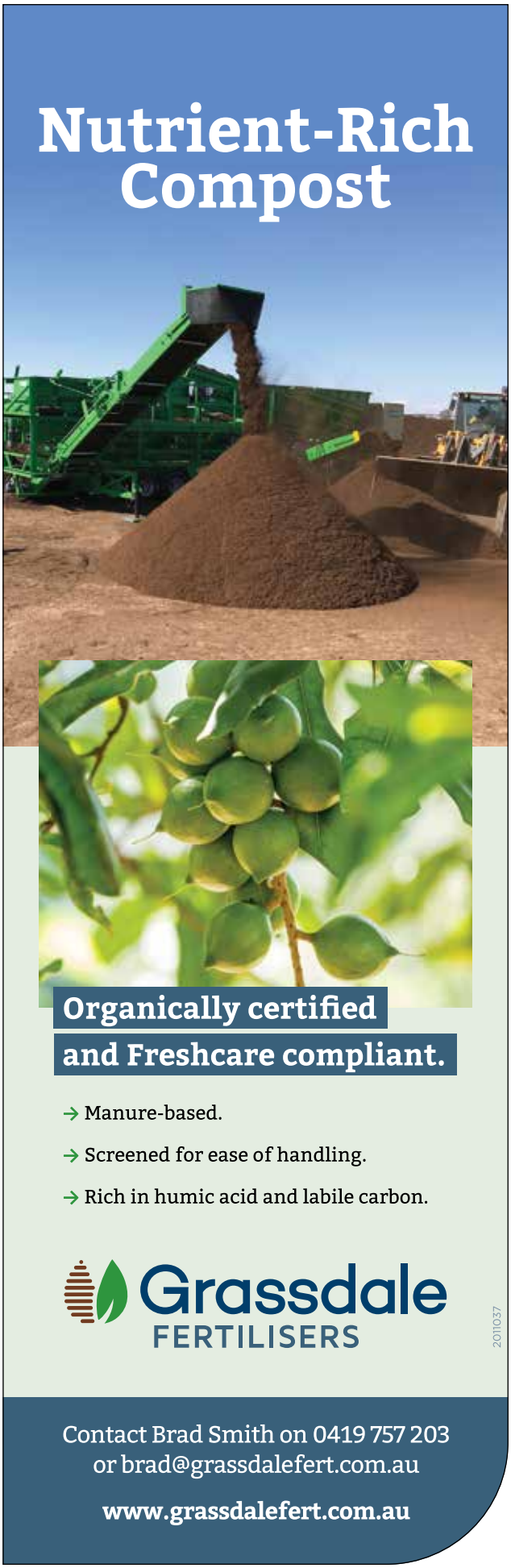
James Thomas, also from Gympie, says the Red Rock finger wheels have allowed them to improve their harvesting efficiency, even in the toughest conditions.

Andrew Pearce, Queensland Grower Liaison for Macadamias Direct, congratulated Jason on his latest innovation.

"Red Rock Macadamias consistently delivers 0% reject and Jason's attention to detail, including his approach to harvesting is a key to these outstanding results," he said.

"Going to the effort and cost of designing and manufacturing his own pick-up wheels is testimony to his commitment to optimise harvest efficiency, production and quality."

For more information about the finger wheels, contact Formatt Machinery, Bundaberg, on (07) 4151 2381



Tree resilience is essential to high performing orchards

Emma Fuss Grower Liaison, Macadamias Direct **M:** 0428 237 787 **E:** emma.fuss@macnut.com.au

Mike Cooper (aka Mr Macadamia) runs four macadamia orchards at Elimbah and Glass House Mountains in Queensland. The farms have approximately 37,000 trees of which 90% are 741 with 7 and 8 metre spacings. Since purchasing the properties in 2006, Mike and his team have been focused on creating high yielding quality orchards that can withstand and take advantage of natural weather variabilities.



Mike and his team at Mr Macadamia have won awards of excellence for the best productivity on a large farm in the Glass House Mountain region in both the 2018 and 2019 seasons.

When asked the reasons for his sustained good performance, Mike Cooper says that there is no silver bullet. "Moisture retention, observing the trees regularly, giving them what they need in small inputs when they require it and taking advantage of long-term weather trends are all critical," he says.

Mike ensures that his trees are at their highest level of health by late August to protect them into the traditionally drier draw-down months between September and November.

Management and weather trends

A base formula that is flexible to changing weather is used for nutrition application, orchard floor management and pest management. This strategy was developed from numerous trials conducted on-farm.

Mike monitors the yearly weather forecast trends on a monthly basis to plan orchard activities and input amounts in advance. Flexibility is kept in the system so that when the trend changes he can change his plan very quickly, maximising weather advantages. As Mike so aptly puts it 'the trend is your friend, as soon as it changes you must change'.

Coming from an intensive agriculture background in pig and poultry farming, Mike is using these previous



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experiences to manage the farms in what he calls a more intensive way. Mike monitors all the trees fortnightly, picking up and then immediately treating any small weakening areas to 'prevent problems, not treat them'.

In July, Mike and his employee Bob comprehensively check all the farms. The employees are skilled at reading tree health, being continuously in the same roles on the farm. As Mike says, 'good employees are critical to the enterprise'.

Setting the tree up for success

Mike's goal is to make the trees as healthy as possible by the end of August to prepare them to withstand the September-November draw down. It is a strategy designed to insure against the risk of nutritional issues occurring when there is limited to no rainfall.

Annual soil nutrient applications occur between February and June/July. Almost 100% of inputs are applied by June/July with liquid fertiliser used throughout harvest. Foliar sprays have been consistently used since 2007 to which he adds insecticides.

Orchard floor management works occur every second year in late July to September. Farms with areas that are bad, storm damaged or at higher risk are treated annually. These works consist of an application of a double ground mulch and a soil conditioner, followed by manure and then a soil profile layer with molasses on top.

Canopy management

Mike and his team prune every second year in line with their orchard floor management program. Pruning consists of hedging with a double hedging machine in a special pattern, creating a shoulder in the top of the tree. Regrowth is controlled by carefully balancing nutrition.

Water retention strategy

Water retention is critical on these non-irrigated farms to build resilience into the orchard and de-stress the trees. When they were first acquired, the farms were badly compacted and had severely exposed roots. This was improved by an inter-row rotary hoe, deep ripping and delving program.

By using hedging as a canopy management tool and closing up the rows more, the amount of light and heat on the orchard floor is reduced, conserving moisture. The orchard floor is also insulated by the mulching program.

Mike says that he would irrigate if he could, but an irrigation scheme is not due in his region until 2028-2030.

Post-harvest strategy

Mike has a robust post-harvest strategy to achieve maximum value from his crop.

"If we can bring in more tonnes more quickly, it's a big advantage, as rain can catch us out with multiple farms and logistical issues," he says. The answer has been to upgrade the processing shed to run faster.

While the farms previously had some of the highest levels of brown centres, Mike now dries his nuts using 50 tonne silos with gas dryers to mitigate this. The NIS are dried to 9% to 10.5% moisture before sorting. Consequently, the brown centres are now at fairly non-existent levels and he is achieving more consistent factory results.

Conclusion

Mike and his team have used many practices to increase productivity and quality on their farms. By taking advantage of natural weather variabilities, conserving moisture and increasing soil and tree health in a timely manner, the team at Mr Macadamia has done an amazing job and well deserve the awards of excellence.



Am I reading this right? Climate information and interpretation in a La Niña year

Dr Chelsea Jarvis, Research Fellow, Centre for Applied Climate Sciences,
University of Southern Queensland, Toowoomba **M:** 0438 264 409 **E:** Chelsea.jarvis@usq.edu.au

Dr Chelsea Jarvis, a climatologist with the Centre for Applied Climate Sciences at the University of Southern Queensland, says the key to using weather and climate information is knowing where to find the information and how to correctly interpret it. This allows growers to make their own judgements without relying on someone else's interpretation.

Weather forecasts

The main source for 7-day weather information is the Bureau of Meteorology's MetEye (http://www.bom.gov.au/australia/meteye/). Many other websites (e.g. Elders, Willy Weather, etc.) use this information for their own websites, so growers may as well go straight to the source.

The main MetEye page does not provide a lot of data, but with a couple of clicks, growers can access more detailed data. First, click the 'Text Views' button on the top right. Second, enter your location and click 'Locate'. Now, click on the 'Detailed 3-Hourly Forecast' in the column on the top right.

This page provides a wealth of information such as percentage chance of rain and amounts, temperature, dew point, relative humidity, and wind speed and direction, all in three hourly intervals. This information can be useful for things such as spraying and irrigating.

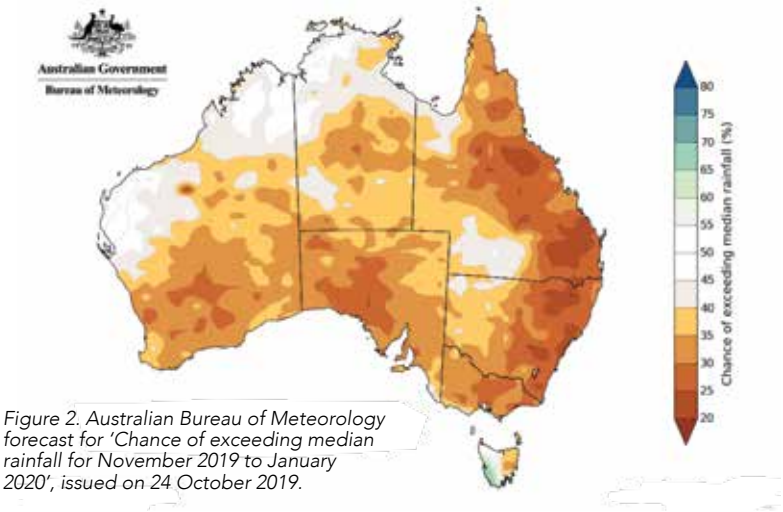


Figure 2. Australian Bureau of Meteorology forecast for 'Chance of exceeding median rainfall for November 2019 to January 2020', issued on 24 October 2019.

The main MetEye page does provide a snapshot of things like temperature and rainfall, but many (many!) people misinterpret the rainfall data. Figure 1 shows how to correctly interpret rainfall data. Note, 'Chance of rain' always means 'Chance of at least 0.2 mm'.

The correct interpretation of this particular forecast for Wednesday 20 May is:

- 100% chance of at least 0.2 mm (certain)
- 50% chance of at least 25 mm (medium chance)
- 25% chance of at least 45 mm (low chance).

Seasonal (1-month and 3-month) forecasts

Beyond a 7-day forecast we have multi-week, monthly and seasonal forecasts.

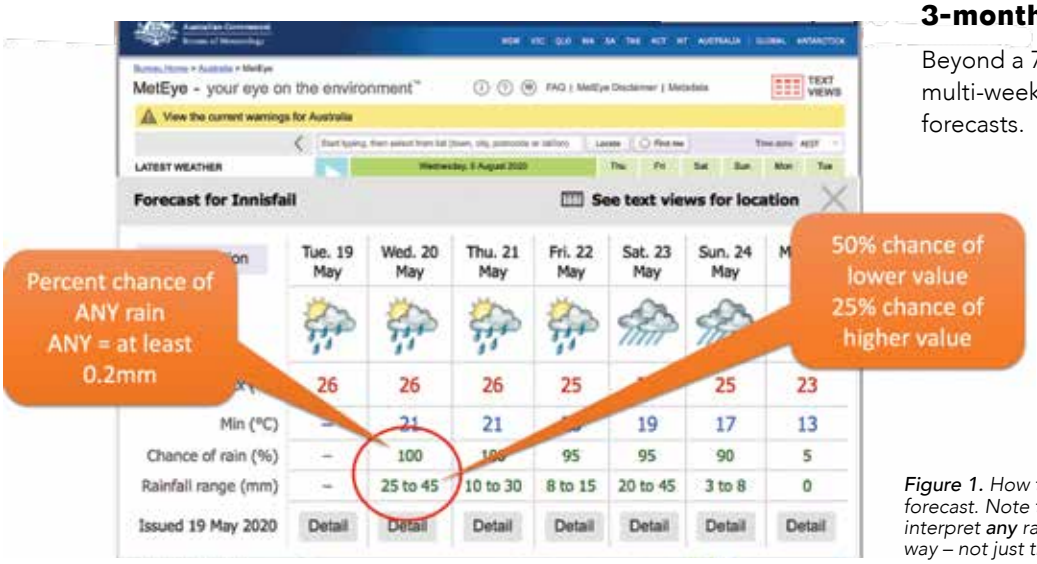


*Figure 1. How to correctly interpret a rainfall forecast. Note this is the correct way to interpret **any** rainfall forecast presented this way – not just the BOM forecast.*

These forecasts are always probabilistic, meaning that they provide information on the likelihood of something happening but there is still a chance conditions may change closer to the date.

Figure 2 shows a forecast from November 2019 to January 2020 for 'Chance of exceeding median rainfall (%)'. For much of the macadamia growing area, we can see there is about a 25-30% chance of exceeding the median. This means there is a 70-75% chance of *not* exceeding the median.

