AUSTRALIAN MACADAMIA SOCIETY

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NEWS BULLETIN

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AUSTRALIAN MACADAMIA SOCIETY

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Front cover. Michael Russo in his orchard. The article on page 21 explains Michael's approach to orchard preparation at 'Hetheringtons'.

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Our Mission

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

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CEO's report



Agriculture is all about risk and opportunity. The risks are constant and often beyond growers' control. The weather regularly features as the greatest constraint to production in the annual macadamia benchmarking reports. The opportunities are often fleeting and require a quick decision to capitalise on a break in the weather or sell to a gap in the market.

Good farmers are the ones who understand and manage the risks and who are ready and bold enough to seize the opportunities.

It is no different at all at the industry level. As the Australian macadamia industry we need to understand the risks facing our industry and have plans to manage them. The most clear and present risk facing us at the moment is not a resurgence of COVID-19 or another east coast low.

The biggest risk currently facing the industry, that growers cannot manage on their own, is oversupply and the potential impact that could have on farm gate price. And this risk is most directly borne by growers with low productivity. Profitability is a function of productivity and price; the greater your productivity, the better able you are to withstand price fluctuations.

It is essential that as an industry we take steps to manage the threat of oversupply. We must stimulate demand. The current marketing program is designed and resourced to sell 200,000 tonnes a year. Now we will have to sell 600,000 tonnes a year. Critically this will need to be done in collaboration with other producing countries.

Average costs per hectare have increased over time and in 2019 the cost of production for many orchards is close to $9,000/ha, almost $1,000 higher than the 2013–18 average. Prices have not always been at a point where they will cover such costs. At the current price of say $6.20/kg, you only need to be producing around 1.5 t/ha to break even. If the price drops to $3.50/kg (not that long ago considered an exceptionally good price) you need to average over 2.5 t/ha just to break even! Are you confident you can do that? I will let you do the sums should the price get even lower than that!

You can cut costs. Many have done so in the past and almost as many have paid the price of declining productivity and a long road to restoring a healthy productive orchard. The less risky option, by far, is to invest in increasing demand and strengthening the price. And you still have the option of improving efficiencies and banking the margin.

This is where the proposed *MACCELERATE* Industry Marketing Fund program comes in; designed to raise an additional $3 million a year to fund market development activities.

If we manage it correctly it is an investment that will be shared not just by all Australian growers, but also by most growers of macadamias around the globe. And it is a good investment even if you plan to exit the industry in the next 2, 5 or 10 years. Nothing will support the price of your orchard as much as a strong in-shell price.

If we focus on the problems rather than the opportunities in this plan, we will still be talking about it in 5 years and we are unlikely to have a $6 plus price.

The opportunities come from a larger, more reliable production base for global macadamias. There is no origin that produces more than 35% of the global crop and this gives the market confidence that, unlike a drought in California and almonds, no single event can dramatically reduce available macadamia kernel. As these origins increase their crops, the confidence of the market grows. If this confidence in supply is coupled with strongly growing demand, we have all sorts of opportunities. New product development will surge as it has for almonds on the back of their 3 billion pound crops, and we will have the volumes to open up major new markets such as India and Indonesia. This added demand will, in turn, support a strong price.

I urge all growers to carefully consider these matters. No one likes to let go of hard-earned income. But it is essential to take a slightly longer term view here. A 6 to 9 cent/kg investment now is likely to repay a $2 to $3 per kg investment over coming years. Your support for the Industry Marketing Fund initiative is vital. Please speak to your processor or call me if you would like to discuss it further.

Jolyon Burnett, CEO

What's on

DATE	EVENT	LOCATION	CONTACT
25 Aug	AMS Board meeting	Video conference	AMS: Phone 1800 262 426, office@macadamias.org
14 Sept	AMS Board meeting	Video conference	
10 Nov	AMS Board meeting	TBC	
11 Nov	AMS Annual General Meeting	TBC	
25 Nov	Australian Macadamia Handlers Association meeting (TBC)	TBC	AMS: Phone 1800 262 426, jacqui.price@macadamias.org

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- Tree physiology and how it affects timing of management decisions
- Using cover crop and inter row technology to improve soils and biodiversity
- How can growers improve pollination for better yields?
- Grower case studies: The secrets behind the success of our best growers
- Factors influencing total kernel recovery
- So, the climate is changing, but what does that mean for macadamias?
- Towards a better understanding of organic amendments and healthy soil
- How South Africa became the world's largest macadamia producer
- The technology changing our orchards
- The do's and don'ts of best practice orchard establishment
- Market update

Social events

- Golf day
- Welcome cocktail reception
- Women in Macadamias luncheon
- Happy hour
- Celebrity chef breakfast
- Gala dinner

Visit the AMS website www.australianmacadamias.org/industry and click on the AusMac2021 link for the full program, social events and to book your tickets & accommodation.






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Australian industry remains well positioned despite disruption caused by COVID-19

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

Supply

The 2020 Australian macadamia crop remains on track to reach the forecast 36,500 t (@3.5% MC). Harvesting conditions have been largely favourable and nut quality is good. All other origins are expected to achieve close to forecasted volumes, with the exception of South Africa.

In June, South African Macadamia Growers' Association (SAMAC) published an updated crop forecast for 2020 of 49,503 t (in-shell at 3.5% moisture content). This is approximately 16% lower than their 2019 crop of 59,050 t and approximately 20% below their initial forecast. This reduction is attributed to extreme heat during flowering and overall drought conditions.

Overall, with the lower Australian and South African crop forecasts, global supply is expected to be down 7% on last year.

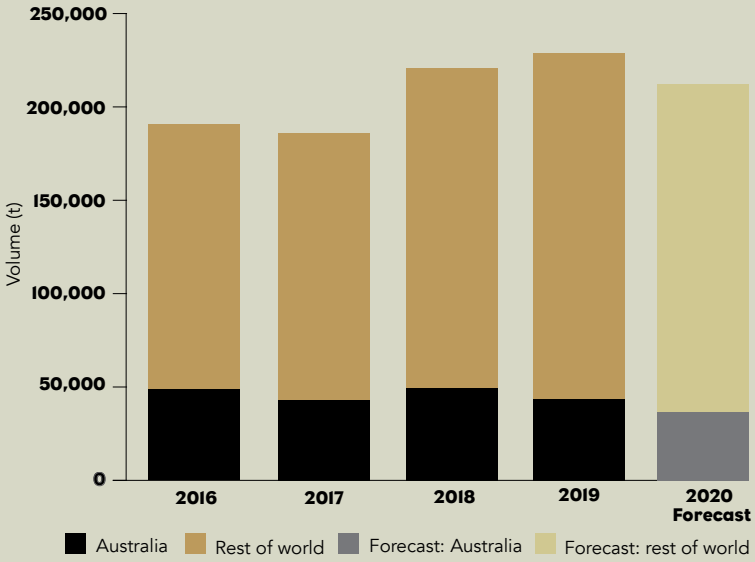

Figure 1. Global macadamia crop volumes 2016–2020 (tonnes).
Source: INC, SAMAC revised forecast June 2020. All volumes are at 3.5% MC.

Demand

In the 12 months to May 2020, we saw a reduction in imports across the majority of markets compared to 2019; primarily off the back of record Q1 (first quarter) shipments in 2019 and the high degree of uncertainty caused by COVID-19 in Q2 (second quarter) of 2020. However overall imports remain strong when compared with 2018, up 16%.

It is evident that the current coronavirus led environment is having an impact. Minor disruptions to international shipping have occurred and a pattern of buying to shorter horizons has emerged. However, sales are improving in Q3 (third quarter) and the Australian industry is well positioned due to the diversity of its customer and market base.

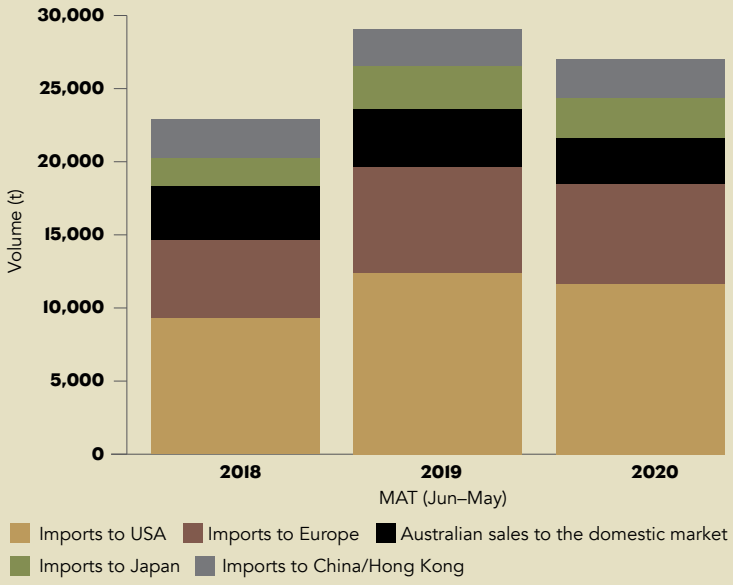

Figure 2. Macadamia kernel imports to top 5 markets (tonnes) MAT June–May.
Sources: USDA, Eurostat, Japan Customs, China Customs, Hong Kong Census & Statistics Department via HIS Markit Inc, AMHA

Australian sales

Kernel availability in the period from July 2018 to June 2019 was high due to a large crop in 2018 and this resulted in higher sales than previous years. A reduction in the 2019 crop coupled with a soft 2020 Q2 due to the impact of COVID-19 has seen a return to previous sales levels of around 10,000 t.

Results were mixed with snack styles selling strongly and ingredient styles down. Retail sales over the last six months have increased significantly in part due to pantry filling by consumers. While the travel sector and smaller retailers will remain impacted due to the loss of retail foot traffic, overall sales with large retail chains is expected to continue its solid position.

The food service channel has been significantly impacted by the restrictions forced upon it due to COVID-19 and the manufacturing sector has also been impacted due to disruptions to the supply chain. The strong investment in marketing to these sectors made over the last three years is expected to place the Australian industry in a good position.

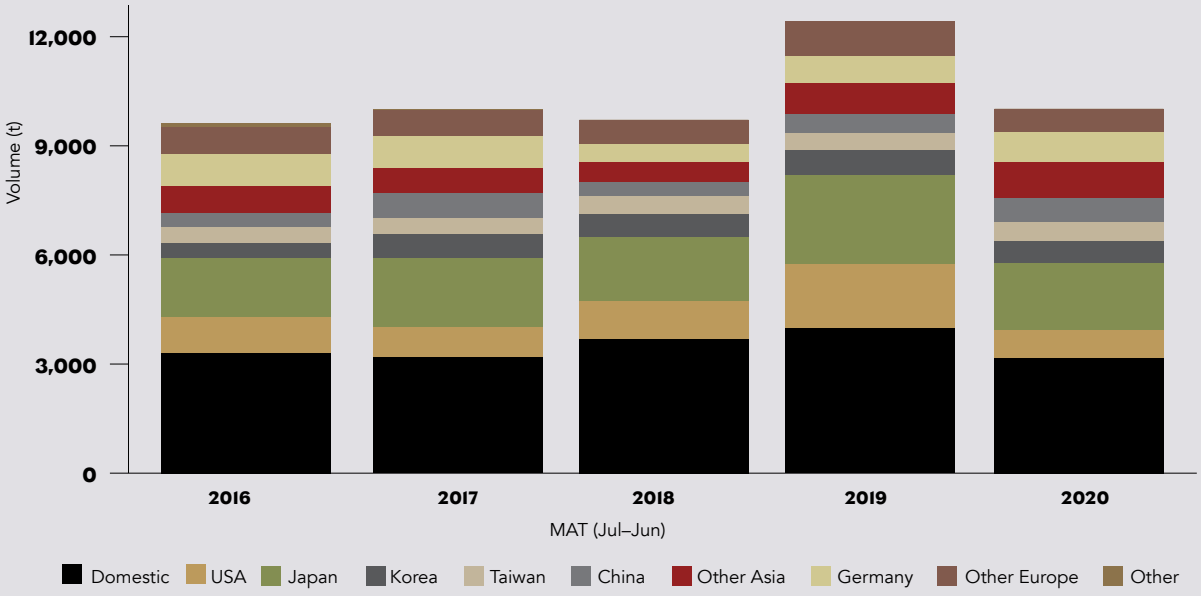

Figure 3. Australian macadamia sales (tonnes) MAT (July–June)
Source: AMHA. In-shell sales quoted at 3.5% MC. AMHA represents 90% production, sales are adjusted to represent non-AMHA members.