In other words, this forecast was saying the odds for November to January of last year (2019 - 2020) were likely to be drier than usual. However, we don't know *how much* drier than normal as this forecast only tells us about rainfall relative to the median. You can find these forecasts here: http://www.bom.gov.au/climate/outlooks/#/rainfall/median/seasonal/0

One critical piece of information for this forecast is *knowing your medians*. If you do not know your median, then a forecast providing information relative to your median will not be useful. Note that median is not the same thing as average. Here is an example demonstrating the difference between median and average:

Rainfall during April in Maryborough, 2000-2010	
Year	**Rain (mm)**
2000	20
2001	98
2002	113
2003	80
2004	185
2005	72
2006	157
2007	83
2008	65
2009	108
2010	221

Median – The middle value of a ranked set of numbers

Maryborough data 2000-2010 ranked from lowest to highest: 20, 65, 72, 80, 83, 98, 108, 113, 157, 185, 221

The median is the number in the middle, in this case 98 mm.

Average – Add a set of numbers and then divide by the total amount of numbers in that set.

For Maryborough: 20+98+113+80+185+72+157+83+65+108+221 = 1202

1202/11 = 109 mm

This is an important distinction because expecting 'average' rainfall when a forecast is for 'median' rainfall can lead to disappointment, as the median is usually lower than the average due to large rainfalls skewing the average.

Fortunately, both median and average data can be found online for many of the macadamia-growing regions. The BOM is a good source for this data (http://www.bom.gov.au/climate/data/) as is ClimateArm (http://www.armonline.com.au/#/ca).

A second piece of critical information is the skill of the forecast. The skill is how many times in the past that forecast has been correct. The BOM provides skill maps for every climate forecast map. The Skill Map (Figure 3) is for the same months as the seasonal forecast above (Figure 2), from November to January.

We can see that, in the past, the forecast for the months of November to January for Queensland and New South Wales has been correct more than half the time (greater than 55% accuracy), and for certain areas (in dark green), this forecast has been correct 75-100% in the past. I usually put faith in the forecast when the skill is over 55%.

A past accuracy of less than 50% is no better than tossing a coin. If you look on the BOM website, you will notice that the skill maps for months like January and February are usually less than 50% for much of Queensland. This is mainly due to the unpredictability of cyclones and tropical lows. You can find the skill maps in the same location as the seasonal forecast maps.

La Niña 2020-2021

El Niño-Southern Oscillation (ENSO) is the main climate influence for eastern Australia. ENSO has two active phases and an inactive phase: El Niño (dry), La Niña (wet), and a neutral phase when ENSO is not active and has no influence on our climate.

An active phase of ENSO (either El Niño or La Niña) usually starts in late winter/early spring, peaks over summer, and then quickly decays (or goes back to neutral) in autumn. 2018-2019 and 2019- March 2020 were both El Niño years and then we began to see a shift in June 2020 to La Niña. We are now in a La Niña phase and it is predicted to continue until March/April 2021.

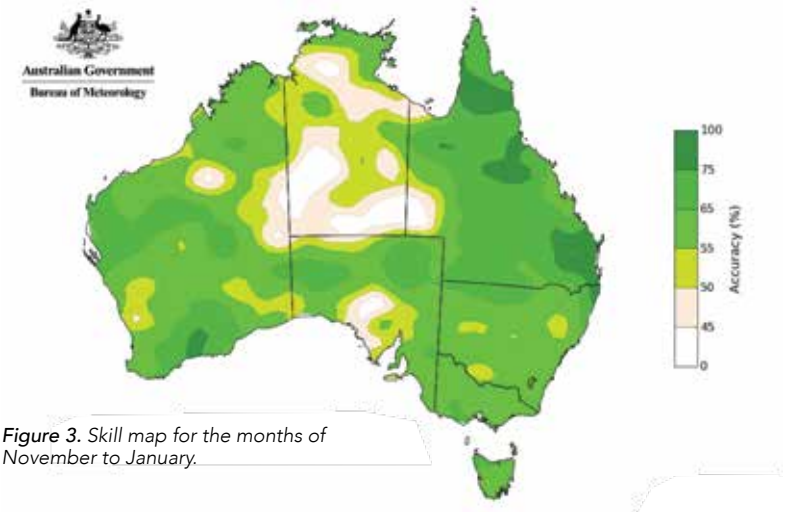


Figure 3. Skill map for the months of November to January.

We can think about ENSO events as *shifting the odds* of the likelihood of things like rainfall and high temperatures. For example, during an El Niño event, the odds are shifted to drier conditions being likely – though flooding can still happen due to other weather and climate activity, such as the Madden Julian Oscillation. During a La Niña event, the odds are shifted to more rainfall, but again, other things can prevent this from happening.

Fortunately, the Seasonal Climate Forecasts issued by the BOM (as well as other groups, such as the UK Met Office) include everything that is going on in our oceans and atmosphere, not just ENSO.

A few things about La Niña

During a La Niña, we can usually expect to receive more rain than median. This is due to there being more moisture in our atmosphere which provides an increased potential for rain and also causes higher humidity.

Rain events during La Niña are usually more widespread and there is an increased chance of more rain events than normal.

Day time temperatures during La Niña are usually lower due to more cloud cover, but they can feel warmer due to increased humidity. Nights are usually warmer, again due to cloud cover which holds in heat.

We generally see more cyclones and tropical lows form during a La Niña.

Every La Niña (and El Niño) is different! For example, this La Niña started much later than most La Niñas. During some La Niñas, we have widespread flooding while during others, rainfall is near (or even slightly below!) normal. This is because ENSO events do not happen alone – there are always a lot of other things going on in our oceans and atmosphere that influence what happens, when and where.

The good news for macadamia growers is that the seasonal forecasts for the months of September to April are usually quite good, as this is the time when ENSO will be active.

If there is an El Niño or La Niña event, the forecasts are generally more accurate because once one of these events starts in the spring, we know it will continue until the following autumn. There is usually poor forecast accuracy from April to at least June, as this is the time the oceans are reorganising themselves and so there are unlikely to be clear patterns.

To learn more about climate and forecasts, please check out the free online Forecasting for Decision Making course offered by the Northern Australia Climate Program at https://nacp.org.au/outreach/training/launchpad.

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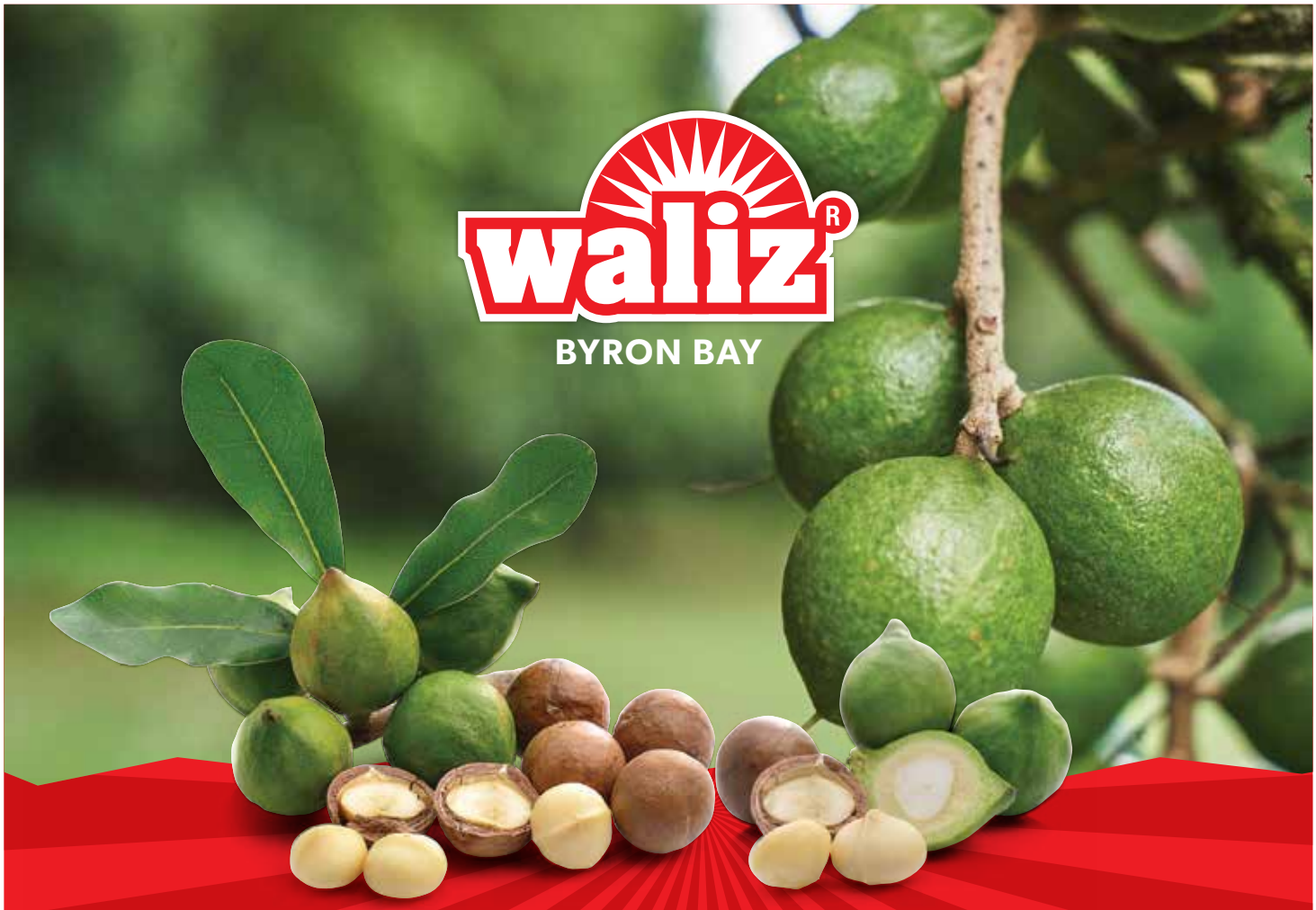
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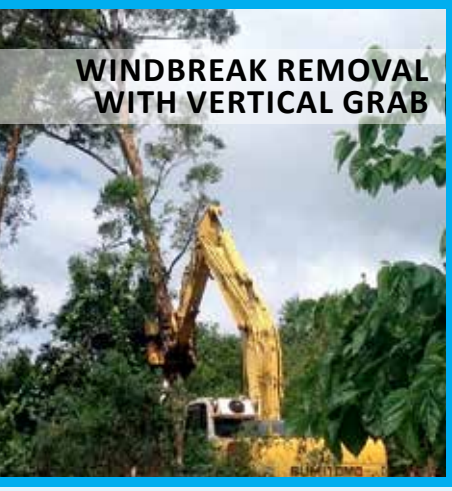
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Macadamia ecophysiology enlightening management: Part 1

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

Macadamias are only a few generations from the wild and understanding the environment they have adapted to over millennia is essential to unlocking the tree's potential. This article is the first part of a series overviewing the unique ecophysiology of macadamias and how this perspective is key to managing an essentially wild crop. From their natural distribution in Australia, to their position in the subtropical rainforest canopy, down to specific tree characteristics; each level provides insights for growers.

Ecophysiology might sound like a mouthful, but it is simply the study of the physical and biological forces that have shaped an organism's physiology over time. Understanding these influences and resulting adaptations allows better outcomes for growers. In essence, understanding ecophysiology allows you to work ***with*** nature rather than ***against*** it.

The new Grower Toolkit the AMS is developing has this ecophysiological approach as its foundation. Essentially, macadamias are wild and possess the traits that have enabled survival over millennia without human intervention. This process of natural selection hones a species' inbuilt survival mechanisms to accentuate and perpetuate species traits that confer the greatest advantage. Compared to other horticultural crops such as apples, macadamias are only at the start of the path to domestication.

Studies show that most commercial varieties are only two to three generations from the wild and even our latest, most advanced varieties are no more than four generations from the wild. Studying the forces that shaped macadamias provides insights into how they not only respond to the current natural environment, but also when an orchardist intervenes to manage them.

Macadamias in the macro-environment – climate and species distribution

There are four species of macadamia, all of which originated in the rainforests of south-east Queensland and northern New South Wales. This article discusses the two species that form the basis of the commercial macadamia industry, *Macadamia integrifolia* and *Macadamia tetraphylla* and their hybrids. The environments and climates these two species have

Distribution of wild macadamias in Australia and their general climate, geology and altitude

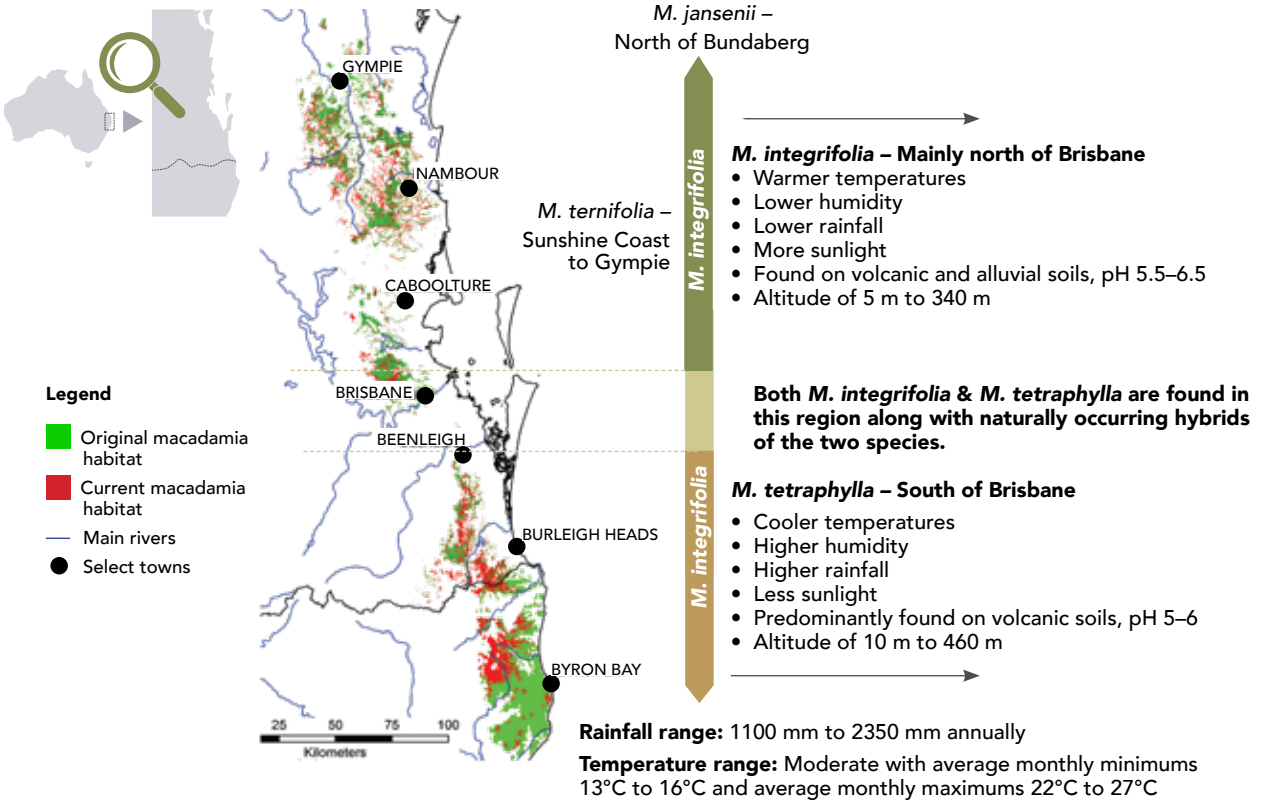


Figure 1. Wild macadamia distribution and environmental conditions. Map reprinted with permission from Craig Hardner, adapted from map and data in Powell et al. (2014), Aust. J. Bot. 62(4) 322–334.

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evolved in (shown in Figure 1) are subtly different, resulting in different physiological characteristics.

Unlike tropical rainforests commonly seen in documentaries which are characterised by high rainfall, subtropical rainforests where macadamias have evolved generally have a distinct dry period (typically in winter) and warm, wet, humid summers. In the macadamia's natural distribution, the wettest months are usually January to March and the driest are August to September. January is generally the hottest month and July the coolest.

Besides climate, geology also played a role in the evolution of macadamias.

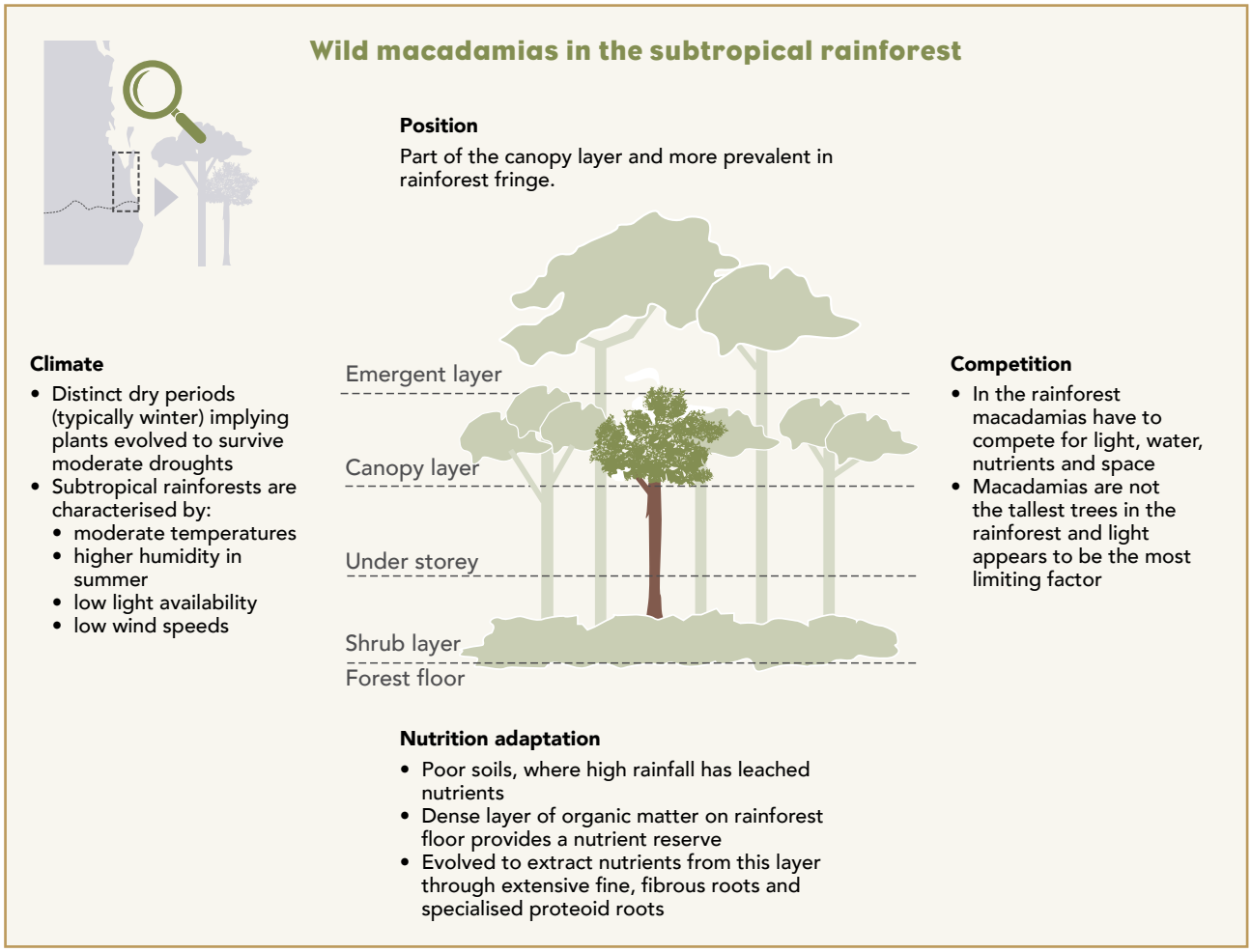
M. integrifolia is mostly found on high-nutrient, slightly acid volcanic soils and on alluvial soils in coastal south-east Qld (mainly north of Brisbane). *M. tetraphylla* is predominantly found in coastal northern NSW up into south-east Qld (south of Brisbane) on slightly acid, well-drained volcanic soils and to a much lesser extent on alluvial soils. Some of these soils may be shallow and rocky, particularly in the areas where M. integrifolia occurs. There is small band stretching south of Brisbane to the NSW border where both *M. integrifolia* and *M. tetraphylla* are found along with naturally occurring hybrids of the two species.

In general, macadamias are found on soils derived from volcanic rock. These soils have an inherently high fertility, but topsoils may have reduced nutrient availability due to leaching and erosion from heavy summer rain, or where certain elements are bound to the soil (such as phosphorous). The rainforest floor is typically covered in organic matter and the constant breakdown and release of this matter provides a source of nutrients which are rapidly absorbed by the roots and recycled through the trees.

Macadamias in the subtropical rainforest environment

One of the defining features of subtropical rainforest is the presence of different layers, or strata. Macadamia's position within the 'canopy layer' (see graphic below) of the rainforest has shaped its evolution.

This canopy zone creates its own microclimate: light is often limiting, humidity is high, temperatures are moderate and there is little wind. This is an environment that is distinctly different from that prevailing in today's orchards. In their undisturbed rainforest environment, macadamias have a markedly different tree structure, with tall trunks, few side branches and a small canopy at the top of the tree.



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Whole-tree adaptations

The macro-environment and subtropical rainforest macadamias evolved in has also led to unique morphological (pertaining to structure/ form) adaptations. In contrast, orchards are artificial environments that macadamia are not well designed for.

Our goal is also not tree survival, but rather maximising yield. A successful transition from the wild to a managed environment requires a good understanding of macadamia physiology from a whole-of-tree basis and even down to specific vegetative/reproductive structures.

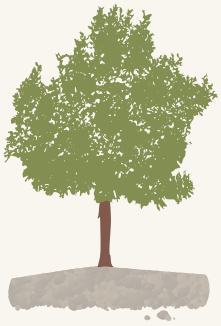
Whole-tree adaptions

Vegetatively biased

- Macadamias favour their own survival over that of progeny
- In most conditions the tree will favour flush over nuts to ensure its survival

Canopy architecture and root distribution

- Canopy channels water down branches and trunk, concentrating it around the trunk base where root density is highest
- This mechanism exploits small rainfall events in a highly variable rainfall environment
- Dense roots at the trunk base ensures exclusive access to water and nutrients directly below, reducing competition



Flush management

- Trees capitalise on favourable conditions and avoid stressful conditions
- Do not flush when water is limiting
- Produce new flush when soil water is replenished after any period of drought
- **Nutrient storage:**
- Stores nutrients in above ground structures; stems, branches and older leaves which allows survival in poor soils
- Starch stored in branches, trunk and roots which act as a buffer during periods of high demand

High hydraulic conductivity

- Allows easy uptake and movement of water throughout its structures, opportunistically using limited resources
- Ensures 'core' structures are always well hydrated

Root adaptations

Macadamia's least researched structure are the roots, which evolved interesting adaptions to survive seasonally wet and dry conditions while maximising both water/ nutrient extraction and maintaining tree stability.

Root length density is highest near the trunk and decreases rapidly towards the outside of the canopy. This adaptation likely relates to the tree's architecture which collects and funnels water down the trunk. This is a valuable feature to convert small rainfall events into something more substantial. Along with a dense, fine, fibrous root system, macadamia have also evolved specialised 'proteoid' roots allowing the extraction of elements such as phosphorus from the soil. Figure 4 highlights some of macadamia's root adaptations.

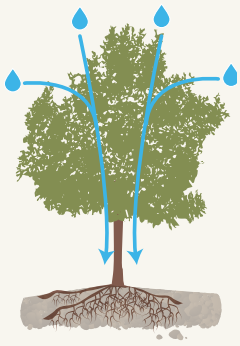
Root adaptions

Scavenging roots

- Evolved proteoid roots, which are energy intensive to produce and only live 6–8 weeks
- Proteoid roots increase root surface area and ability to scavenge for nutrients in poor soils
- Efficient at taking up limiting elements
- Fine, fibrous root system exploits thick leaf litter layer decaying on rainforest floor
- Extensive and specialised root network as major limiting factor in rainforest environments is nutrient availability

Low water uptake

- Roots are highly effective at withdrawing limited water from the soil profile
- Roots efficiently take up nutrients in the soil solution, essential in a high rainfall, low nutrient setting



Structure

<40cm

- Shallow, fine and cluster roots enabling rapid water uptake
- Dense mat of surface roots outcompetes other plants for resources

>60cm

- Anchor root system, not a tap root and able to exploit large areas around the tree
- Wide anchorage roots access water from deeper soil layers
- Able to redistribute water throughout the fibrous root system, conserving resources

Disease susceptibility

- Have evolved in the absence of root disease organisms such as *Phytophthora cinnamomi*

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Leaf adaptations

Macadamias evolved mechanisms in response to the environmental conditions they have been exposed to. The most significant of these are low light, high humidity and distinct dry periods. In many ways, macadamia leaves are the stars of the show and modulate a range of conditions within their natural habitat.

They have specialised water conserving adaptations such a thick waxy cuticle, a low stomatal density and the ability to close stoma at low humidity. While these mechanisms are useful for water conservation, they may limit photosynthesis when conditions are good.

Macadamia leaves' low light compensation point (efficiency in low light) means they actively photosynthesise at light levels found in a well-lit indoor room. Again, these conservative adaptations may be helpful in their natural setting but may limit photosynthesis in an orchard situation.