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Clarification regarding *Winter 2020 News Bulletin* article: 'New macadamia registration providing early IPM options'

The last edition of the *News Bulletin* included an article on the registration of Transform® for the control of macadamia lace bug. The article was written by Nick Koch and Karen Deane of Corteva Agriscience and clarification regarding the trial referenced in the following statement is required:

> 'A recent study conducted by macadamia consultant Chris Fuller showed that Transform was not present within native bee hives after commercial applications to surrounding macadamia orchards. This study demonstrates that dried spray deposits are not transferred and don't adversely affect hive health.'

This study involved taking samples from native bee hives to assess any hive impact following applications of Transform® in neighbouring orchards. Corteva Agriscience has provided the following information to the AMS:

"Whilst it is true that the study concluded that no residues were detected, details of the trial design should be considered.

The objective of the study was to assess if Transform® insecticide accumulates in native bee (*T. carbonaria*) hives at or above detectable levels (the level of quantification, or LOQ). The duration of the study was over a period of two seasons. Three applications of Transform® where made on a macadamia orchard at Downsfield Queensland; on 3 November 2017, 22 October 2018 and 19 November 2018. Samples for testing were collected from hives on 9 September 2019. Sampling was replicated and assessed three substrates from the hive including pollen, brood and propolis. Samples were tested by Eurofins Agrosciences Testing Pty Ltd.

It should be noted that the samples were taken approximately 10 months after the last application of Transform® and that applications where targeted at fruitspotting bug and after the flowering period. LOQ detection levels for Transform® (sulfoxaflor) are 0.01 mg/kg. In this trial Transform® was not detected in the native bee hives at or above this level.

The study was commissioned by Corteva Agriscience and all work is representative of the finding of Corteva Agriscience and not that of consultant Chris Fuller. Chris Fuller was a co-operator in this trial and was involved in protocol development, site selection and sample collection."

Chris Fuller has confirmed with the AMS that the trial was conducted as part of Tranform's use pattern for fruitspotting bug control when applied in October to November, which is well after bees have stopped foraging in the orchard. Chris Fuller advised that a more thorough investigation of the impacts of Transform® use around flowering would be required, given the likelihood of bee activity during this period and to gain greater confidence of native bee safety.

Corteva Agriscience has committed to a trial this season to assess any impacts on native bee hives with Transform® use during flowering, and results will be provided to industry once fully analysed. More information for growers regarding bee safety can be found in the AMS factsheet *Successful Bee Management During Flowering* as well as in Corteva Agriscience's full statement regarding this trial, which is available by calling the AMS on 1800 262 426.

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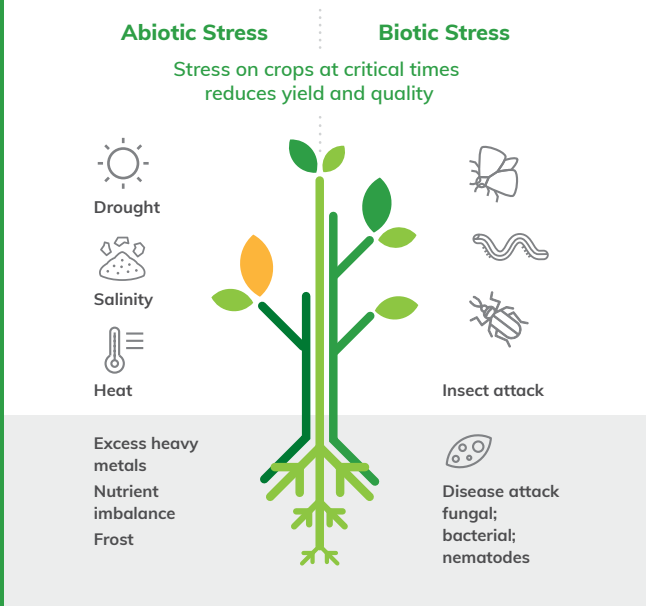

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Leoni's orchard rounds

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

We have all heard the word 'unprecedented' used in many contexts over the last few months. Growers and the industry at large were not too sure what to expect of the unprecedented 2020 growing season. As harvest draws to a close, most convey a general sense of relief when analysing the 2020 crop, although smaller than we had hoped. Final crop statistics will be available later in the year but there are general crop trends for the season.

Higher total kernel recovery %

The long-term industry average TKR is approximately 34%. Crop from NSW looks to be 2.5% higher and QLD 3% higher than this long-term figure and back to the pre-drought kernel recovery results of the 2018 season.

Markedly thinner shells and size variability

Many wonder whether thinner shells have contributed to the higher kernel recoveries growers are achieving. Within the same regions, growing conditions and in particular rainfall varied vastly and many growers struggled to maintain adequate soil moisture, certainly a factor in the season's size variability.

Lower immaturity than was expected

Considering the dry conditions, crop immaturity predictions were pessimistic. Although immaturity was higher, particularly in NSW with so many dryland orchards unable to mitigate the effects of drought, reject levels could have been worse. Industry long-term reject kernel recovery is approximately 2.7% and the 2020 season looks to be tracking closer to 3%. These RKR figures include an increase in the incidence of brown centres (internal discolouration), particularly in central QLD this year.

Lower overall yields

The current crop forecast for the 2020 season is 39,000 tonnes in-shell (@10% moisture) and while quality is up, for many yield is steady or down. Final industry productivity figures will be collated over the next few months, but early predictions when taking the bearing hectares under planting and crop forecast as a basis indicate industry productivity to be in the region of 2 t/ha in-shell.

Figure 1 represents the Australian macadamia industry's productivity (i.e. tonnes per bearing hectare) from 2010 to 2019. As a grower once said to me, "The price at the moment can be life changing". Productivity is a measure of how much we are taking advantage of record prices.

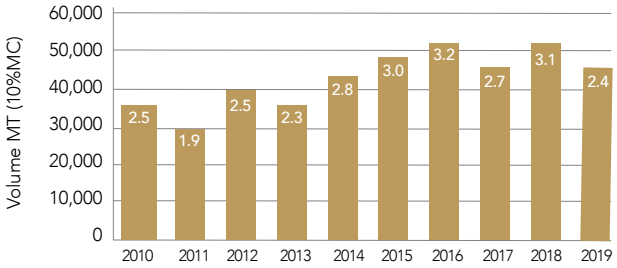

Figure 1. *Australian macadamia industry productivity 2010–2019. Production tonnes in-shell (10%MC) shown on left axis and productivity (tonnes/bearing hectare) figure provided for each year.*



Leoni Kojetin and Scott Allcott surveying a new orchard in Bundaberg.

The honest truth is that productivity of close to 2 t/ha is a blow for an expanding, progressive and innovative industry such as macadamia. It is even more difficult to put into context when assessing industry's achievements prior to 2010. In 2004, industry production was 43,700 tonnes with a productivity of 3.8 t/ha and in 2006 industry production was 43,900 tonnes with a productivity of 3.6 t/ha.

There are factors moderating the impact of this productive shortfall. Quality (if measured by total kernel recovery) has been on the increase and with the introduction of new varieties this is likely to trend even higher. Largely though, the price over recent years has been the most appreciable buffer and continues to drive investment and protect farm profitability.

PRICE x PRODUCTIVITY = PROFITABILITY

In a global context and with a secure future in mind, the AMS has launched two new initiatives to secure industry growth and profitability. The first is the Industry Marketing Fund initiative that Jolyon discusses in his CEO's column, keeping demand ahead of supply and supporting stable prices.

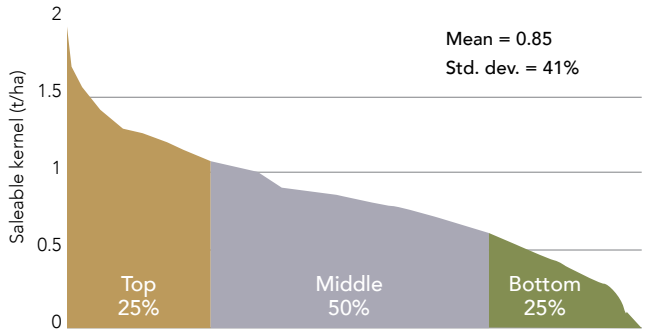

Figure 2. 2009 to 2019 average productivity (SK tonnes/bearing hectare) for 374 farms participating in benchmarking; showing averages for top 25%, middle 50% and bottom 25% of farms. (Source: DAFQ Benchmarking Project, MC18002).

The second initiative addresses the other crucial factor in the profitability equation: productivity. There is enormous variability in the production of Australian orchards as demonstrated in Figure 2. It shows Benchmarking Project average data of farm productivity (saleable kernel t/ha) for the period 2009 to 2019 for 374 participating farms. There is a standard deviation in productivity of 41% across all benchmarking farms and no doubt the deviation is higher across the whole industry.

New Grower Toolkit

The AMS is developing a Grower Toolkit that aims to raise the tide of productivity. It will include orchard assessment tools to identify limitations, yield gain opportunities and practical production tools based on each aspect of orchard management. It is an honest and evidence-based grower focussed guide to maximise the crop's potential and your farm profitability.

Macadamia cultivation is in its infancy with many cultivars being only one or two generations out of their wild, native environment. The Grower Toolkit is prefaced on understanding the macadamia tree and its uniquely adapted characteristics which inform management principles. The completed version will be launched to industry at the AusMac Conference, now postponed to early February 2021.

As a preview though, you can download the August MacGroup webinar (from the AMS website) in which the orchard assessment tool is introduced. This edition of the Bulletin contains an array of information on different aspects of orchard management, in particular, nutrition. We have included an article which expands on parts of the nutrition chapter of the Grower Toolkit on page 30. If you have any questions or comments please contact me.

I look forward to seeing you out in the orchard.



How South Africa is pushing the envelope with macadamia profitability



SAMAC Director, Myles Osborn.

AUSTRALIAN MACADAMIA SOCIETY

AusMac2021

9–11 February Sunshine Coast Convention Centre Qld

Myles Osborn, a respected grower and SAMAC Director, will be hosting a session at AusMac2021 on Tuesday 9 February.

Myles will outline the keys to success in South African orchards and how the industry has overcome unique challenges across a variety of growing environments.

Tickets on sale now via the AMS website.

Having grown up on the family farm in South Africa, worked in London in investment banking and trading and then returned home to work in the sugar cane industry, Myles Osborn is sure to bring a different perspective when he speaks at AusMac2021.

Myles now manages the family farm in Kwa-Zulu Natal (KZN), a subtropical area in north-east South Africa, where the family began planting the estate's 210 hectares of macadamia trees in 2005. KZN is the fastest growing macadamia region in South Africa and has a similar climate to our coastal growing areas.

Sixty hectares of the trees on Myles' farm are in production now, and the plan is to increase this by 30 hectares each year to a total area of 400 hectares. The aim is to reduce the farm's reliance on sugar cane, the profitability of which is declining.

Analyse the numbers

The key lessons that Myles has brought with him from the world of finance are the importance of benchmarking, and the collection and analysis of data to identify the net value of an enterprise and make decisions that maintain or improve its viability.

In his presentation, he will describe how, at the farm level, he and other growers are pushing the envelope on understanding the elements of net profitability and management practices that can improve it.

"Farming must be driven by figures, not pub talk or gut feel, so that decisions are made based on data and measurement," he explained.

Myles has applied this approach to determining the most profitable variety for him to grow on the farm.

He explained that Beaumont is a popular high yielding variety in South Africa, with some growers consistently attaining yields over 5 t/ha. This compares to 816, which generally is a lower yielding variety with very few farmers able to attain consistent high yields of over 4.5 t/ha. On the face of it, it would seem the sensible choice would be to choose the highest yielding variety, but that is not necessarily so said Myles. The reason for this is that the traditional South African payment system is different to the Australian one where growers are paid on total sound kernel.