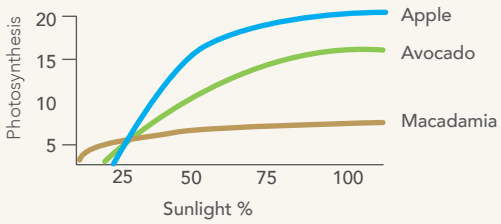
Leaf adaptions

Tough evergreen leaves

- Sclerophyllous evergreen leaves are long lived
- Tough, leathery leaves protect against predation
- Large energy investment into specialised leaves

Evolved to reduce water loss

- Hypostomatous leaves, ie have stomatal pores on the under ('hypo') side of the leaf, limiting water loss
- Low stomatal density, also limits water loss
- Stomata highly sensitive to humidity and close when humidity is low, even with sufficient soil moisture
- Thick wax layer that limits water loss



At the same light level, macadamia leaves photosynthesise at less than half the rate of an apple leaf.



Light adapted

- Waxy layer on leaves serves as a magnifier when light is limiting at the leaf surface
- This protects the leaf from increased light, which can be detrimental to leaves accustomed to shaded conditions
- Adapted to shade with a low light saturation point
- Produce small, sustaining amounts of energy at very low light levels

Photosynthetically limited

- Sclerophyllous leaves pose limitations to photosynthesis
- Macadamias have a low photosynthetic rate compared to other crops such as avocado and apples
- Low photosynthetic rate could be favourable in low nutrient environments
- Photosynthesis can require large amounts of elements such as nitrogen, which is limited in rainforest soils
- Low light compensation point means macadamia leaves can photosynthesise at low light levels

Photosynthesis graph source: adapted from Huett (2004).

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Flowering adaptations

Macadamias have evolved to flower using a combination of currently produced energy and stored tree reserves, another conservative strategy ensuring heavy flowering in ideal conditions. Growers need to be aware of how the influences of one season can flow into another. They also flower in the driest period of the year, suggesting little natural selection to resist fungal flower diseases caused by wet weather.

In the rainforest, macadamias can be separated by long distances and pollen has to move amongst widely separated trees. As the rainforest is a low wind environment, wind pollination is not a viable option. Macadamias have traits that allow for successful insect pollination, likely by small native bees, but also adaptations that ensure maximum out-crossing.

Flower adaptions

Timing

- Flowering synchronised with cool, winter temperatures; and timed to develop in spring ensuring nuts mature at the start of the rainy season

Flowering resources

- Flowers have low light requirements
- Macadamia use current carbohydrate and stored tree reserves to flower. If tree reserves are depleted they may not flower in that year

Susceptibility to weather:

- Evolved to flower during a dry spring; leading to susceptibility to flower diseases during prolonged wet weather
- Adaptated to low humidity and potential flower desiccation so flowers borne on the inside of the canopy (not terminal shoots)



Pollination

- Cross-pollination increases genetic variability with offspring more tolerant to environmental fluctuations
- Self-crossing can lead to the accumulation of inferior genetic traits, resulting in poor survival
- Flowers release pollen ahead of stigma receptiveness (protandry), reducing the chance of self-fertilisation and aiding genetic diversity
- Adapted to low wind habitats and consequently limited pollination by wind
- Large racemes and nectar entice pollinators
- Small flowers with a small stigmatic area (receptive to pollen) evolved for pollination by small native pollinators

Maximising reproduction

- A tree only needs to produce a single offspring over a lifetime to ensure its genetic legacy
- Flowering strategy to maximises reproductive potential so under good conditions many flowers are produced
- Crop size adjusted in response to environment and resource availability

Nut/Seed adaptations

Critical to a species' survival is reproduction and redistribution of its seed; in macadamias, what we refer to as the nut. The seed (shell and embryo) has evolved to ensure its progeny are self-sufficient and able to survive on the rainforest floor. Macadamia's risk averse and conservative traits also apply to reproduction and trees prioritise self-preservation over reproduction.

After flowering, which is dependent on resource availability, the tree adjusts crop load mid-way through the season in response to environmental conditions, a feature that often causes orchardists great frustration. Understanding the interplay between vegetative and reproductive processes can be the difference between little to no production and a profitable crop.

Nut/Seed adaption

Irregular bearing

- Macadamias are irregular bearers in their natural habitat, spreading resource demand over multiple seasons
- Rainforest seed predators are not supported continuously

Crop load adjustment:

- Crop load adjusts to meet resource availability during the season (e.g. November nut drop)
- Adjustment prevents over investing resources in the nut during sub-optimal conditions



Germination

- Nut encapsulated in nutrient-rich husk. When the seed is mature and falls, the husk starts to decompose, potentially releasing resources for the nutrient-poor seed
- Husk holds significant moisture to assist germination
- Shell protects the embryo from predation and allows for a dormancy period
- Germination will only occur once conditions are favourable, ensuring species survival

Energy investment

- Nuts are energy dense and nutrient poor in nature
- Maximum energy is invested into the nut as nutrient resources are finite in the rainforest
- High nut energy content allows for rapid germination and seedling establishment on the forest floor

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Management example: leaf physiology and its implications for the timing and extent of pruning

As an example of how these evolved adaptations have implications for management, we can look at how the physiology of macadamia leaves affects their response to the timing of pruning. The infographic below (Figure 8) is read in a clockwise direction around the central image. The functions of leaves and their basic physiology is explained, together with how the environment affects this physiology, which impacts directly on management decisions.

Macadamias invest a lot of energy in leaves and consequently they are long lived. However, if they become shaded for any length of time the leaves lose some of their photosynthetic capacity and, even when returned to high light conditions, they cannot regain all their former capacity. In maximising cropping potential, it is important to ensure all leaves are maintained in a well-lit state throughout their life.

Large energy investment in leaves and potential shade-reduced photosynthetic capacity have implications for pruning. For example, if a hedger removes the outside of the canopy prior to flowering, then trees can suffer a significant drop in energy supply. This is because when the old leaves are suddenly exposed to high light conditions they cannot make up for the loss of carbohydrates from the photosynthetically vigorous young leaves. Additionally, if the pruning then promotes a strong flush at a critical time, for example just prior to nut shed, then the competition for the limited energy supply could mean that the nut shed will be exacerbated and the final crop reduced. These small insights into how the trees function can help improve your management. In this example, changing the extent/date of your pruning by even a few weeks could result in large changes in yield.

Leaves and photosynthesis

Light exposure and orchard productivity

Macadamia growth and production is directly proportional to the interception of sunlight. Leaves convert this energy into carbohydrates which are used for growth and maintenance.

Macadamias have thick, evergreen sclerophyllous leaves. Leaf production is energy intensive and leaf shed is kept to a minimum in their natural setting.

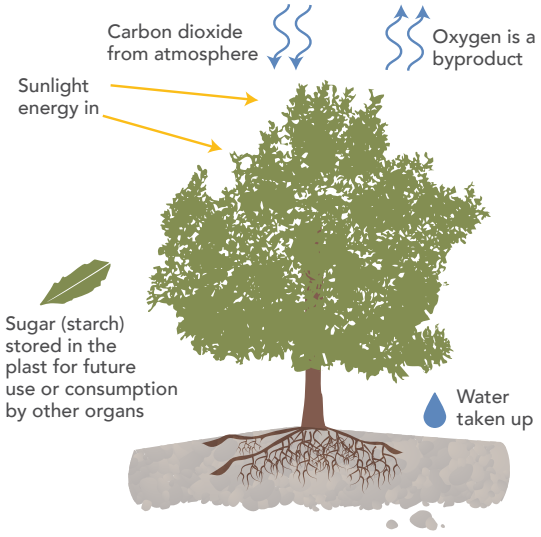
Young leaf photosynthetic capacity

Soft and immature flush leaves are initially net sinks (users) of carbohydrates produced by photosynthesis.

Young hardened-off leaves are the most photosynthetically active parts of the canopy and leaf photosynthetic rates tend to decline with leaf age.

Light exposure & photosynthesis

Although macadamias have some shade tolerance with a low light compensation point (sugars made -> sugars used), lack of light exposure will lead to reduced photosynthesis and ultimately leaf abscission of shaded leaves.



Shade-induced loss of photosynthetic capacity

Leaves in dark, shaded conditions have a much lower photosynthetic rate, leading to low carbohydrate production/ low yield.

Shade-induced loss of photosynthetic capacity cannot be readily reversed by re-exposure to light by pruning.

Maintaining light exposure throughout the entire canopy, over the crop lifetime is essential.

Pruning objective

The objective is to ensure as many leaves as possible are well lit, while minimising leaf loss.

Correct pruning timing is essential. If a strong leaf flush coincides with nutlet abscission, the tree will preferentially allocate resources to the flush and away from the developing nuts, leading to greater nut loss and a reduced final crop.

Hedging - loss of photosynthetic capacity

Severe hedging will reduce photosynthetic capacity due to the lost active outer layer leaves. The new outer layer of canopy is shade-adapted, with around 75% of the photosynthetic capacity of previously irradiated canopy. Removing outer leaves through hedging at the wrong time (within 10 weeks after flowering) can lead to reduced yield and quality.

Pruning considerations

Maximum light interception occurs at a completely closed canopy, but optimal sun exposed leaf area dictates the use of hedgerows with a sufficiently wide alley.

If large quantities of leaves are removed it could result in carbohydrate/energy deficits required by the regeneration of new flush

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The management of wild trees for a productive crop

The biggest difference between macadamia's natural environment and our orchard environment is what is expected of the tree. In the rainforest it's all about surviving on as little as possible for as long as possible while waiting for a good year to provide an opportunity to breed and successfully produce offspring. In an orchard, our expectations are far higher. We want the tree to grow as quickly as possible and produce as much as crop as possible, year after year; and we do this by providing unlimited resources.

This approach has worked well in other tree crops such as apples which have a long domestication history and have been the focus of intense breeding programs. In macadamia however, we are still dealing with essentially wild trees. Understanding how they respond when we move them into an orchard environment is vital if we want to produce constantly high yields without creating significant management problems.

This practical approach of working to first understand the forces that have shaped trees over time, and second develop tools and strategies that both complement and exploit its ecophysiological adaptations, is the approach of the AMS Grower Toolkit. In part two of this series, we will examine a number of orchard operations using this approach and expand on how you as a manager can capitalise on macadamia's ecophysiological adaptations.

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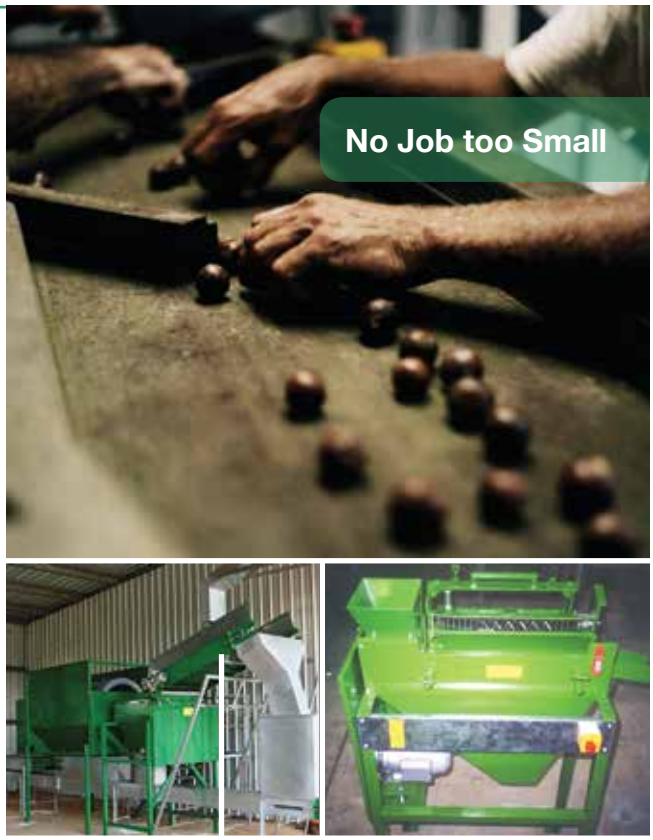
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Collection under way for the Wild Macadamia Arboretum

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MCT's current major project is to develop a Wild Macadamia Arboretum. So far, the value of this undertaking is amply matched by the challenges of implementing it.

The aim of the project is to collect a sample of wild macadamia diversity from across the four species' habitat to grow in a wild macadamia arboretum, where it can be preserved for research and future habitat restoration.

This was last done at the turn of the century, when Steve Faulkner travelled from Coolgardie in the south to Bulburin in the north, collecting cuttings from 76 sites. The cuttings were grown by Henry and David Bell and planted in the National Germplasm trials established by the CSIRO. Two of these trials are still maintained as valuable resources for macadamia research programs, at Tiaro in Queensland and Alstonville in NSW.

The MCT Wild Macadamia Arboretum will expand the number of sites represented more than three-fold, by adding trees from additional sites to complement and expand the original collection, and by increasing the representation of *Macadamias tetraphylla* and *ternifolia*. In some cases, we will collect from 'wild' trees that no longer grow in their original ecosystem, but instead have been preserved as shade trees in paddocks or kept for their nut production when the rest of the forest was cleared. Some of these trees may be the last representative of a lost population.

The challenges

We thought that finding a suitable site and hosts who would commit to looking after an arboretum into the foreseeable future would be the largest hurdle, but in fact industry members stepped up to the task, and we



MCT Executive Officer Denise Bond inspects a 90-year old M. tetraphylla. *(Photo: Iain Stych)*

now have two excellent sites.The site provided by the Steinhardt family will grow all four species, while the site provided by the Caccianiga family will be dedicated to *Macadamia tetraphylla*. Each site is subject to an agreement detailing the long-term conservation of the trees.