The 'style' payment system in South Africa is designed so that growers are paid on the percentage of premium kernel and on the style spread in each consignment. So whole nuts receive the highest payment, then halves and then lower prices again for pieces. This means that growers in South Africa consider different factors when assessing the best variety for their situation than we do in Australia.

After doing the numbers on his farm, he figured out that because 816 has large premium kernels, he only needs to attain 78% of the Beaumont yield per hectare (3.8 t/ha vs 5 t/ha) to attain the same net revenue per hectare. Therefore, Myles concluded that although farmers tend towards yield, net revenue per hectare will drive the correct decisions in the orchard. A downside of this project management approach for Myles is that he spends a lot more time in the office than he would like, but it is a crucial part of running a successful farming enterprise.

Marketing focus

As well as running the family farm, Myles is a board member and Director Commercial with South African Macadamia Growers' Association (SAMAC), where his focus is on driving more diversified market access for South African macadamias.

At AusMac2021 he will give conference participants an insight into how the industry in South Africa is advancing, particularly as far as marketing is concerned.

While global supply is growing, he doesn't see this as a threat to the macadamia industry, rather he looks forward to the opportunities this will unlock for expanding the market for macadamias and developing new products. One area with much promise the industry is focusing on is the dietary value of nuts.

"The health trend across the globe, that all nuts are riding on, is particularly important for macadamias and we as a global industry need not reinvent the wheel but follow the success of the Almond Board of California in ensuring that demand is kept abreast of global supply," he said.

Same tree, different industry

The new SAMAC is taking a more active role in research and development.

Nutrition is one area where both the organisation and individual growers are experimenting with new approaches, one of which is using low-flow drip to feed and water trees daily. This is an intensive process that involves taking regular measurements of soil moisture status and EC and adjusting nutrition application continuously.

"Growers from lower rainfall areas who have been doing this are getting exciting results in the way of earlier, bigger crops. But we do have a question as to whether this approach will be effective in high rainfall areas," he said.

Another area of investigation is to do with tree structure and complexity. He is aware of the work being done in Australia on tree physiology and tree height and explained that, in the absence of a dwarf variety, South Africa is forced to take a different route.

"In general, we are looking to keep trees to around five to six metres tall and maintain their complexity at the same time," he explained.

Complexity is a shorthand way of describing an approach where growers increase the productive capacity of trees by encouraging a constant renewal of fruiting wood at all layers of the canopy. This involves:

- restricting tree height
- maintaining good sunlight throughout the canopy
- rejuvenating wood with robust annual pruning
- maintaining high nutrition levels.

The return on this intensive management is highly productive wood that is constantly regenerating so that trees have a high carrying capacity and are small enough to easily maintain.

Myles emphasised that maintaining complexity is crucial to the aim of targeting consistent high production over time, not simply high production.

South African information to Australia

Myles acknowledged that for many years Australia has been the source of much of the advice on growing macadamias. Some of this was applicable to South Africa but some was not. The industry has put much effort into developing information that is relevant to the different South African growing regions and now it is in the fortunate situation of having many consultants and advisors. This will be augmented in the future by a comprehensive and extensive research program that SAMAC has put in place over the last two years.

And this will give Myles the opportunity to reverse an historic trend and bring South African information to Australia, rather than the other way around.

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Jacqui Price hits the ground running as our new Market Development Manager

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



Market Development Manager Jacqui Price with Bundaberg grower Geoff Chivers.

We're delighted to introduce the latest addition to the Australian Macadamia Society team, with Jacqui Price joining as Market Development Manager. Here Jacqui shares her story with us, including why she's so pleased to be back in the macadamia industry, and what she's looking forward to in her new role.

Sometimes the perfect opportunity comes along at just the right time, and that's certainly how I felt a few months ago when I learnt that the AMS was looking for a new Market Development Manager.

I've previously worked with Nutworks and Agrimac Macadamias, and been a member of the Australian Macadamias Marketing Committee for three years, so I know what a dynamic and innovative industry this is. I'm thrilled to be back serving an industry I respect so deeply and that has afforded me many wonderful experiences over the years.

As a passionate food marketer, it's a privilege to work with a market leader brand like Australian Macadamias. Macadamias are so well aligned with what is important to today's consumers, catering to the desire for health, indulgence and taste. We have a great story to tell, and it resonates with people the world over.

My introduction to the role has been hugely rewarding, and I'm continuing to ride a steep learning curve as I step into the shoes that were worn so expertly by Lynne Ziehlke for more than a decade. Lynne has created a strong foundation upon which to grow demand for our product, and she leaves an extraordinary legacy that I'm eager to build on. Rest assured I'm committed to ensuring the transition from Lynne to myself is as seamless as possible, so that the marketing program can continue to deliver strong outcomes.

I have joined the AMS at the dawn of the next major chapter in the industry's global marketing strategy, with the two-year *#DiscoverMacadamias* program having kicked off in July. I'm excited to be guiding the implementation of this activity over the next two years, particularly the deep consumer insights we will gain from our new consumer research project across both domestic and key export markets, and the opportunity that brings to deliver even more reasons for both consumers and manufacturers to embrace macadamias.

The value the industry places on its marketing program is evident from the warm and enthusiastic welcome I have received across the board. The generosity everyone has shown by dedicating time to share their views, experience and business insights has been invaluable, and has helped bring me up to speed very quickly.

One of the highlights of my time so far has been meeting with growers in the Northern Rivers and Bundaberg, and I'm looking forward to spending more time on-farm in the months ahead. As a Sunshine Coast local, where I'm also involved with FAN, the Sunshine Coast's Food & Agribusiness Network, I eagerly anticipate getting to know growers from the Glasshouse Mountains region too.

I'm embracing my new role with a great deal of energy and enthusiasm, and am particularly looking forward to engaging with industry to understand concerns and opportunities for the future in order to develop a sound strategic plan for 2022–2027. It's a great privilege to be doing this with the support of the incredibly knowledgeable, talented and passionate team at the AMS.

If we haven't had the opportunity to meet yet, I hope we will soon. Feel free to reach out to me in the meantime if you'd like to discuss any aspect of our industry's marketing strategy.

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2020 Season review

Kim Jones, Cropwatch Independent Laboratories **M**: 0488 340 808

In this article Kim Jones provides a wrap-up of the 2020 season (to end of June) based on his experience with quality analysis samples from Rockhampton in the north to Nambucca Heads in the south; a good representation of the broader industry.

The analysis is split into Central Queensland (Rockhampton to Maryborough), South East Queensland (Gympie and Glasshouse Mountains) and New South Wales (Northern Rivers and Mid North Coast). Data for each region up until the end of June 2020 is compared to averages in each state for the same period last season. The data does not include any grower yields, simply in-shell and kernel quality.

Total kernel recovery (TKR) for the 2020 crop is up by about 1.5–2% on last season (see Table 1), and although detail on nut size is not recorded, my general observation is that nut size is smaller. This is unusual because the rule of thumb would say that smaller nuts have lower kernel recovery, so the increased TKR this season seems to be due to thinner shells.

Average **NSW premium kernel** is up from 26.4% in 2019 to 28.8% this season (Figure 1). QLD premium kernel is similar to last season, at 30.85% in 2019 compared to 30.75% this season. Total kernel in QLD is higher while premium kernel is lower due to more kernel being graded as light shrivelled and light discoloured commercial grade kernel.

Saleable kernel recovery (SKR) is higher for both states this season; up 1% to 34% in QLD and up 2% in NSW to 32.2%.

These results are better than expected after the prolonged drought, but put in perspective the 2019 season was a poor season for quality. TKR for QLD in 2019 was 1.5% lower than the 2018 season and NSW was down 3%. This year's bounce in quality only gets us back to just below 2018 levels.

	Total kernel recovery (%)				
	Qld 2019	Central Qld 2020	SE Qld 2020	NSW 2019	NSW 2020
March	34.2	36.0	37.0	32.3	34.3
April	35.3	36.4	35.9	33.3	36.3
May	35.7	37.8	37.3	34.9	37.5
June	36.2	38.8	37.9	35.2	37.8
Average	**35.4**	**37.2**	**37.0**	**33.9**	**36.5**

Table 1. Total kernel recovery is higher this season compared to last season. QLD is 1.7% higher and NSW is 2.6% higher than 2019.

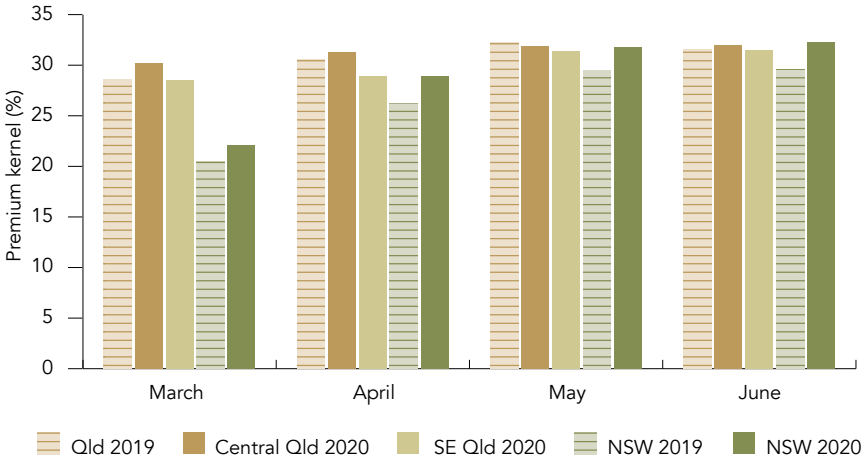

Figure 1. Percent premium kernel in 2020 is similar to 2019 in QLD (average 30.75%), and up in NSW from 26.4% in 2019 to an average of 28.8% in 2020.

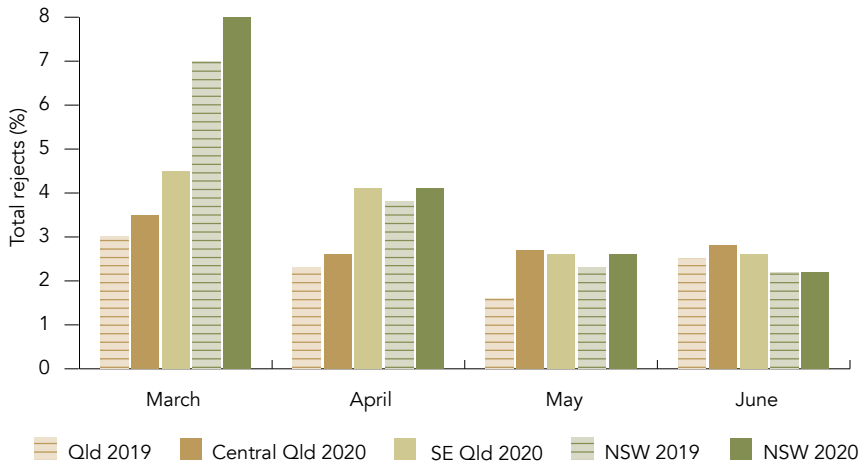

Figure 2. Total rejects for both NSW and QLD are slightly higher this year than last. As usual the reject % drops as the season progresses. Total rejects in NSW have dropped from a high of 8% in March 2020 to a low of 2.2% in June 2020.

Total rejects by month is shown in Figure 2. NSW had extremely high reject levels in March 2020. An 8% reject loss means that more than 25% of that harvest round was rejected. In some cases it was over 90%. This may be due to delivery of a clean-up round as the first harvest. This slows processing, adds unnecessary costs and increases the chance of cross-contamination with premium kernel, increasing health risks.

Figures 3, 4 and 5 show the breakdown of **regional rejects** by month and highlights are as follows:

- In **Central QLD** shrivelled kernel was 0.9%, higher than the usual level of less than 0.4%. Internal discolouration is the other major reject, also at 0.9% and double the 2019 level.
- **SE QLD** had higher mould and internal discolouration, both above 1% in March and April. Mould subsequently dropped to about 0.2% in May–June and internal discolouration fell to about 0.5% in May–June. Insect and shrivelled rejects are both tracking at about 0.8% across the season.
- **NSW** had very high reject levels in March made up of shrivelled (2.9%), mould (2.1%) and insect damage (1.5%). Quality improved in April after the first harvest rounds. Insect damage remained relatively high, mainly due to fruitspotting bug, averaging 1.1%. Late fruitspotting bug has been an issue this season and suggests that some growers lacked control after shell hardening. Internal discolouration has remained an issue across the season, averaging 0.6%.