The next step was to get permits to collect cutting material from wild trees. As species that are vulnerable to extinction or already considered endangered, all macadamias (except the cultivated varieties) are covered by Federal and State biodiversity protection laws. These laws were designed to protect native plants from exploitation. Without them, some species would effectively be mined from the bush, so the legislation has been critical in protecting plants, such as orchids, from extinction.



New growth on a M. tetraphylla *sucker (Photos: Denise Bond)*



New growth on mature branch.



M. tetraphylla *shows glorious sunset colours and a mix of three leaves and four leaves per whorl.*

In the case of macadamias however, the plant protection laws can have a perverse effect as some legislation does not anticipate collection of cuttings as part of a long-term conservation strategy. So far we have been granted a permit to collect in NSW, but despite applying in March 2019, we have still not received a permit to collect from protected areas in Queensland. In Queensland, we can collect from private land with the consent of the landholder, but it can be time-consuming to find the relevant person, although most people are only too happy to be involved once they hear about the project.

The next challenge is to collect material that is suitable for cuttings – it needs to be from a recent flush, but already hardened off. Too young or too old and there are not enough of the right hormones coursing through the stem for the cutting to strike roots. For most of 2019, it was simply too dry to find suitable cutting material. Things have improved since the start of the wet season, but the response varies greatly at different sites, particularly depending on whether the tree is under full canopy or on an exposed edge.

We have been lucky to secure the support of three native plant nurseries, who although being paid, are going above and beyond to deal with the less-than-ideal cutting material that is often all we can obtain from wild trees in difficult-to-access sites.

The successes

Collections began last year with cuttings from a sample of the genetic diversity growing at the two National Germplasm trials, and then moved to the southernmost populations of *M. tetraphylla* and have now reached Mullumbimby. The sites are a mixture of small remnant patches of original forest, especially along creeks, and trees grown from nuts that were collected from the local bush and planted around farmhouses.

One impressive collection of six planted trees is verified to be 90 years old, and provides a wonderful example of genetic diversity – we visited when the trees had a flush of new growth, and each tree sported a different colour, ranging from deep burgundy to sunset red. They also had different growth forms and nut size and numbers. It would be interesting to know if the six trees were from nuts collected under one tree and are exhibiting a diversity of male pollen parents, or if they were collected from different mother trees. In the hope of answering this kind of question, we collect a leaf sample from each tree to send to Dr Cathy Nock at Southern Cross University. Some of the samples will have their DNA analysed as part of the Hort Innovation project MC18004: *Genetic diversity and population structure of wild and domesticated macadamias.*

A community effort

In 1999, the National Macadamia Germplasm Conservation Program was supported by the Australian Macadamia Society, CSIRO, Horticulture Australia Limited, the University of Queensland, NSW Agriculture, Tiaro and Caboolture local councils and the World Wildlife Fund.

By contrast, the Wild Macadamia Arboretum is being undertaken by the Macadamia Conservation Trust, a small non-government organisation, with some financial support from the AMS and much cooperation and in-kind support from the macadamia research community, the arboretum hosts, participating native plant nurseries and bush regeneration companies, landholders who kindly give permission to visit and collect cuttings and a small band of committed Wild Macadamia Champions.

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Cooperative approach essential to manage feral pigs

Darren Marshall Southern Queensland Landscapes **M:** 0429 056 450 **E:** darren.marshall@sqlandscapes.org.au

Two decades in feral pig research

Darren Marshall has spent the past 20 years working in feral pig research and control in Australia and the United States.

After growing up on a cattle farm in northern New South Wales, he joined the army and did an environmental science degree.

The combination of his military training and environmental studies sparked his interest in feral animal control to help landholders and protect biodiversity.

These days, Darren works with a wide range of government, private and landholder clients to develop and implement feral pig management programs at Southern Queensland Landscapes.



After 20 years in feral pig research and control, Darren Marshall says it's essential for landholders to work together and use effective measures to control feral pigs.

If Darren Marshall has one message for landholders grappling to control feral pigs, it's the importance of working together and using effective control measures.

Individual landholders may shoot a few pigs on their place, but unless they control 75% of the population, their impact will last only a few months.

"Not only are pigs smart, but they are prolific breeders, second only to rabbits," Darren says.

"The challenge is to achieve 75% control of feral pigs and this requires neighbours from different industries to work together and maintain control over the longer term."

After two decades of trialling a whole range of control methods, Darren says his work with GPS collars over the past five years has been a game changer.

The collars are allowing him to track pig movement and behaviour and show landholders exactly what's happening on their properties and across an entire district.

And there's no better way to motivate neighbours to act than to see the data that's been collected from pigs every 30 minutes over the previous year or two.

Darren says the data collected by these GPS collars is dispelling one of the biggest myths that pigs live in national parks and travel 30 or 40 kilometres onto farms every night.

"This is not the case. Pigs look for food, water and shelter, and once they find all three, they don't move far at all."

"In harsher conditions out west, they may cover a massive area, but this is far less likely to be the case in macadamias."

Data from the GPS collars also shows that feral pigs live in distinct groups, with females of all generations staying together, while young males form bachelor groups or become lone boars as they age.

"The females are the factory, so control programs need to target them, rather than the big lone boars which shooters will often go after," Darren said.

Darren is currently managing contracts to collar feral pigs down the east coast over 10 different sites.

His work is routinely funded by state government departments, Landcare groups and mining companies.

Using GPS collars

The first step is to identify a landscape and target a representative sample of pigs from across the district, rather than one mob.

Each of the pigs selected is tranquilised before an ear tag is inserted, a range of measurements is taken and the GPS tracking collar is fitted.

"Valued at $3000 each, the collars take a GPS point every 30 minutes and we collect this data over one or

two years to ensure we cover all seasons of the year," Darren said.

"When we present that data back to landholders, it is a real eye opener, showing clearly who is impacted most and who's most vulnerable.

"Equipped with this information, we then work with landholders to develop a control strategy."

Darren says aerial shooting is a good option, but so too is a coordinated baiting effort, aimed at hitting the 75% target.

Baiting programs rely on free feeding grain to attract pigs to one area for seven to 10 consecutive days before toxic baits are added to the grain to control them.

"While some landholders find this free feeding program difficult to sustain, it is important to attract as many pigs as possible before baiting," Darren said.

Darren has extensive experience with the use of 1080 poison, favouring it because it is tolerated by native animals.

He has done a lot of trial work with Hoggone from Animal Control Technologies, a more humane option based on sodium nitrite.

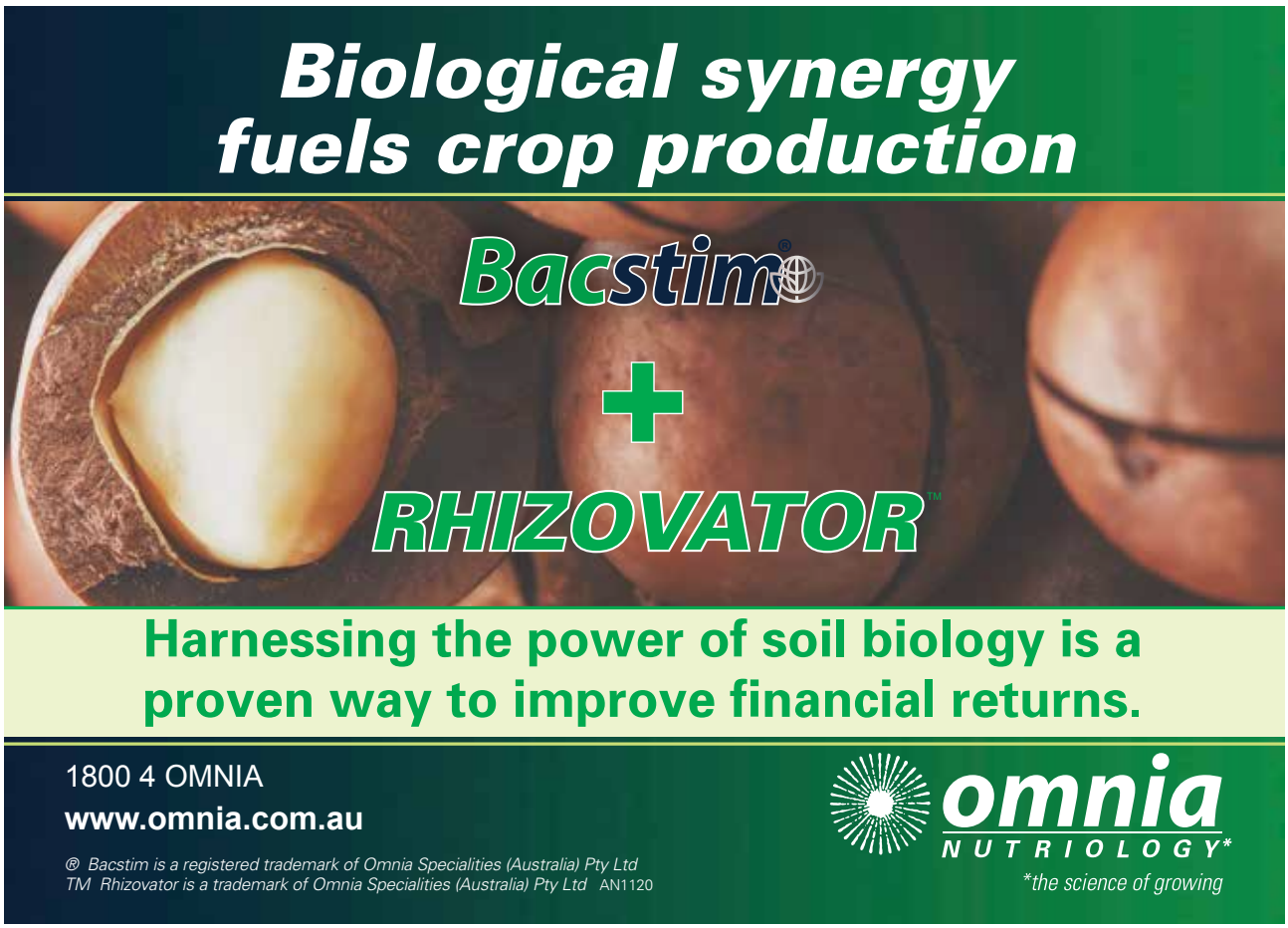
Darren said landholders routinely underestimate pigs.

"They're as smart as dogs and survivors breed fast. Feral pigs are also moving into new areas and new industries, as growers turn to higher protein crops which attract them.

"Landholders need to keep monitoring and take a coordinated approach to controlling feral pigs."



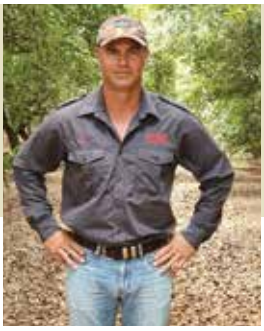
Darren Marshall says his work with GPS collars has been a game changer, allowing him to track feral pigs and show landholders what's happening on their properties and in their neighbourhood.



How a hobby turned into a full-time business

Ricky Rogers Ricky Rogers Pest Animal Management **M:** 0427 825 822 **E:** rogersricky1979@gmail.com

As growers around the Gympie district can testify, feral pigs have become a significant problem over the past few years, developing an appetite for macadamia which is proving costly. However, Ricky Rogers is showing that with the correct management, there are effective ways to manage the pest.



What began as a hobby has turned into a full-time business for Ricky Rogers, who is working mainly with macadamia growers around Gympie to manage feral pigs.

After 20 years of recreational hunting, Ricky set up Ricky Rogers Pest Animal Management five years ago to cope with the increasing number of requests from growers for help to get on top of their feral pig problems.

The numbers are staggering. Two years ago, Ricky removed 215 pigs off three macadamia farms around Gympie. On other places, he's taken more than 200 pigs in a year and trapped three consecutive groups on one farm over the same period.

On one night alone, he counted up to 100 pigs in a single group on one farm, feasting on high value macadamia kernels.

"The losses can be huge, with a large mob eating up to half a tonne of nuts per night, particularly when the kernels start drying out in the shells," he said.

These days, Ricky is working as a contractor to Gympie Regional Council and is building an impressive reputation for his professionalism – and that means aiming for 100% eradication of feral pigs.

His approach takes time and patience.

"The first step involves setting up monitoring cameras around the farm, so I can watch the pigs and start to identify mobs and individuals," he said.

"Then I set up feed piles of grain or nuts around the farm to draw in as many pigs as we can.

"This generally takes two to three weeks, but my overall objective is to feed them well and make them comfortable with the aim of attracting as many pigs as possible to the group before I set up one or two big cage traps. At this stage, I want all of them in front of the camera and that could be as many as 50 or 60 pigs.

"Ideally, the pigs become so comfortable that they will sleep in the cages before I activate the doors remotely from my phone," Ricky said.

Each cage is big enough to house 40 pigs and he can set up two or three depending on the size of the group.

Once the pigs are trapped, Ricky shoots them humanely before checking to see if there are any remaining pigs still on the loose.

This approach generally eradicates 95% of the pigs in one step, but he says it is essential to clean up any remaining pigs.

"Pigs are smart, so it's important to keep an eye on what's going on, particularly on properties which are located near forests and native vegetation where another group can appear a few weeks later," he said.

Over the past decade, Ricky has found that pigs are less of problem when there's a lot of rain and plenty of alternative food sources in the hills and mountains around Gympie.

But when conditions turn dry in autumn and the nuts are dropping from April to June, they are more likely to be found in macadamia orchards.

Ricky cautioned against random shooting or chasing feral pigs before a trapping program began.

"It's tempting to try and discourage feral pigs but the more comfortable they become with pre-feeding, the more effectively they can be targeted in a control program."

Ricky also called on growers and their neighbours to work together to eradicate feral pigs.

"Neighbours don't always realise the losses that feral pigs cause macadamia growers, so it is wise to work collectively and as quickly as possible, with the help of a professional," he said.



Ricky Rogers says controlling feral pigs takes time and patience.



After pre-feeding feral pigs to attract as many as possible, Ricky uses cage traps like this one to capture them.



Monitoring cameras allow Ricky to identify the movement of feral pig mobs and individuals into cage traps before he closes the gates remotely.

Hard learnt lessons about feral pigs

Gympie district macadamia grower, Nathan Townsend, has learnt the hard way about managing feral pigs.

Nathan manages 5,500 trees at Canina, including his own farm, his parents' farm and a small lease block.

After moving to the property in December 2017, Nathan quickly learnt that pigs were a huge problem, moving out of bushland in the Goomboorian National Park to his farm.

"The national park is known to be home to large groups of feral pigs. Close by, the terrain is quite steep and there are several macadamia farms among many rural residential properties on small acreages," he said.

From the very first week he moved in, Nathan realised there was a huge problem with feral pigs, as the farm had been neglected for 10 years.

"Among the locals, our place was called the pig farm. There were broken nuts everywhere and you could hear the pigs cracking the nuts in their jaws at night," he said.

Early on, Nathan tried hunting the pigs by himself and he was up most nights for weeks on end at the start of harvest.

"The pigs were so prolific I couldn't get on top of them, so I lost a lot of nuts and ended up behind with harvesting," he said.

"It's hard to estimate our total losses to pigs, but I regularly found 10 kgs of kernels in their stomachs.

"With the help of Ricky Rogers and my neighbours, we have now culled 150 pigs from my farm and others nearby. Most were culled after we tracked them on foot and ambushed them with dogs.

"One technique we used was to funnel them from the orchard into a small hole in the fence where one of us would be waiting on the other side.

"Ricky also used traps, often getting six to eight pigs a night."

Nathan was surprised to find that of all the pigs they culled, at least half were females, which were usually pregnant with an average of 11 piglets per sow.

Since collaborating with Ricky and his neighbours, Nathan has been able to largely eradicate feral pigs from his place and focus on production.

"It's been two years now since I've seen any feral pigs, but I listen out for them and check the orchard regularly for any evidence of them," he said.

"And I highly recommend Ricky to other macadamia growers – he is patient, trustworthy and reliable."



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The top 20 of 2020: the year's most inspiring macadamia products

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



As we waved goodbye to 2020, we took the opportunity to review how macadamias featured on the global product development stage over the past 12 months. As always, it was fascinating to uncover all the ways brands big and small embraced macadamias as an ingredient that adds taste, texture, indulgence and health credentials to a range of food and beverage products.

In a year characterised by supply chain and consumer behaviour disruptions, we initially feared that new products would be few and far between. Fortunately this was not the case. Despite all the ups, downs and uncertainty of last year, we were impressed by the breadth and depth of the offerings that came to market, particularly in Australia and the US.

From milk to beer and everything in between, here are the most inspiring macadamia product discoveries for the unusual year that was 2020.

The wellness wave

Health and wellbeing took centre stage last year, spurred on by the COVID-19 pandemic.

Teeccino Prebiotic Superboost Herbal Tea – Macadamia Flavour (USA)
Teeccino creates healthy herbal coffees and teas to support digestion, elimination and the immune system. Last year it launched a range of prebiotic superboost blend tea bags to help promote good gut health, with macadamia among the variants.

Toyo Nut Terragrano 'Nuts For Beauty' Pop-Up Store (Japan)
Japanese nut company Toyo Nut Co.,Ltd. ran a unique pop-up store in Tokyo under its Terragrano brand. Featuring a spectacular 'wall of nuts', customers could browse the display of 16 different nut types, including macadamias, while learning about the health and beauty benefits they offer. Also available were consultations with a dietitian who could personalise nut suggestions to suit the customer's needs, with their recommendations packaged into individual daily servings and presented in a 5-day set-box.

Butterfly Superfood nut butters (USA)
This brand burst onto the American retail scene in 2020, taking nut butter to new heights with a host of experimental flavours including Chocolate Reishi, Cinnamon Vanilla, and Rosemary. The range is made with a blend of macadamias, walnuts and cashews, and aims to deliver on function, fun and flavour.

Cymbiotika Bio Charged Activated Charcoal Dietary Supplement (USA)
According to Cymbiotika, activated charcoal binds to chemicals and toxins and prevents these substances from absorbing into the body. 2020 saw the release of a blend containing organic sprouted macadamia nuts as a key ingredient, and is said to assist in 'longevity and nutritional support' when taken daily.

Taika Macadamia Latte (USA)
Taika Macadamia Latte is promoted as 'coffee that accentuates reality'. Made on a base of macadamia milk, it contains the 'ideal' amount of caffeine, as well as adaptogens and functional mushrooms. It is sugar free, plant based and low in calories, with a coffee ice cream flavour.



The year of macadamia milk

Plant based milks have been gaining popularity for several years now, but 2020 felt like macadamia milk's moment, with a host of new brands and markets entering the category.

Vitasoy HEALTH PLUS Plant Milk with Macadamia & Almond (China)
Vitasoy expanded its premium plant milk offerings in China under the HEALTH PLUS brand. In 2020 it launched a combined macadamia and almond milk to meet the demands of health-conscious consumers with the product offering a high plant protein content with a rich, nutty and delicious taste.

Kikkoman macadamia milk (Japan)
Iconic Japanese food and beverage brand Kikkoman launched Japan's first domestically-made mainstream macadamia milk. Produced using Australian grown macadamias – a selling point promoted on the front of pack – it delivers the flavour, thickness and satisfaction that is considered ideal by the Japanese consumer.



Bickford's Macadamia Premium Plant Milk (Australia)
2020 saw Bickford's expand into plant based milks, including a 100% Australian barista-ready macadamia milk. Free from preservatives and artificial sweeteners, colours and flavours, Bickford's says it is a move inspired by the increased focus on 'the health of ourselves and the planet'.

The continued rise of plant-based

Consumer interest in plant based eating shows no signs of abating, with macadamias featuring in numerous plant based innovations last year.

Jumbo Lekker Tasty Veggie Nut Burger and Tasty Veggie Nutballs (Netherlands)
Dutch supermarket chain Jumbo launched its own range of vegan and vegetarian products under the brand Lekker Veggie. The label's Veggie Nut Burger and Tasty Veggie Nutballs both feature macadamias, with products described as 'pre-cooked vegetarian meat substitutes based on nuts and soy protein, with added iron and B12'.

Flying Squirrel Plant-Based Camembert (Ireland)
Made from macadamias and cashews, this camembert alternative was developed by an Irish vegan who missed his cheese. It features the white rind and creamy centre you'd expect from a traditional camembert, 'without any compromise to quality or taste'.

Siggi's Non Dairy Yoghurt (USA)
Siggi's launched its first non-dairy plant-based blend boasting a short ingredient list that includes macadamias. Described as a 'not-too-sweet coconut concoction', it's rich and creamy with '3 times more protein and 40% less sugar than leading yoghurt alternatives'.

Milkadamia macadamia oil spray (USA)
Milkadamia launched its macadamia oil spray in two variants. While other plant based oils such as olive, canola and coconut oil have been on the market in spray form for many years, sprayable macadamia oil is a rarer find. Available in pure and infused variants, the latter contains natural flavours that 'impart a layered umami flavour to vegan and vegetarian dishes'. Packaged in propellant-free bottles, the oil has a 'rich, buttery taste without the cholesterol', ideal for grilling, roasting and stir-frying.





Provenance meets indulgence

Two Australian innovations in the chocolate confectionery category blended carefully curated local ingredients to create uniquely indulgent and sophisticated treats.

Haigh's Dark Archie Rose Signature Dry Gin Ganache (Australia)
Haigh's enhanced the native botanicals in Archie Rose Distilling Co.'s Signature Dry Gin by combining them with peppermint gum, mountain pepper leaf, macadamias and sandalwood nuts. The result is a 'complex and uniquely Australian dark chocolate'.

KoKo Black Macadamia & Spotted Gum Honey Caramelised White Chocolate Block (Australia)
This product is part of Koko Black's new Australian Native Collection that celebrates the unique flavours and ingredients of Australia. Described as native ingredients and superfoods reimagined in chocolate, the range was inspired by Australia's 'ancient superfoods foraged by our Indigenous peoples for thousands of years' with the macadamia variant delivering a 'nostalgic biscuit-like' flavour.

Macadamias as self-care

Two high-profile beauty launches caught our eye, with macadamia oil featured as a hero ingredient.

Go-To Face Hero extra (Australia)
Australian skin care brand Go-To has fast amassed a cult following and 2020 saw one of its signature products, Face Hero, relaunched in luxurious gold packaging with macadamia oil flagged on front of pack. Containing 10 plant and nut oils, it's described as a 'calming, restorative super oil, loaded with essential fatty acids, vitamins, antioxidants, and suitable for all ages and skin types'.

Macabalm (Australia)

Macabalm is an organic macadamia moisturising balm suitable for everyday skin concerns. A multi-tasking balm, it hydrates, heals and illuminates and contains an abundance of antioxidants, vitamins and minerals. This, combined with 'its natural ability to mimic our skin's lipid system' is said to be what makes the macadamia 'a powerful ingredient that hydrates like no other'.



Comfortably fun

Products that offered comfort or fun were popular last year, as consumers sought out safe ways to counter the anxieties of the global pandemic.

T2 Blueberry Crumble Tea (Australia)
This loose leaf flavoured black tea is described as 'comforting and warming for the soul' with blueberries, chocolate flakes and macadamias to 'lure your tastebuds in a sweet embrace'.

MyMuesli Apple Macadamia Cinnamon Granola (Germany)
This beautifully packaged special Christmas product combines crunchy granola and oatmeal with roasted macadamias, apple pieces, plums and salted caramel crispies to create a breakfast reminiscent of a 'winter bakery' – perfect for cold European mornings.

Bestore Sparkling Hawaiian Macadamia, Sakura & White Peach Flavour (China)
Sparkling beverages are nothing new, but in China, it's a concept that has now entered the snacking space with the launch of these flavoured macadamias that 'sparkle' on the tongue. Launched to appeal to Gen Z consumers, it ticks all the boxes as a delicious, nutritious, memorable and socially sharable snack.

Other Half Brewing BA BANANAVERSARY Imperial Stout (USA)
This dessert-inspired beer combines bourbon barrel aged stout with bananas, macadamias, coconut and vanilla. The result is a uniquely fun beverage described as 'bourbon banana goodness'.



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Innovative mulcher protects groundcover on steep slopes

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Lance and Ina Emery own 'Mill Farm' at Nashua in the NSW Northern Rivers.

The productive area of the farm is around 40 hectares with an average tree stocking rate of only 180 trees/ha. This is because most of the orchard is planted on steep country, so wide spacings have been allowed for the steep areas of the farm to maximise groundcover establishment and minimise erosion. Mill Farm is constantly evolving to improve production and tree health while reducing environmental harm.

Over the past 15 years, Lance has focused firmly on improving his orchard floor, drainage and canopy. Techniques he has employed include, but are not limited to, limb removal, tree removal, installing drains, groundcover establishment and large inputs of organic matter.

His passion for sustainable productivity and machinery innovation has allowed him to reap the rewards of the lucrative macadamia industry in recent years. Even though Lance's orchard contains a lot of old Hawaiian cultivars, his high yield consistency from season to season is impressive.

About eight years ago, Lance and other Northern Rivers macadamia growers were confronted with the issue of macadamia seed weevil. One of the recommended control measures was to mulch up infected nuts that lay on the ground. Mulching proved an effective control measure in conjunction with chemical control.

However, seed weevil first infects nuts once they reach about 10 mm in diameter, so this meant the mulcher had to be set very close to the soil surface to destroy the infected nuts. Lance had worked so hard at optimising the health of his orchard floor so he couldn't fathom scalping it with a mulcher to destroy the nuts containing seed weevil larvae.

A mulcher set at ground level can kill orchard ground covers. Due to shading caused by a tree crop and repeated machinery traffic, orchard ground covers can be shy to return to their former vigour if excessively disturbed.