Keeping in mind that these figures are expressed as a percentage by weight of in-shell, it gives a false impression of the **crop lost.** Often insect damaged kernel, shrivelled kernel and to a lesser degree mouldy kernel, have a much lower weight than premium kernel. Expressing it on a weight basis, nuts affected by insects and shrivelled are vastly under-estimated.

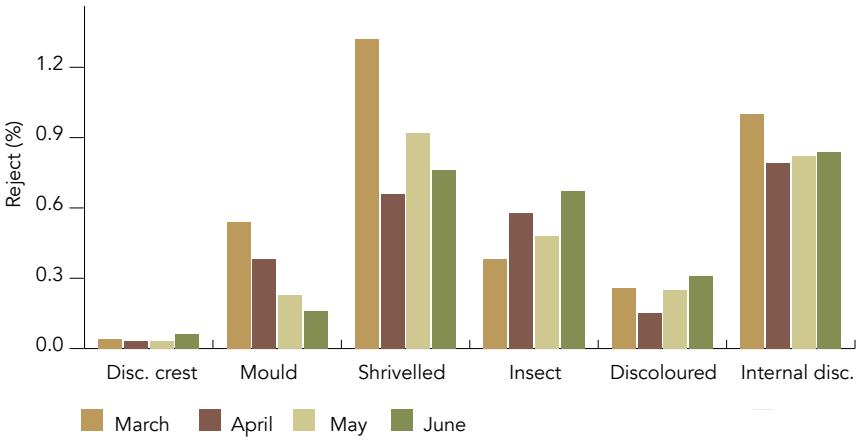

Figure 3. Central Qld reject breakdown shows that shrivelled and internal discolouration are the major causes for reject kernel, both running at season averages of 0.9%.

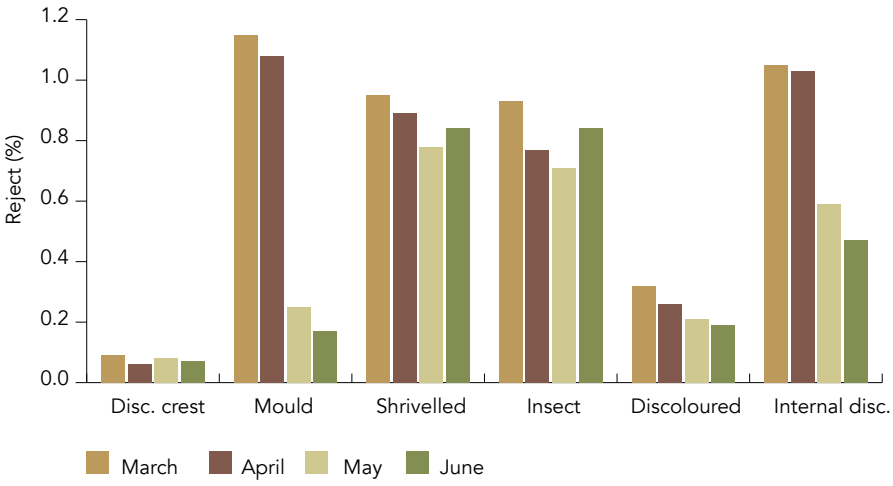

Figure 4. SE Qld had high levels of mould and internal discolouration in March and April. Mould dropped to low levels in May, and while internal discolouration declined, significant levels remained in May and June. Season averages show shrivelled (0.9%), insect (0.8%) and internal (0.8%) are the major causes for reject in SE QLD.

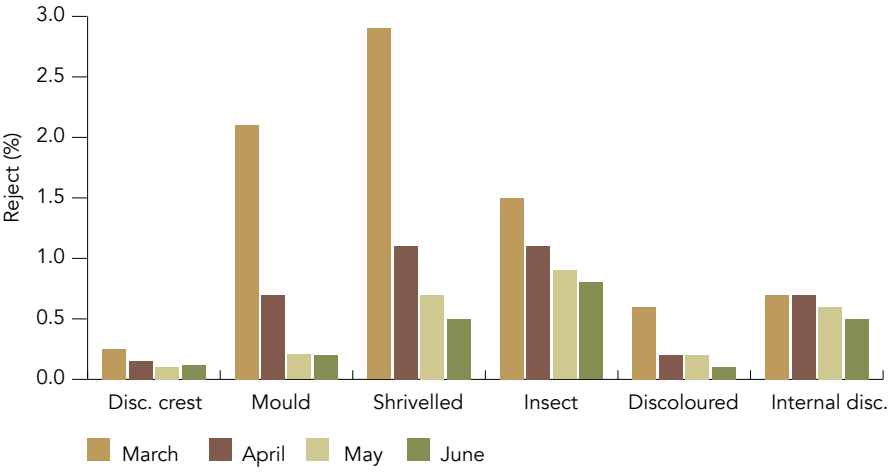

Figure 5. NSW had high levels of mould, shrivelled and insect in March. Across the season shrivelled kernel at 1.3% and insect damage at 1.1% have been the major reject causes.

A 2% loss due to insect damage sounds small, but converted to a kernel percentage (multiplying by 3 and adding a factor for reduced kernel weight), then 2% converts to about 10%. So if you are losing 10% of your total farm income to insects, this is an issue worth chasing.

Other kernel quality anomalies this season include:

- More pitted centres. Often the pit is a more hollow kernel, not necessarily occurring in the centre of the two halves.
- More blue/grey discoloured kernel (Figure 6). There are always some kernels with a blue hue, but this year there seemed to be more than ever before, often in very large kernel.

In summary, SKR is about 1.5% higher than last year, partially making up for the drop in total in-shell production. The current AMS forecast for 2020 is 39,000 MT (@10% MC) down by 7,600 MT from the 2019 season. Higher kernel recovery means that the total saleable kernel this season will drop by about 2,000 MT, assuming the total crop comes in on forecast.

The 2020 season will not go down in history as one to remember but this may be a blessing considering the result could have been worse. While drought has affected growers and overall industry yield is down, the quality is certainly an improvement over last season. No one predicted that the drought would have a bigger impact on the shell than the kernel, resulting in higher TKR, but this highlights how little we know about the macadamia tree.



Figure 6. *Blue-grey kernel, usually in extra larger kernels.*





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Orchard preparation the key to long-term macadamia success

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Michael Russo has challenged the rule of thumb that poor country surely couldn't support macadamia trees. His intensive orchard establishment protocol and focus on long-term efficiency has so far proven successful on a site facing many challenges.

Orchard: 'Hetheringtons'

Owner: Mman Investments (Michael Russo)

Location: Farnsfield, Queensland

Total size: 47 ha with 14,000 trees

Cultivars: A203 & 741; 2 years old; planted at 9.5 m x 3.55 m spacing

Soils: Ex-cane land, Alloway sandy loam (redoxic hydrosol) to Gooburrum loam (red dermasol)

The Russo family have a long growing history in the larger Bundaberg and Childers region where the extended family farm a range of broadacre crops including sugar cane, peanuts, barley, sorghum and corn. Michael Russo, a fourth-generation grower, diversified into macadamia and brought with him years of crop establishment experience that saw him determined to 'get it right from the start'.

The 47-hectare orchard that he established at Farnsfield is an interesting case study of considered preparation on generally poorer country and establishment principles designed to get the best out of the orchard for years to come. The farm, which he named 'Hetheringtons', was not the first macadamia orchard he has established, with another orchard in close proximity that had been planted 2 years earlier.

The 47-hectare block was unique in the challenges it posed, having grown marginal cane with evident drainage constraints for many years. The proximity of the property, which neighbours an existing farm, made it a highly desirable block and it also had a water allocation and dam. Michael believed macadamia would be viable in the deficient soils if he implemented a significant soil amelioration and drainage plan, beginning years before the first trees were planted.

Understanding the soils and re-engineering the drainage

When the land was purchased and after engaging a professional consultant, the first step was an extensive soil analysis. This involved not only standard surface soil sampling but digging over 80 soil trenches to a depth of 2 metres to get a complete understanding of the soil profile. This analysis informed the re-engineering of drainage on the block which had been an issue.

Redirecting sub-surface water flows from the neighbouring property, managing roadway runoff and considering drainage through the clay base under the loam soils were a priority. From the beginning Michael considered maximising orchard efficiency and the potential for longer rows which meant that the existing drainage lines had to be reoriented. Following the substantial drainage work the site was then laser levelled and double brushed.

Farming experience helps establish fertile garden beds

Once the blank canvas was established, Michael relied on his farming experience to begin restoring the poor soils typical of ex-cane land. A peanut crop was put in for nitrogen fixation as well as creating a more workable soil. After the peanut hay was ploughed in Michael followed up with a sorghum crop which was also ploughed in, incorporating **organic matter** into the very low carbon content soils.

Experience had taught him that although this longer term strategy potentially added years to his establishment timeframe, these rotational crops were essential to getting the best out of the poor soils for years to come.

After the cover crops were ploughed in, the site was limed to correct pH and improve the cation exchange capacity (CEC), and then ripped to improve soil structure. Without improving the **soil structure** first, Michael felt that he would be constantly 'chasing his tail' on this block and funding retrospective soil corrective activities which would not be as effective.

While lifting **soil fertility** across the entire site was important, most effort was concentrated more specifically on creating fertile strips into which the trees were planted. While many others growers start with incorporating ameliorants into mounds, Michael did the opposite and deep-ripped mill mud, gypsum and other fertilisers into 'garden bed' strips (i.e. the tree rows) to create ideal growing conditions for tree roots. More organic matter in the form of hay from his other crops was incorporated into the tree rows with a rotary hoe.

Once the soil improvements were made, mounds were created. The height of the **graded mounds** varied across the orchard depending on the depth of soil and drainage considerations, with lower mounds (about 400 mm) on the ridges and higher mounds (about 600 mm) in lower lying areas.

The cane crop had stripped the soil of essential **micronutrients,** in particular zinc and copper, which are immobile elements and difficult to make available once an orchard is established. These were sprayed onto the mounds and incorporated with a power harrow along the sides of the tree rows, which also 'sealed' the mounds to retain moisture.

The **irrigation** infrastructure was completed; with drip irrigation prepared on planting with the idea to convert to sprinklers in later years.

Cultivars to suit the soils and maximise efficiency

In choosing cultivars, Michael relied on consultant advice and his own experience to carefully match cultivars to soil types. In total he has 180 hectares of macadamia already planted and another 64 hectares under development.

The cultivars that he has planted have been 344 on the poorest soils, 741 on marginal to good areas, and he is planting A203 and MCT1 on the best soils.

Michael is planning for the future and believes that small gains in operational efficiency will add up to large returns and lower costs over time. All his orchards are GIS located and he is preparing for the likely introduction of more GIS-driven orchard operations, including considering larger headland areas.

The cultivars have been planted by irrigation block to manage each separately, with the longest rows as possible on each site for offload efficiency amongst other factors. All trees were planted with a mechanical planter into soil that had been kept as moist as possible and watered immediately through the trickle tape laid on planting. Broadcast fertiliser was also applied to establish ground cover quickly.



The main orchard drain which was part of the extensive drainage management required on the block.

Planning for the long term

Michael plans to transition from the drip irrigation to sprinklers at year 4, most likely 70 L/hr emitters with a large radius like he has installed on other orchards. Some of the reasoning behind larger volume sprinklers are the efficiency of watering the majority of the root profile quickly and also providing some interrow moisture for cover crops. He is keeping his options open and there is some thought to a hybrid system that takes advantage of both drip and sprinkler irrigation going forward.

Some of the monitoring tools he has installed to inform irrigation scheduling are GDots, as well as trialling capacitance probes in representative areas which indicate soil temperate and soil moisture down to 400 mm. Currently, irrigation events are controlled manually but Michael is investigating a range of agronomic and farm management software to automate processes. Unfortunately, there are limited technological solutions that integrate all the aspects of management, including mapping, monitoring and yield. He is confident that with the advances in technology this will change.