Unwilling to destroy his hard work, Lance came up with an innovative idea – designing an 'all in one' mulcher with a broom to sweep the nuts up into the mulching blades. This would allow the mulcher to be set well above the ground level without destroying the valuable groundcover.

It took quite a few meetings (and Friday arvo beers) with local fabricator Dave Hunter to convince him to help bring the idea to life. Dave had a good understanding of Lance's predicament as he is also a farmer and happens to operate a mulcher on his own farm. By the third Friday, Lance had Dave making chalk drawings on the shed floor.

In 2019, Lance and Dave completed their first creation. While it managed to do the job there was room for improvement and the sweeping mulcher has evolved ever since and there are further improvements planned.

The initial mulcher was a 2.5 m wide high body machine with a 600 mm diameter road broom. Lance operated it successfully on his 55 hp John Deere tractor, but found it was under powered. The 85 hp John Deere was better suited for the size of this unit.

In 2020, Lance and Dave mounted a custom made 400 mm diameter broom to a 'Lands' 2.3 m wide high body mulcher. Because his two John Deere tractors were tied up applying manure and mulch across the farm, Lance wanted a smaller unit to mount to his 99 hp Carraro. This smaller unit also allows better access under the canopy to get closer to the trunk.

Lance is now waiting on the delivery of a 2 m wide Berti Lands high body mulcher to attach a 400 mm diameter broom. This smaller and narrower unit will be better suited to the Carraro and follow the ground level more efficiently.

Through trial and error, Lance and Dave found the 'Y' blades performed best and will be trialling the multi-bladed Y knives on the next model. As with all mulchers, the sweeping mulcher is fitted with a mulch bar inside the body of the mulcher. Because the Berti Lands mulcher allows for it, the next unit will be trialled with a second mulch bar to test for enhanced efficiency.

Lance and Dave chose to attach the broom to the new Lands high body mulcher as this design is approved for EU safety standards. This high level of safety standard will not only allow safer use of the machine in the orchard but it will also adhere to higher safety standards. Safety Standards Australia may follow the EU standard in the future.

All attachments are bolted, without alteration, to the original Lands mulcher. For this reason, Berti has confirmed that the warranty for the mulcher would be honoured. Locally sourced components have been used for the attachments for easy access to parts. The broom can be turned off and the height can be adjusted.





Lance Emery has found the mulcher is not only useful for cleaning up nuts infected with seed weevil but it also destroys large piles of sticks and nuts without damaging the valuable groundcover.

Recently, Dave has had CAD drawings completed for all components to allow efficient construction of units in the future while Lance has secured a patent pending on the design.

The machine is not only useful for cleaning up seed weevil infected nuts, but also destroying old nuts and small dead sticks. At a recent demonstration on Lance's property, the sweeping mulcher performed an impressive job of destroying large piles of sticks and nuts without destroying the grass. The grass layer was retained at 50 mm high.

The broom height can be adjusted using a square threaded bolt. Broom height increases or decreases the aggression of the sweeping. To ensure all nuts are swept into the machine, the broom can be lowered. However, Lance knows all too well how badly erosion can affect his steep terrain, so he does not like to attack too aggressively as this affects the health of the groundcover.

In paddocks of younger trees, Lance allows the grass to grow long and thick before mulching it down. In that situation, he raises and disengages the broom and opens the back door hydraulically. The unit is then operated in the same way as a regular mulcher.

Lance and Dave expect to have the 2 m wide sweeping mulcher completed in time to show it off at Primex 2021 scheduled for 20 – 22 May. Hopefully, after a few beers, they will come up with a catchy name for the unit.



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Phytophthora disease control with phosphonates and holistic strategies in macadamia

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Phytophthora are well known plant pathogens that have devastated agricultural and horticultural crops including macadamia. Phytophthora is a major concern and constraint to macadamia production. In the last decade, the Australian macadamia industry has responded to these challenges through funding of disease management projects with matching funding to levy funds from the Commonwealth Government through Hort Innovation.

These previous disease management projects have provided significant outcomes, which enable science-based and effective management for Phytophthora diseases in macadamia. The previous projects have provided significant advances in knowledge, including the methods and timing of application of control options, disease resistance among cultivars, soil organic amendment and chemical control options.

The information obtained from these prior projects has generated all the data that enabled the registration of a potassium phosphonate product for Phytophthora control, and delivery of efficient and profitable integrated management strategies to manage the diseases in macadamia.

Disease symptoms

Many species of Phytophthora are associated with macadamia, but few cause a number of diseases in macadamia (Jeff-Ego et al. 2020). The major diseases include Phytophthora root rot, stem canker and macadamia quick decline. Phytophthora root rot and stem canker are the most common diseases in macadamia orchards worldwide.

Phytophthora root rot is expressed in the canopy as slow tree decline. Prolonged periods of root infection, followed by adverse weather conditions, lead to the characteristic dieback symptoms. Diseased trees with slow decline symptoms are widespread in macadamia orchards.

Slow decline (Fig. 1) is mostly caused by the soilborne *Phytophthora cinnamomi* pathogen and is expressed as a gradual decline of tree health with pale light green to yellow leaves, sparse canopy and twigs on branches empty of leaves. Specifically, there is substantial reduction in incremental growth with sparse canopy and the plant might gradually die. New leaf flushes and shoot growth are usually absent or sparse.

- The slow progression of the canopy symptoms is due to Phytophthora root rot.
- Infection of the root compromises its structural integrity, destroys and reduces new growth and inhibits sufficient supply of water and nutrients to the tree canopy.
- Slow decline symptoms in macadamia are often confused with poor tree health due to nutritional deficiency, but the key distinguishing feature is addition of fertiliser leads to 'boom and burst' response of the foliage, not continuous improvement in tree health.

Macadamia quick decline (MQD) (Fig. 2) is caused by *Phytophthora heveae* and *Phytophthora tropicalis* (Ko 2009b; Keith et al. 2016; Sugiyama et al. 2020). MQD has been reported from China and Hawaii. Although the pathogen, *Phytophthora tropicalis,* has recently been identified in historical collections in North Queensland, there is no report of its occurrence in macadamia orchards in Australia.



Figure 1: Macadamia trees with slow decline symptoms due to Phytophthora *root rot caused by Phytophthora cinnamomi (left) and healthy without decline symptoms (right).*



Figure 2: Macadamia tree with quick decline symptoms caused by Phytophthora tropicalis and close-up of the tree trunk shows extensive sap bleeding.

It is important for growers to pay attention to MQD symptoms. Unlike slow decline that occurs over several years until eventual tree death, MQD causes tree death a few months after infection.

MQD symptoms progress rapidly in the entire canopy of affected trees. Leaves subtly turn from dark green to dull green, sporadic browning of leaves occurs throughout the canopy and within two to three months, the whole canopy turns brown, which signifies the tree is completely dead (Ko 2009a).

- The leaves in the tree canopy are retained and light leaf litter may be present before complete browning of leaves and tree death.
- MQD trees exhibit excessive sap bleeding from the trunk.
- In Hawaii, MQD trees have frass from ambrosia beetle feeding and orange fruiting bodies of the fungus *Nectria rugulosa*.

Stem canker (Fig. 3) is caused by *Phytophthora cinnamomi* and *Phytophthora multivora*. The pathogens infect macadamia trunks via wounds causing canker and bleeding of the wound (Jeff-Ego et al. 2020). If left unabated, the trunk may be completed girdled and causes tree death.

Infection of nursery plants

Phytophthora root rot in nursery plants may not express slow decline symptoms until after transplanting to the orchard. Young planting materials may remain infected and later, develop severe root rot and stem cankers under adverse environmental conditions in the field.



Figure 3. Macadamia tree with stem canker symptoms caused by Phytophthora cinnamomi.

Disease management

Management strategies for all these Phytophthora species are largely similar, but some diseases are difficult to manage and the challenges they pose to productivity are of continuing concern to growers.

Control options based on an integrated management system are best for Phytophthora diseases. These include choosing tolerant cultivars, planting clean pathogen-free trees, adopting cultural practices including soil health and orchard floor management (with soil organic amendments, water (flooding or ponding) and nutrient control, soil biology), and chemical applications using metalaxyl or phosphonates (aka phosacid).

Start Clean – Stay Healthy – Stay Safe

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Understanding the chemical products used for Phytophthora control

Given the recent advances in the development of diagnostic tools and new fungicides, it is important to have a good understanding of the role, safety and mechanisms of the chemical products play in disease management in macadamias.

Metalaxyl, fosetyl (and its aluminium salt) and phosphonic acid (formulated as the potassium or sodium salts) are systemic fungicides with protectant action against a number of oomycetes (often referred to as water moulds) such as Phytophthora, Pythium and downy mildew pathogens and to a limited extent, some fungi and some plant pathogenic bacteria. These chemicals are rapidly absorbed through leaves, stem and roots.

Metalaxyl is the most important acylalanine fungicides, commonly sold as Ridomil for use in the soil. The fungicide has suffered severe resistance problems to the pathogens.

Fosetyl-Al and phosphonic acid products are generally referred to as phosphonates and are at times marketed as fertilisers.

Parameters	Metalaxyl	Potassium phosphonates	Fosetyl-Al
Formulation	Granules or wettable powders	Liquid	Powder or granules
Concentration	50 g/kg	400 – 630 g/kg	800 g/kg
Nature of compound	Systemic (absorbed through leaves and roots)	Systemic (absorbed through leaves, stem and roots)	Systemic (absorbed through leaves and roots)
Mode of application	Soil and foliar	Plant and soil	Soil
Chemical formula	$C_{15}H_{21}NO_4$	H_3PO_3	$C_6H_{18}AlO_9P_3$ [Fosetyl - $C_2H_7O_3P$]
Ecological Effects Risk Assessment	Minimal (if any) risks to birds, small mammals, fish species and honey bees	Non-toxic to birds and freshwater fish and low risk for honey bees	No risk to birds or fish and non-toxic to honey bees
Examples of product	Ridomil	Agri-Fos 600, Phospot 600	Aliette

However, in Australia, phosphonate products are primarily registered as fungicides for disease control. We use the term phosphonate to describe products that contain the salts and esters of phosphorous acid (H_3PO_3), but they differ in formulation and use pattern.

Mode of action

Metalaxyl is fungicidal and sometimes curative. Phosphonic acid can translocate upward and downward via xylem and phloem throughout the plant. Phosphonates eventually break down to phosphite (Phi), which is the active compound against the pathogens. The mode of action is complex including direct stimulation of the plant's defences to prevent further destruction and invasion of the tissue by the pathogen, while at the same time stopping the pathogen in its tracks.

Types of product and use pattern

In a broad sense, phosphonates can be grouped into two categories, with the key differences described below:

Alkali metal salts of phosphorous acid (potassium, ammonium and sodium phosphonates)

- Phosphorous acid (H_3PO_3) is a solid material and when mixed with water, forms its liquid form phosphonic acid.
- Phosphonic acid is a strong acid and the low pH of this liquid form will damage plants if used directly.
- Alkali salts such as potassium hydroxide (KOH) and sodium hydroxide (NaOH) are added to phosphonic acid to neutralise the acid and decrease the potential for plant injury.
- These phosphonates are therefore alkali metal salts of phosphorous acid, and contain cations (e.g. K+, Na+ or NH4+) and hydrogen phosphite (HPO_3^{-2}) or dihydrogen phosphite (H^2PO^3-) anions.
- They are marketed as potassium phosphonate as mono- and di-potassium salts of phosphorous acid, ammonium phosphonate and sodium phosphonate.

Fosetyl-aluminum (fosetyl-Al)

- Fosetyl-Al is produced when phosphorous acid is mixed with ethanol and aluminum ions.
- The resulting solution contains aluminum tris O-ethyl phosphonate (i.e. fosetyl-Al).
- After application, fosetyl-Al dissociates into the O-ethyl phosphonate and aluminium ion.
- Fosetyl-Al is not a stable molecule and degrades easily into Fosetyl, which further degrades easily into phosphonic acid and its salts.
- It is not registered for use in macadamia in Australia.

The best time to apply phosphonate is during root flushing periods. This ensures the action against root infection by Phytophthora is effective and allows new roots to grow without being destroyed by the balance. In macadamia, a net positive root growth is essential to prevent slow decline.

Conclusion

Fosetyl-Al is not registered for use in macadamia, whereas some phosphorous acids are registered. So far in Australia, through national residue testing, there has been no detectable limit of phosphite in macadamia kernel at the point of sale. Fungicide resistance to phosphorous acid products is very limited, rare and mostly under laboratory conditions. The product is not persistent in the environment and there is no data or evidence of human or environmental harm from the use of phosphorous acid products.

The cations (K+, Na+ or NH4+) in phosphonates are principally added to the strong phosphonic acid to stabilise the acid to prevent burning of the plants. Their usefulness as a source of nutrient is very limited and should not be used as a substitute for nutrition. Mode of application rather than the type of cation used in the product influences the efficacy of phosphonate.

Integrated disease management, specifically attention to soil health, is the best strategy for managing Phytophthora diseases in macadamia.

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Carbon sequestration by macadamia trees: a review of past research

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This is the first of a series of articles to review past research funded by the Australian macadamia industry that is still relevant today.