The cost of precocity

A clear strategy that has defined the orchard establishment protocol at 'Hetherintgons' are practices which serve a long-term goal, not necessarily short-term gains. Michael is aware of the need for many growers, as with his operation, to achieve early yield which is crucial for cash flow. He is aiming to be driven primarily by decisions which support lifetime productivity and his young tree pruning regime is a good example of this.

On planting, and regularly during early growth, young trees have been pruned back to direct resources into root growth. Reducing canopy wind resistance before the roots have established and the trunk has thickened is a risk management strategy and a deliberate tactic. Trees are not staked, and Michael knows the importance of straight, self-supporting trees for functional future orchard operations.

At a glance, it may seem that some early yield is sacrificed, but he believes this will be outweighed by gains in productivity if early attention is placed on letting young trees thrive. Potentially, a desire for precocity could compromise long-term orchard production.

Michael has employed his years of experience to establish this block with a productive future in mind.



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In this article, Drs Manson and Smit look at the macadamia industry's current nutritional standards and present an alternative option. They pose some provoking questions: Do the industry's current nutrition programs, particularly nitrogen, support the crucial balance between vegetative and reproductive growth? Or are we mis-timing nutrient applications in mature bearing orchards and inadvertently reducing orchard productivity?

Plant nutrition is a complex subject. To help navigate these complexities it is helpful to compare plant nutrition with human nutrition. Both plants and humans need macronutrients and micronutrients to maintain health and be productive. If we follow this analogy, we could pose the following questions in relation to people:

1. Will eating only chocolate make a person healthy and productive?
2. Can kids have more chocolate than adults and grow up to be healthy?
3. Could eating chocolate during or before exercise make a person perform better?
4. If someone exercises frequently, can they eat more chocolate?

The first two questions are pretty simple to answer, but the last two are not as clear cut. Research suggests that runners who consume chocolate markedly outperform their non-chocolate consuming counterparts. Similarly, active individuals can consume more chocolate than inactive individuals, although in moderation.

Our chocolate analogy applied to plant nutrition could ask similar questions about nitrogen:

1. Will a tree be healthy and productive if we provide only nitrogen?
2. Can small trees use more nitrogen than large trees?
3. Could supplying nitrogen at certain times of the year increase nut productivity?
4. If a tree produced a significant amount of nuts, would it benefit from more nitrogen?

The first two questions are again intuitive, but the last two are complex.

Firstly, we know that trees need nitrogen for growth and energy production and that it is an essential macronutrient. Secondly, we know during the oil accumulation stage that nuts require significant energy, and that higher producing trees use more energy and therefore require more nitrogen. The complex component is how much nitrogen do the trees need and the need to apply 'moderation'. Although nitrogen is essential, we need to know when and how much to apply in order to maximise growth and ultimately yield.

These principles apply to a range of plant nutrients, but before we discuss nutrient timing, let's recap on the differences between macronutrients and micronutrients and their functions.

Nutrients and their functions

Macronutrients

Macronutrients are divided into two categories: primary and secondary.

Primary macronutrients are nitrogen (N), phosphorus (P) and potassium (K). All are required in relatively large quantities by plants.

Secondary macronutrients are calcium (Ca), magnesium (Mg) and sulphur (S). These are required in lesser quantities relative to primary macronutrients.

> TIP: The terms 'primary' and 'secondary' relate to the quantity needed, and not their importance to plant growth; all are equally important.

Macronutrients, as summarised in Table 1, are essential to a range of critically important plant functions.

Macronutrients	Function in plants
Primary	
Nitrogen (N)	Used to create amino acids, which are the building blocks of proteins and enzymes that are required for all plant growth
Phosphorous (P)	In photosynthesis and respiration, P plays a major role in energy storage and transfer
Potassium (K)	Vital for plant growth because K is known to be an enzyme activator that promotes metabolism, and is essential for storing energy reserves
Secondary	
Calcium (Ca)	Major role in the formation of cell wall membranes and their plasticity, affecting normal cell division by maintaining cell integrity
Magnesium (Mg)	Major constituent of the chlorophyll molecule, and therefore actively involved in photosynthesis
Sulphur (S)	Essential in forming plant proteins because it is a constituent of certain amino acids and vital for oil formation

Table 1. Primary function of plant macronutrients.

Micronutrients

Micronutrients include zinc (Zn), iron (Fe), manganese (Mn), copper (Cu), boron (B), molybdenum (Mo) and chlorine (Cl). Plants require micronutrients in far smaller quantities than any macronutrient, with only trace quantities needed.

Micronutrients	Function in plants
Boron (B)	Integral for pollen germination and pollen tube growth
Copper (Cu)	Essential in several plant enzyme systems and involved in photosynthesis as well as disease resistance
Iron (Fe)	Crucial in plant metabolic systems (photosynthesis and respiration) and strongly associated with protein metabolism
Manganese (Mn)	Functions as part of the plant enzyme system, activating several metabolic functions
Zinc (Zn)	Essential for the formation of plant hormones which are important regulators of plant growth and development
Chlorine (Cl)	Critical in photosynthesis, where it is involved in the evolution of oxygen
Molybdenum (Mo)	Necessary component of two major enzymes in plants, which are required for normal assimilation of nitrogen

Table 2. Primary function of plant micronutrients.

Macronutrient requirements of macadamias – From planting to production

Back to the chocolate/nitrogen analogy, kids/small trees can't consume the same amount of chocolate/nitrogen as adults/mature trees to be healthy. Giving more chocolate or nitrogen than is required is not only wasteful, but irresponsible.

The challenge, as macadamia growers, is to provide the right amount of nutrients at the right time of year to ensure the ideal balance between vegetative (leaf) growth and reproductive (nut) growth is maintained.

There is a clear distinction between the nutrient requirements for young, non-bearing trees and mature, bearing trees. In trees younger than 2 years, there is only a slight increase in nutrient requirements each year. There is an increase in N required from around 2 years after planting.

After 3 to 4 years, there is a significant increase to support growth and the developing crop. Any nutrition program for bearing trees also needs to take nutrient removal by the crop into consideration (see Table 3).

Combining the changing nutrient needs of trees due to their age with what we know is removed by the crop is the key to determining nutritional requirements over the life of an orchard.

For example, a scenario for nitrogen applications for a 5-year-old macadamia orchard yielding 1 t/ha in-shell could look as follows:

5-year-old orchard, yielding I t/ha



- N application of approximately 100 kg/ha/year
- N removal by the crop of approximately 10 kg/ha/year
- Assume that 10 kg/ha/year N is lost through leaching or volatilisation
- Therefore, approximately 80 kg/ha/year of N would be available for vegetative growth and maintenance
- This rate of N (80 kg/ha/year), should propel the tree into growing vegetatively whilst also continuing to produce a good crop.

When the trees in this orchard reach maturity, a maximum leaf area has been achieved (>8 years) and a yield of 5.5 t/ha in-shell has been realised, the scenario could look as follows:

>8-year-old orchard, yielding 5.5 t/ha



- N application of approximately 140 kg/ha/year
- N removal by the crop of approximately 55 kg/ha/year
- Assume that 20 kg/ha/year N is lost through leaching or volatilisation
- Therefore, approximately 65 kg/ha/year of N would be available for vegetative growth and maintenance
- This would imply that the tree still has an abundance of N available for growth and would continue to grow vegetatively at the same rate as a 5-year-old tree
- Considering the cost of pruning (to control excessive vegetative growth) and diminishing yields observed with decreased light penetration, this is problematic for the sustainable production of macadamias

	Kilograms of nutrient removed per tonne of crop							
	Macronutrients					Micronutrients		
	N	P	K	Ca	Mg	Cu	Zn	B
Husk	4.03	0.37	7.33	0.22	0.25	0.002	0.003	0.003
Shell	1.93	0.06	0.72	0.12	0.12	0.008	0.004	0.002
Kernel	4.54	0.80	1.10	0.12	0.37	0.002	0.006	0.002
TOTAL kg	**10.5**	**1.23**	**9.15**	**0.74**	**0.74**	**0.012**	**0.013**	**0.007**

Table 3. Kilograms of nutrients removed per tonne of crop[1].

A proposed alternative

Table 4 has been adapted from previously published research and proposes two distinct growth phases. The first phase is the high vigour vegetative growth phase that extends from planting through to the year that total canopy coverage is achieved (estimated as 8 years of age in this example).

The second phase is the mature production phase where maximum yields can be expected and extends from canopy closure through to the end of the life of the plantation. The theoretical nutrient prescription presented here separates crop requirements and tree growth and maintenance requirements and is designed to **reduce vegetative vigour of the trees once the orchard reaches canopy closure.** Tree growth and maintenance requirements for the maximum growth phase (6-8 years) and for sustained reduced vegetative vigour after age 8 years are presented.

Maximum nutrient requirement	N (kg/ha/yr)
Maximum replacement for crop	
Crop replacement for 5.5 t/ha in-shell	55
Tree growth and maintenance	
Maximum growth phase (6–8 yrs)	70
Mature bearing production phase (8 yrs+)	35

Table 4. Maximum amount (kg/ha/yr) of nitrogen (N) required to replace nitrogen removed from in-shell harvest of 5.5 t/ha[A].

A. Table adapted from Table 24, *Macadamias Growers Guide*, 2004, p. 116.

Back to the chocolate analogy, a marathon runner (or a mature macadamia bearing 5.5 t in-shell/ha) could easily consume 500 g of chocolate and burn the equivalent 2,500 calories in a race. Most of us are not marathon runners and consuming 500 g of chocolate regularly would likely lead to weight gain. Is this inadvertently happening in macadamias? Are we over-feeding our trees?

We believe this is indeed the case and current management of N, in particular, is promoting vegetative growth and subsequently depressing crop production in mature bearing orchards. It is proposed that the N requirements be amended once trees reach maximum canopy size (approximately at 8 years of age).

Table 5 and Figure 1 demonstrate a proposed nitrogen schedule to optimise growth and yield in a newly established orchard through to age 10 years. We consider that these delivery rates will help manage the balance between tree growth and maintenance of a maturing orchard as well as replacement of nitrogen removed in the harvested crop.

Age	Growth requirement (% of maximum)	Crop requirement (% of maximum)	N (kg/ha/yr)
0	20	0	14
1	30	4	24
2	40	7	34
3	53	22	54
4	67	41	77
5	80	56	97
6	100	78	128
7	100	93	139
8	100	100	144
9	50	100	109
10+	50	100	109

Table 5. Proposed nitrogen (N) delivery schedule (kg/ha/yr) for a developing macadamia orchard from establishment through to age 10 years.

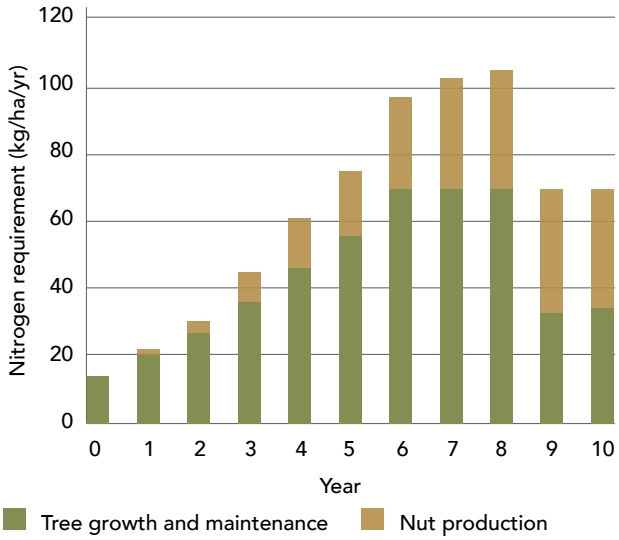

Figure 1. Proposed nitrogen (N) schedule for a developing macadamia orchard from establishment through to age 10 years with two phases of vigour management: 0–8 years and 8+ years.

Seasonal variation of macadamia macronutrient requirements and implications for management

There are undoubtedly seasonal periods where specific nutrients are in higher demand than others, but it's still important to maintain the balance between vegetative (leaf) growth and reproductive (nut) growth. For example, N promotes vegetative growth and K is important for reproductive growth and plant metabolism. If vegetative growth is promoted, typically through N applications, the transport of nutrients would be directed away from reproductive growth, leading to significant potential yield loss.