The Australian macadamia industry has often led the way in horticultural research and development, and in 2007 we funded research that modelled the carbon sequestration by macadamia trees. At the time, carbon credits and the likely introduction of a carbon trading scheme were being discussed by the Australian Government.

It was felt that the macadamia industry could capitalise if we had the data to back us up. The project and resulting estimate of carbon sequestration was the first time any Australian horticultural industry had acted to capture the potential value of sequestration that it generates.

The study was carried out by Graham Jones, Tim Murphy, Jerry Vanclay and Kevin Glencross, Southern Cross University, Lismore. Cliff and Greg James, Deenford Plantations, Knockrow, cooperated with the research and provided the site and the trees for the destructive carbon measurements.

Twenty-five-year-old variety 344 trees from a commercial thinning operation were used for destructive measurements to obtain wet and dry weight biomass ratios and to measure the carbon content of the wood and bark. A second stand of 17-year-old 344 trees and a mixed planting of 10-year-old A varieties were also surveyed for tree height and diameter growth.

Forestry techniques were used to estimate tree height with age, and forestry allometric equations were used to determine tree volume, carbon content and hence the amounts on CO_2 equivalent/ha (CO_2e/ha) sequestered by the trees. Soil carbon was not included.

Macadamia tree carbon sequestration potential

The carbon fraction of the wood and bark was 46.3% and 47.4% respectively. Based on estimates from the tree height and trunk diameter and the above-ground and below-ground expansion factors, the researcher estimated that an average tree holds 154 kg of biomass. The carbon density fraction then converts this to 71.3 kg of carbon, which is equal to 262 kg of CO_2e per tree. At 355 trees per hectare, this gives an estimated sequestration value for the surveyed stand of 93 tonnes of CO_2e/ha. Applying a linear extrapolation over time yields an estimated annual sequestration rate of 4 t CO_2e/ha/yr.

Carbon budget estimate

The estimated 4 t CO_2e/ha/yr requires further studies across other sites and regions to be able to be used in any accredited way. The estimate does align with a prior study by Murphy (unpublished) that estimated a 7-year-old plantation, that had not reached its maximum growth rate, sequestered about 3 t CO_2e/ha/yr.

The 3 to 4 t CO_2e/ha/yr only accounts for the carbon stored in the tree. To this we also need to add the carbon in the fruit. The researchers were a bit optimistic with potential yields and used a total nut in husk dry weight of 7.9 t/ha and of this, estimated the kernel dry weight to be 2.19 t/ha. They estimated from this there would be an additional 1 t/ha of carbon in the kernel or 3.7 t CO_2e/ha, and 2.7 t/ha in the shell and husk or 10 t CO_2e/ha. A more realistic figure would be 5.5 t nut in husk/ha dry weight and 1.5 t/ha kernel dry weight. That would give us 0.72 t/ha carbon in the kernel (2.7 t CO_2e/ha/yr) and 2.35 t/ha carbon in the shell and husk (8.7 t CO_2e/ha/yr).

Adding the fruit and tree carbon together we arrive at a revised (from the original research) 15.4 t CO_2e/ha/yr. The original research estimated 17.6 t CO2e/ha/yr and calculated about 300,000 t CO_2e/yr for the whole industry in 2007 which was 0.05% of the total emissions in Australia in 2007.

The overall carbon budget needs to be considered with emissions from farming activity factored in. The key emissions from the farming sector include fuel and electricity, nitrogenous fertilisers and animal manures. For an accurate value of the carbon budget these emissions must be subtracted from the carbon

	PROJECT	Sequestered CO2e/ha/yr	REVISED	Sequestered CO2e/ha/yr
Trees (based on 355 trees/ha):		4.0 t		4.0 t
Carbon in shell and husk:	2.7 t/ha	10.0 t	2.35 t/ha	8.7 t
based on nut in husk (dry weight) of	7.9 t/ha		5.5 t/ha	
Carbon in kernel:	1 t/ha	3.7 t	0.72 t/ha	2.7 t
based on kernel (dry weight) of	2.19 t/ha		1.5 t/ha	
TOTAL CARBON		**17.6 t**		**15.4 t**

stored in the tree and fruit (husk, shell and kernel). The researchers estimated that fuel and electricity from two farms in the Northern Rivers was equivalent to about 1 t CO_2e/ha/yr which leaves the industry with approximately net 14.5 t CO_2e/ha/yr sequestered.

With climate change and government policy in the hot seat right now there could be an opportunity for the industry to build on this earlier preliminary research for the benefit of the whole industry. This project was the first step of an industry-wide carbon audit process.

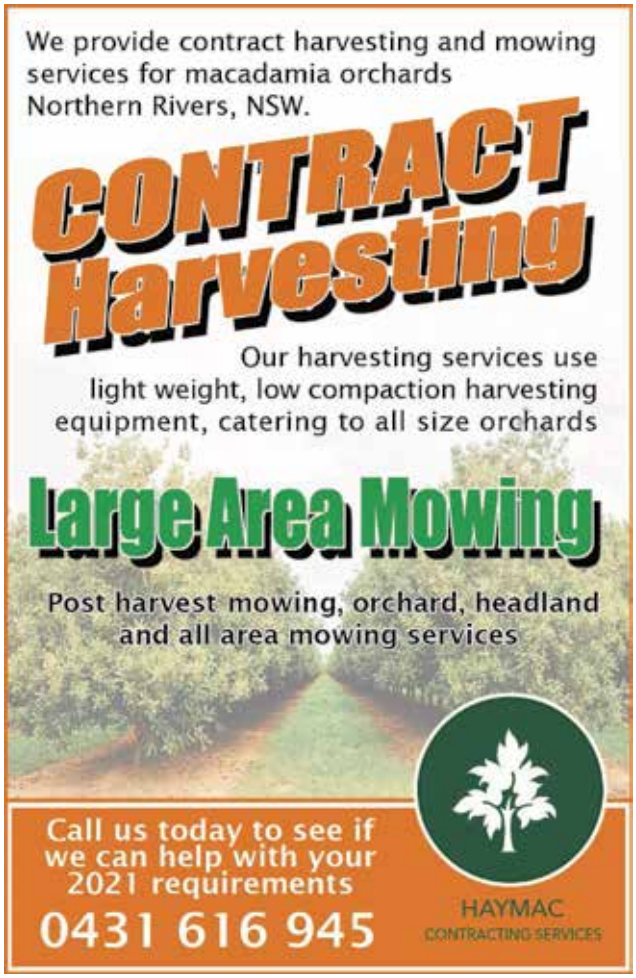
The real economic value of this research may be in marketing the product. The Australian macadamia industry has a clean and green reputation and this sequestration estimate could help increase this reputation as being a carbon friendly industry.

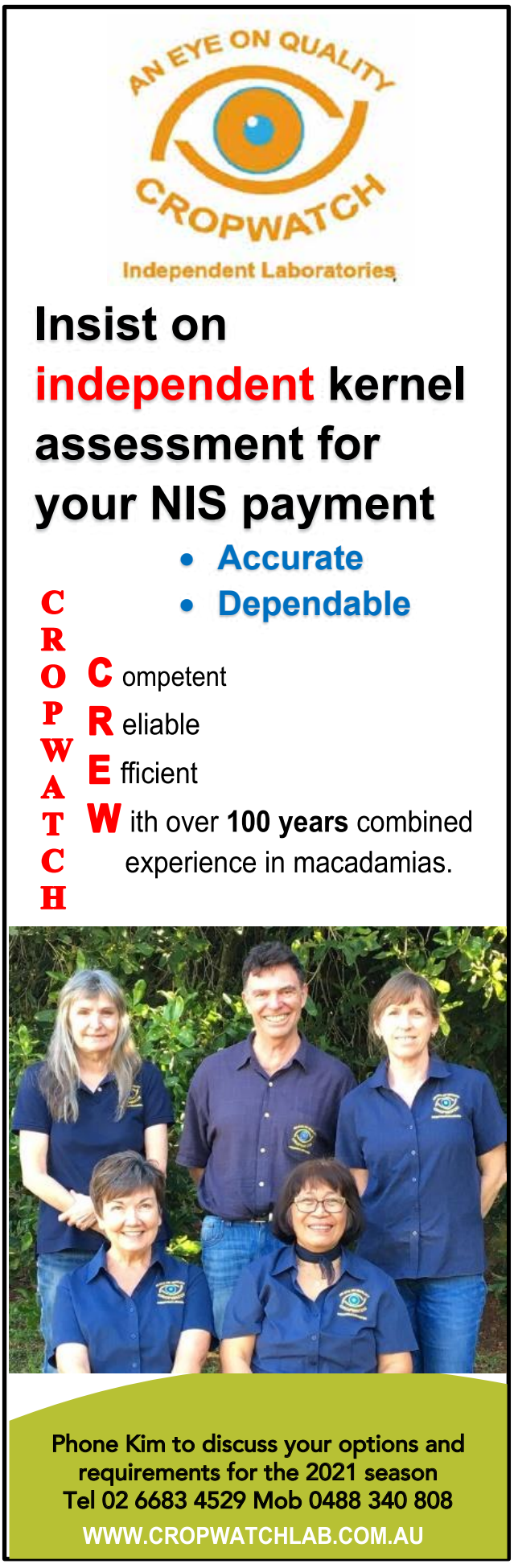
This research was funded by the Australian Macadamia Society, MPC and Suncoast Gold with in-kind contributions from Cliff and Greg James, Deenford Plantations. It was presented at the 2008 AMS Conference and a copy of the presentation can be obtained from the AMS. The research was published in 2013.

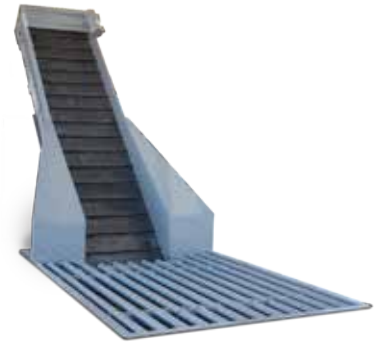
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Jones Graham, Peter Leihn, Jerry Vanclay, Greg James and Kevin Glencross 2008, AMS conference Concurrent Session 3 – Climate Change and Carbon Trading: Implications for the Macadamia Industry, Carbon Sequestration by macadamia plantations: Risks and opportunities.

Murphy Tim, Graham Jones, Jerry Vanclay, Kevin Glencross 2013, 'Preliminary carbon sequestration modelling for the Australian macadamia industry', Agroforest Syst, 87:689-698.







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



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



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

SAVAGE

The Savage Grayline for Macadamia Cleaning



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

Savage Equipment has been in the nut-cleaning business for decades. We have designed and built plants for small and large-volume cleaning operations in many parts of the planet. Let us help you build a world-class macadamia cleaning plant to meet your needs and surpasses your expectations



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



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



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



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

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R&D Projects : Your levies at work

The industry levy collected by the Levies Revenue Service goes to: 1) the National Residue Survey 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: 1) research and development (which is matched dollar-for-dollar by the Commonwealth Government), and 2) marketing and promotion.

The table below lists current projects being funded by your levy and voluntary contributions.

Project no.	Project name	Delivery partner	Expected end date (subject to change)
Macadamia Fund investments: levy projects			
MCI5004	Australian macadamia industry innovation and adoption program	Australian Macadamia Society	Feb 2021
MCI6000	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 Department of Primary Industries	Oct 2021
MCI6005	IPM program for the Australian macadamia industry	Qld Department of Agriculture and Fisheries	Sep 2021
MCI6006	IPM program for the Australian macadamia industry	IPM Technologies	Oct 2021
MCI6007	IPM program for the Australian macadamia industry	University of the Sunshine Coast	Jul 2021
MCI6018	Macadamia integrated disease management	The University of Queensland	May 2022
MCI7005	The effect of macadamia nuts on cardiometabolic risk factors and adiposity: a randomised intervention study	Loma Linda University	Jun 2020 (ongoing)
MCI7006	Macadamia regional variety trials series 4	Qld Department of Agriculture and Fisheries	Aug 2026
MCI8000	Australian macadamia communication program	Australian Macadamia Society	Feb 2022
MCI8002	Benchmarking the macadamia industry 2019–2021	Qld Department of Agriculture and Fisheries	Mar 2022
MCI8003	Macadamia crop forecasting 2020–2022	Qld Department of Agriculture and Fisheries	Apr 2022
MCI8004	Genetic diversity and population structure of wild and domesticated	Southern Cross University	July 2021
MCI9000	National macadamia breeding and evaluation program	University of Queensland	Dec 2024
MTI6005	Enhanced National Bee Pest Surveillance Program	Plant Health Australia	Dec 2021
MTI9008	Strategic agrichemical review process (SARP) – Updates	AGK Services	May 2020 (ongoing)
STI6006	Generation of residue, efficacy and crop safety data for pesticide applications in horticulture crops 2017	Eurofins Agrisearch	Feb 2020 (ongoing)

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

Hort Innovation Strategic levy investment | MACADAMIA FUND

Australian macadamia minor use and emergency permits

Current at February 2021

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

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

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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