Trees are generally good at maintaining this natural balance, but mismanagement and poorly planned fertiliser applications could have a major impact on yield. Figure 2 demonstrates the variation in foliar

concentrations of macronutrients in mature bearing macadamias by month, and it could be interpreted as follows:

- A decrease in foliar nutrient concentration – the nutrient requirement is higher
- An increase in foliar nutrient concentration – the nutrient requirement is lower.

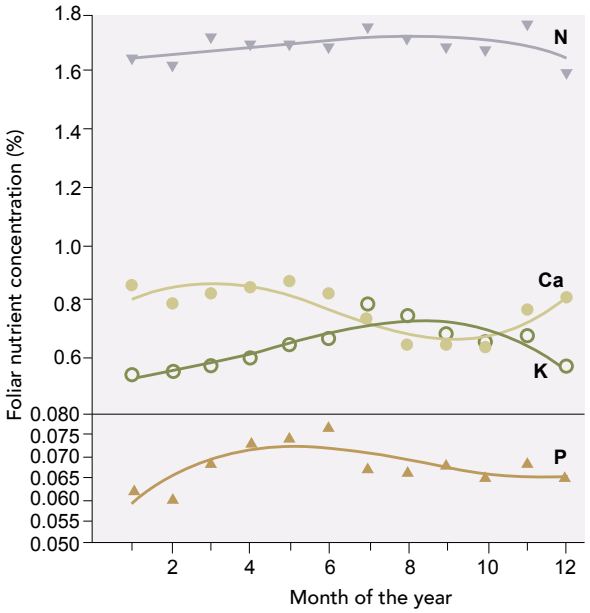

Figure 2. Monthly changes in foliar concentrations of nitrogen (N), calcium (Ca), potassium (K) and phosphorus (P) in macadamia foliage. Values are means of several cultivars grown in several regions over three years[2].

In the pursuit of balance there are many considerations. N is the primary nutritional driver of vegetative growth and could disrupt reproductive growth. So, would it be beneficial or detrimental to apply N during periods of nut growth? Surprisingly, the answer is yes, it is beneficial, but in a significantly lower ratio to K.

More K is utilised during the reproductive growth phase as oil, fundamentally made of amino acids, is produced and this process does require N, albeit in small quantities (see Table 1). In general, keeping N applications to a minimum from October to February avoids inhibiting reproductive growth, but also reduces the risk of nutrient leaching during this period of increased rainfall. N leaching or volatilisation decreases nutrient use efficiency and increases risk of environmental contamination.

If you have a fertigation system, a proposed nutrient fertigation delivery schedule for N and K for a mature bearing orchard is proposed below in Figures 3 and 4.

Have we considered everything?

The concept of balancing vegetative and reproductive growth is not only extremely complex, but also highly contested because plants don't necessarily respond the way we expect and we can't manage nature, although we try our best. The concept proposed in this article does clearly highlight some of the shortcomings of our current nutrition management guidelines and supports the need for more in-depth research regarding the nutrient requirements of macadamias.

The question we ask as scientists, ecologists and growers is whether or not a tree which is highly adapted to nutrient poor soils, resulting in effective nutrient uptake and use, would produce any greater agronomic benefit if supplied with more nutrients?

Is a rethink of nutrient management, both quantity and application timing, especially for mature trees, required to balance vegetative with reproductive growth?

References

1. Bryen & Vimpany 1997, *AMS News Bulletin,* September 1997: Technical papers.

2. Source for N, Ca and K data is Huett & Vimpany (2007); and for P data is Stephenson & Cull (1986); both cited in Wehr B and Smith T 2016, *Review of macadamia nutrition* (MC15012), final report to Hort Innovation Australia, Sydney.

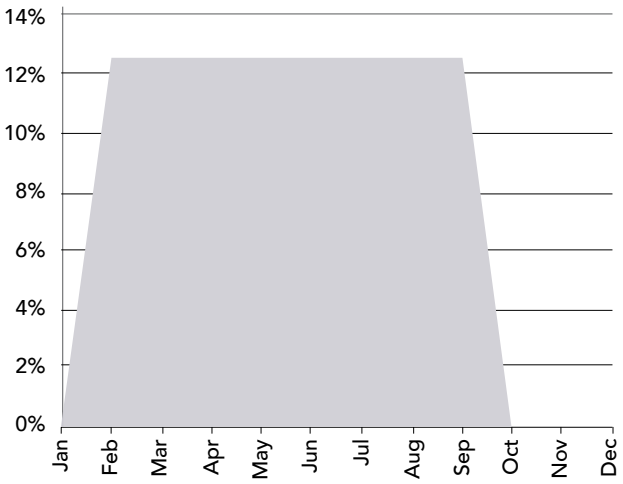

Figure 3. Proposed annual nitrogen (N) fertigation delivery schedule for a mature orchard as percent of annual budget applied per month. October to January – no fertigated N is scheduled to limit sap N levels and reduce the risk of an untimely vegetative flush in spring/early summer that may compete with nut set/growth.

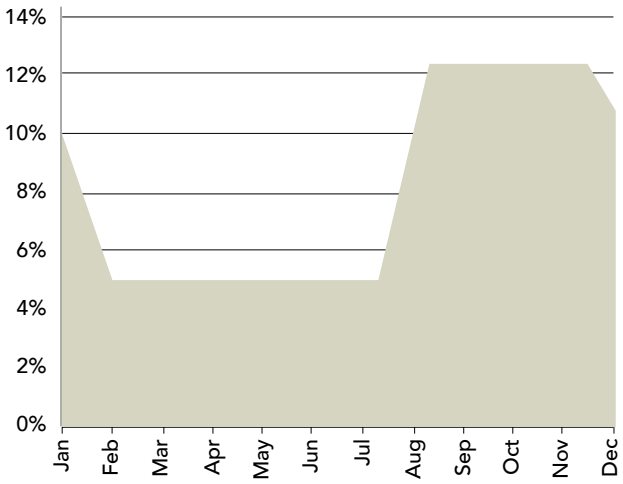

Figure 4. Proposed annual potassium (K) fertigation delivery schedule for a mature orchard as percent of annual budget applied per month. February to July sees a reduced K delivery to match reduced orchard K demand through the non-fruiting season.

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The mobility & uptake of nutrients in macadamia

Dr Theunis Smit, Armand Smit, Leoni Kojetin & Dr Chris Searle

This article expands on information in the new Grower Toolkit that the AMS is developing. It examines the pathways of nutrient uptake, their mobility within the tree, and discusses their interrelationships with nutrient management practices to increase nutrient use efficiency.

Understanding the uptake and mobility of nutrients is not only key to understanding plant nutrition, but ultimately prescribes best management practices for nutrition choices and application methods.

Movement of nutrients to the soil–root interface

For plants to take up readily available soil mineral elements (i.e. nutrients), roots need to come into contact with nutrients dissolved in the soil solution. There are three nutrient pathways for dissolved mineral elements to reach plant roots; mass-flow, diffusion and interception as depicted in Figure 1. The approximate proportion of nutrients taken up by these pathways is shown in Table 1.

Mass-flow

Within the soil, nutrients can move to the root surface through both mass-flow and diffusion. Mass-flow is a convective process where nutrients are dissolved and transported to plant roots through the movement of water. The uptake of water by roots sets up a pressure gradient which leads to the continual flow and replacement of water and dissolved nutrients in the area surrounding the root. This process is driven by water loss from the leaves (plant transpiration).

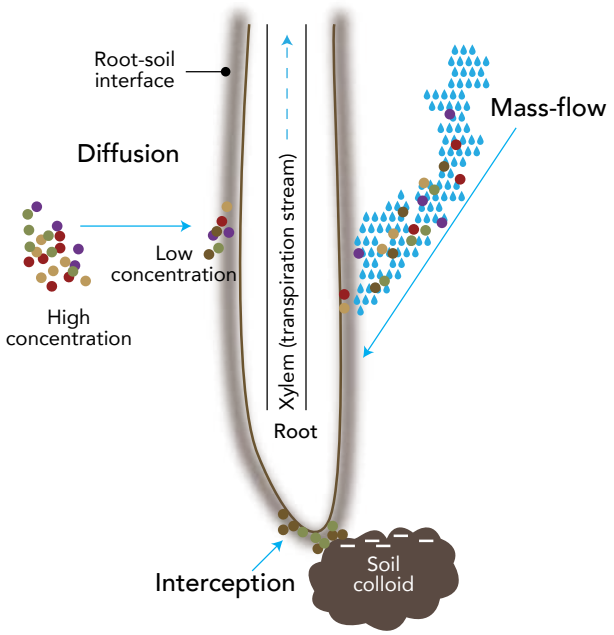

Figure 1. Nutrient mobility in the soil and root interface. Nutrients move by means of mass-flow (with water), diffusion (from a high to low concentration) or by interception (contact with soil colloids).

Diffusion

Diffusion occurs when roots extract nutrients from the soil solution directly adjacent to the roots. This sets up a concentration gradient moving nutrients from the area of higher concentration in the soil to the area of lower concentration surrounding the roots.

Interception

Roots can also absorb dissolved nutrients through contact-uptake or interception. This occurs when roots grow and come into direct contact with soil particles (colloids) that have nutrients adsorbed to the colloid (i.e. adhered or bound to the surface).

Depending on the soil texture and structure, as well as the chemical properties of the nutrients, they are either weakly or strongly adsorbed by soil minerals. Combined with nutrient solubility, the strength/degree of adsorption ultimately determines the nutrient pathway to plant roots.

Weakly adsorbed minerals include:

- sulfate (SO_4^{2-})
- magnesium (Mg^{2+})
- nitrate (NO_3^-).

Strongly adsorbed minerals include:

- phosphate (PO_4^{3-})
- calcium (Ca^{2+})
- aluminium (Al^{3+})
- zinc (Zn^{2+}).

Nutrient	Taken up by interception	Taken up by mass-flow	Taken up by diffusion
Nitrogen (N)			●
Phosphorous (P)			●●
Potassium (K)		●	●●
Calcium (Ca)	●●	●●	
Magnesium (Mg)	●	●●	
Sulfur (S)		●●	
Copper (Cu)		●●	
Zinc (Zn)		●	●●
Boron (B)		●●	
Iron (Fe)		●●	
Manganese (Mn)		●●	

●● *The majority of the nutrient is taken up by the pathway*

● *Less than half of the nutrient is taken up by the pathway*

No symbol implies that an insignificant amount is taken up by the pathway.

Table 1. Approximate proportion of nutrients taken up by various pathways. Source: Lambers et al. 2008 and Hort Innovation 2016.

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Nutrients that are weakly held and are highly soluble generally move to plant roots through mass-flow (e.g. nitrates). Strongly held nutrients (e.g. phosphates and zinc) with low solubility are either intercepted or moved to roots through diffusion. Nutrients moving through mass-flow are therefore taken up when water is available, while nutrients taken up through diffusion and interception are favoured by root systems with a larger surface area.

Balanced uptake of nutrients is contingent on orchard management practices that:

- ensure root zone water availability and
- sustain the development of an actively growing dense root system.

Understanding macadamia ecophysiology

Macadamia are uniquely evolved plants and understanding their ecophysiology is essential to correctly managing nutrients. They have long-lived, thick waxy leaves designed to limit water loss and wide shallow root systems that are efficient at taking up and recycling organic matter on the orchard floor.

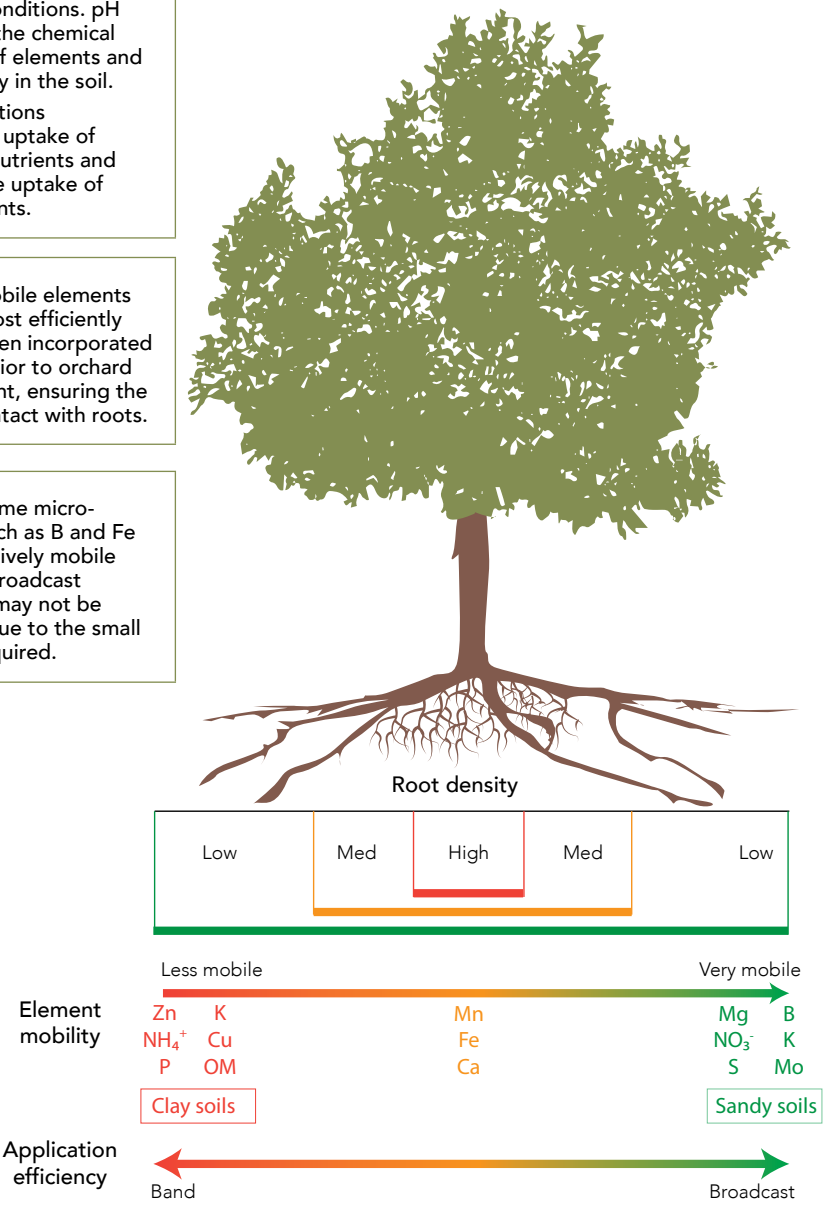
The density of macadamias roots generally decreases with distance from the tree trunk and uptake of immobile nutrients in the soil is less likely further away from the tree trunk. Differing nutrition application methods are therefore more appropriate for certain nutrients. Moreover, effective nutrient placement not only ensures efficient uptake by the tree, but also increases the efficiency of nutrient use.

Macadamia are adapted to acidic soil conditions. pH will change the chemical properties of elements and their mobility in the soil.

Acidic conditions increase the uptake of most micronutrients and decrease the uptake of macronutrients.

Highly immobile elements are often most efficiently taken up when incorporated in the soil prior to orchard establishment, ensuring the greatest contact with roots.

Although some micro-elements such as B and Fe may be relatively mobile in the soil, broadcast application may not be applicable due to the small amounts required.



Nutrient soil mobility determines the likelihood of nutrients being lost into the environment, with highly mobile nutrients being leached more readily. Immobile elements are however easily lost to the environment through erosion.

Consider downstream surface and groundwater sources in all your nutrient application decisions.

Crop plants typically use less than half of the fertiliser applied to the soil around them. The remaining elements may be lost to the environment.

Applying nutrients in regions with the highest root density will always ensure the most efficient use of nutrients.

Immobile nutrients are most effectively taken up if **banded** close to the tree trunk i.e. where the roots are denser.

More **mobile** soil nutrients, such as N, can be effectively taken up using a **broadcast** application method.

Figure 2. General element mobility in soil.
Note: 'OM' means organic matter.

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Mobility of soil nutrients in relation to fertiliser application

The surfaces of soil particles are negatively charged which attracts and binds positively charged mineral elements. Clay soils are generally more negatively charged than sandy soils and therefore have a greater ability to attract positively charged elements (i.e. they have a higher cation exchange capacity or CEC which indicates a greater ability to hold onto more positively charged nutrients).

This ability to attract elements ultimately influences element mobility in the soil. Some elements such as potassium (K+, which is positively charged) may be completely immobile in negatively charged clay soils whilst being highly mobile in sandier, less negatively charged soils.

Similarly, mineral elements which are strongly adsorbed to the soil surface (e.g. P) are generally less mobile in the soil and generally move in the soil mainly through the process of diffusion. In contrast, nutrients that are weakly adsorbed to the soil surface (e.g. N) are transported through mass-flow and are generally more mobile in the soil.

Uptake of nutrients by roots

Roots take up mineral elements in the form of mineral ions (i.e. charged particles). Once dissolved minerals or ions reach the area directly adjacent to plant roots (by mass-flow, diffusion or interception as described above), they are absorbed through either a passive or active process.

Passive uptake

This involves the diffusion of ions (nutrients) down a concentration gradient, from the higher concentration in the soil solution to the lower concentration inside the root. The ions continuously diffuse into the root until a concentration equilibrium is reached. No plant energy is used for the uptake of nutrients during this process.

Active uptake

This involves the uptake of nutrients against a concentration gradient. This process requires cellular energy to transport nutrients across a semi-permeable membrane to the interior parts of the root.

Mineral elements cannot all be passively taken up by the roots. These minerals are presented in the soil as charged ions, which cannot easily move across the cell membranes. Also, the concentration of minerals in the soil is sometimes lower than the concentration of minerals inside the roots. Most minerals are therefore taken up by the roots through an active process, using cellular energy.

Mobility of nutrients in plants in relation to fertiliser application

After being absorbed by plant roots through either active or passive uptake, mineral elements are translocated (moved) to different parts of the plant through the xylem (transpiration stream) where they serve numerous biological functions. There are different means for the translocation of mineral elements in plants and certain elements are translocated through specific channels. Therefore, elements have different levels of mobility once absorbed by the plant roots.

Once incorporated into plant tissue, some elements can be immobile while others can be remobilised. Immobile elements are typically structural elements such as Ca, Fe and S which are not remobilised once incorporated into the cell structure, usually cell walls. These elements move primarily in an upward direction in the xylem water to the cell where they stay in place. See Figure 3.

Elements that can be remobilised can leave their original location and move to areas of greater demand. Mobile elements are generally elements involved in essential metabolic processes such as the formation of enzymes and/or proteins, for example N, P, K and Mg.

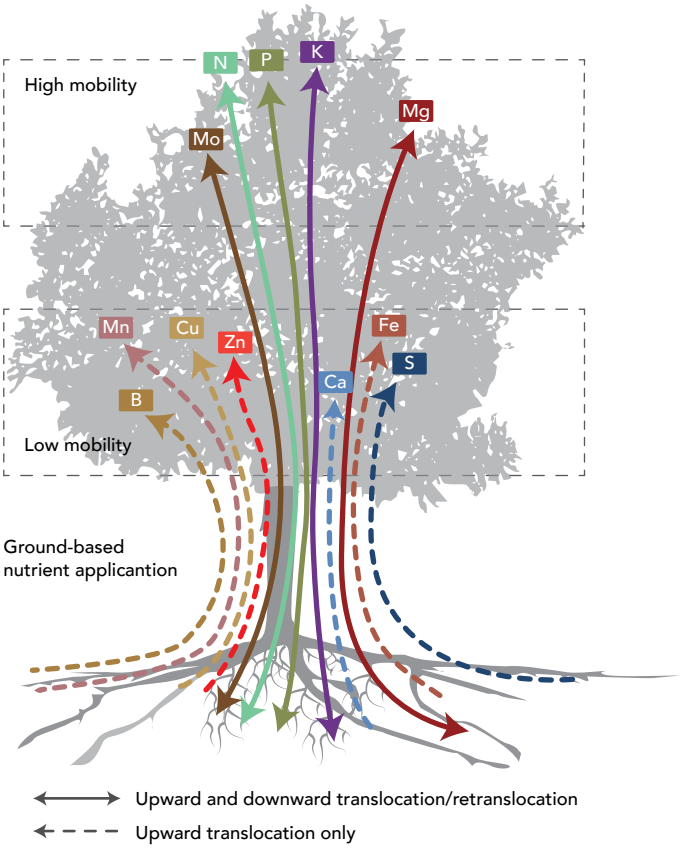

Figure 3. Element translocation within the tree from ground-based nutrients.

- **Mobile** soil nutrients are best applied is smaller applications more often.
- **Deficiencies** of mobile nutrients symptoms are first evident in **older leaves.**
- **Immobile** soil nutrients can be applied less often.
- Deficiencies of **immobile** nutrients are first evident in **younger leaves.**

See the nutrient toxicity and deficiency symptoms article on page 35.

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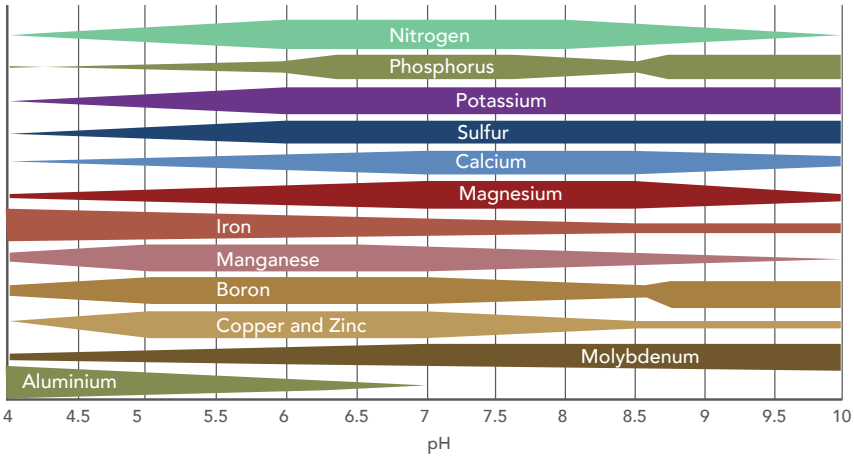

- As pH decreases, cation exchange capacity (CEC) decreases.
- As pH decreases macronutrients are less available and micronutrients are more available.

Figure 4. The effect of pH on element availability.

Knowing which elements are mobile or immobile is helpful in diagnosing deficiency symptoms. Since immobile elements cannot be remobilised within the plant, deficiency symptoms occur primarily in new growth. Whereas when mobile elements become limiting, they can be remobilised, or scavenged, from older growth and moved to where they are most needed, thus causing deficiency symptoms in older growth.

Information regarding element mobility is important for understanding deficiencies, but also determines the correct fertiliser choice and application method, particularly for foliar fertilisers.

The effect of pH on nutrient availability

Soil pH has a critical effect on the chemical properties of elements and in turn their availability as shown in Figure 4. The pH of soil is the measurement of the concentration of hydrogen ions in soil water, represented on a logarithmic scale from pH 1 to pH 14.

Soils constituents have both positive and negative charges and the balance of these charges is controlled by pH. The greater the concentration of hydrogen ions, the lower the pH and the greater the acidity. In acidic soils, to which macadamia are adapted, basic cations such as K, Ca, Mg and Na held by the soil colloids are replaced by hydrogen ions. Soil acidification is a natural process accelerated by the decomposition of organic matter which produces humic and fluvic acids as well as the release of N.

At higher, more alkaline soil pH, increased P availability will cause fixation of essential micronutrients such as Fe and Zn, which can lead to plant deficiencies. At soil pH below 5, Al availability increases and can be toxic to plant roots.

Foliar fertiliser application in macadamias

In addition to absorbing nutrients from soil-based fertilisers, most plants can absorb mineral nutrients applied to their leaves, a process known as foliar application. In limited cases this has agronomic advantages over the application of nutrients to the soil.

Foliar applications can reduce the lag time between application and uptake by the plant. They can also circumvent the problem of restricted uptake of a nutrient from the soil. Nutrient movement into the plant seems to involve diffusion through the cuticle and uptake by leaf cells, although uptake through the stomatal pores also occurs. Nutrients applied to leaves can save a plant when soil-applied nutrients would be too slow to correct a deficiency.

Foliar uptake of elements in macadamias may, however, be severely limited due to the very thick waxy surface (cuticles) on macadamia which prevents nutrients entering the leaves, and because the stomata (leaf pores) are on the underside of the leaf. Timing foliar application sprays to occur when there is a young, soft flush and before it develops the waxy cuticle may aid in foliar uptake and efficiency.

The efficiency of foliar applications of nutrients with low or primarily upward plant mobility is generally limited to the uptake site (see Figure 5). Nutrients such as Ca, Fe, B and Zn are readily fixed or incorporated into leaf structural components and will not be remobilised or translocated to other parts of the tree. Foliar applications of these elements are less effective than a more mobile element such as N which not only benefits the site where it is taken up but can also move to other areas of the tree, if required.

Generally, the use of foliar applications to correct deficiencies can lead to poor nutrient use efficiency and, given the cost of foliar fertiliser, may also lead to a poor return on investment. This poor return is due to the low uptake and translocation of most foliar applications (see Figure 5 and Table 2).

The nutrient use efficiency of foliar-applied elements is therefore highly dependent on the application time and purpose. Foliar applications can target either leaf or floral uptake. Foliar applications of Zn, B and Fe have been shown to be effective if applied to recently emerged flowers or young, soft flush as this is where they are required.

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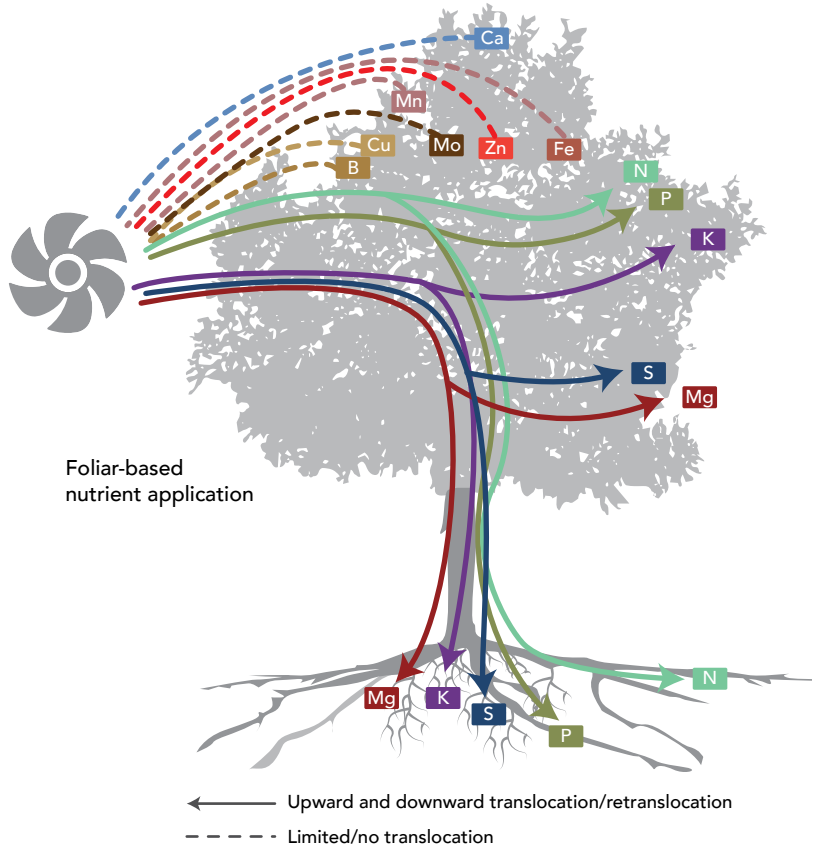

Figure 5. Element translocation within the the tree from foliar application.

Element	Foliar uptake	Translocation
Ca	✓ limited	✗
Fe, Mo, B, Mn	✓	✗
Zn, Cu	✓	✓ partly
N, S, K, P, Mg	✓	✓

Table 2. Elemental foliar (leaf) uptake and mobility.
Note: Figure 5 and Table 2 depict element mobility, but many of these are not efficient when applied to macadamias as a foliar.

Take home points

- Different elements have different levels of mobility in the soil and in the plant.
- Elements with low soil mobility should be applied close to the tree trunk using a band fertiliser application method.
- More mobile elements can be applied using a broadcast fertiliser application method.
- Nutrient uptake of all elements will be most efficient where root densities are highest (i.e. near the tree trunk).
- Nutrient mobility and the possibility of environmental losses should be considered in all nutrient application decisions.
- pH has a critical effect on the availability of nutrients.
- Foliar fertiliser applications can provide short-term benefits ('quick fixes'), especially in deficient trees with restricted uptake of a nutrient from the soil.
- Foliar application uptake and efficiency is best when the application is timed to coincide with recently emerged flowers or young, soft leaves.

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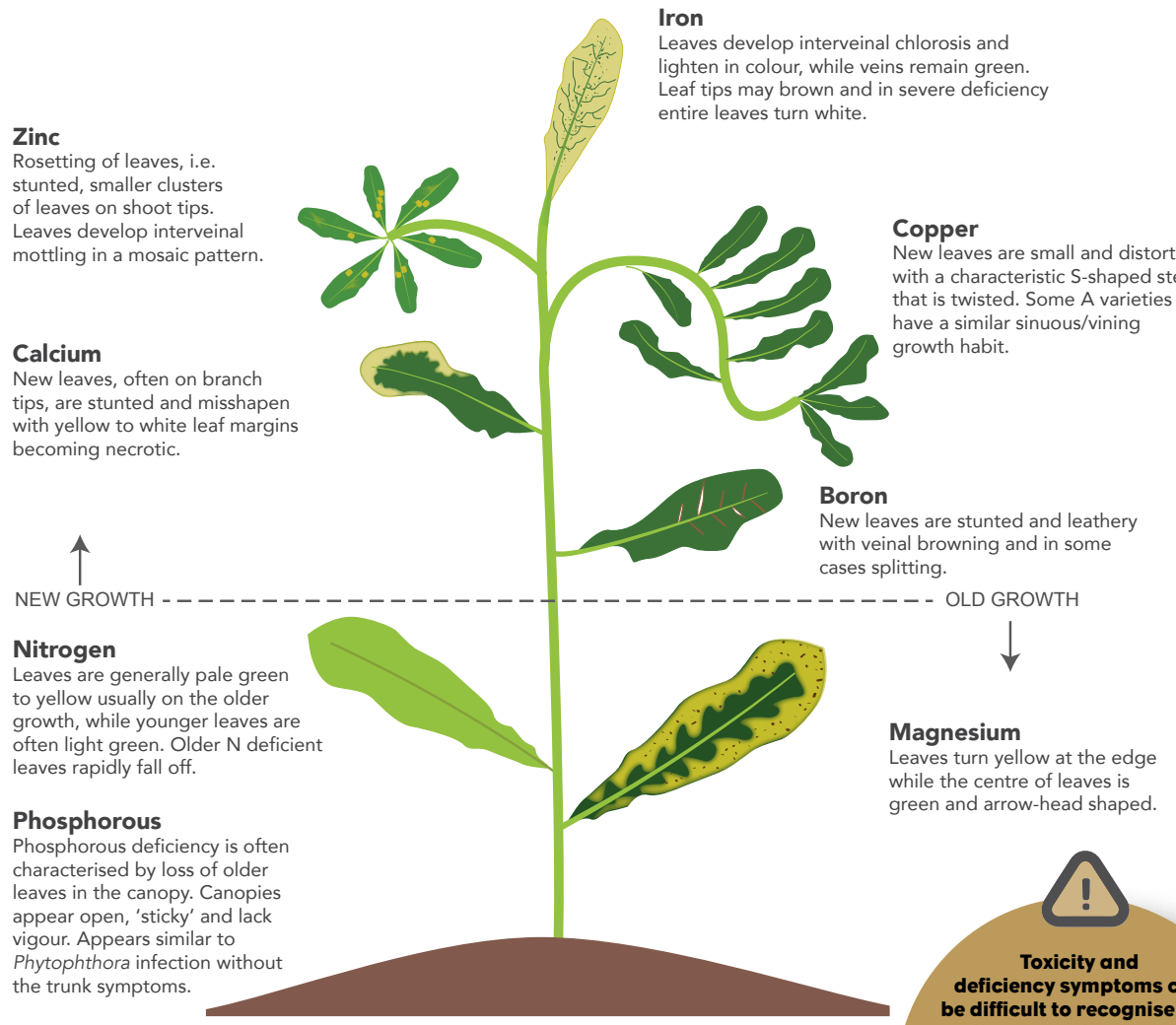
Identifying toxicity & deficiency symptoms

Regularly inspecting trees in the orchard is an effective way of identifying indicators of nutrient availability, as well as issues with soils and root health. Unfortunately, when toxicity and deficiency symptoms are visible, the damage has been done and identification becomes more of a post-mortem than a preventative strategy.

Common nutrient deficiencies



Iron
Leaves develop interveinal chlorosis and lighten in colour, while veins remain green. Leaf tips may brown and in severe deficiency entire leaves turn white.

Zinc
Rosetting of leaves, i.e. stunted, smaller clusters of leaves on shoot tips. Leaves develop interveinal mottling in a mosaic pattern.

Copper
New leaves are small and distorted with a characteristic S-shaped stem that is twisted. Some A varieties have a similar sinuous/vining growth habit.

Calcium
New leaves, often on branch tips, are stunted and misshapen with yellow to white leaf margins becoming necrotic.

Boron
New leaves are stunted and leathery with veinal browning and in some cases splitting.

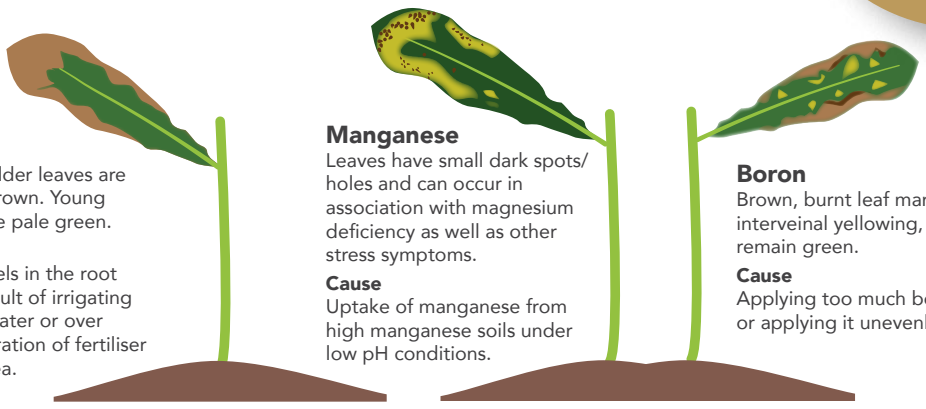
Nitrogen
Leaves are generally pale green to yellow usually on the older growth, while younger leaves are often light green. Older N deficient leaves rapidly fall off.

Magnesium
Leaves turn yellow at the edge while the centre of leaves is green and arrow-head shaped.

Phosphorous
Phosphorous deficiency is often characterised by loss of older leaves in the canopy. Canopies appear open, 'sticky' and lack vigour. Appears similar to *Phytophthora* infection without the trunk symptoms.

Toxicity and deficiency symptoms can be difficult to recognise and differentiate from certain pest or disease symptoms. Growers are best to engage a professional consultant to assist with diagnosis and possible corrective action as part of a balanced nutritional program.

Common toxicities



Salt
Margins of older leaves are noticeably brown. Young leaves can be pale green.

Cause
High salt levels in the root zone as a result of irrigating with saline water or over use/concentration of fertiliser in a small area.

Manganese
Leaves have small dark spots/holes and can occur in association with magnesium deficiency as well as other stress symptoms.

Cause
Uptake of manganese from high manganese soils under low pH conditions.

Boron
Brown, burnt leaf margins with some interveinal yellowing, while veins remain green.

Cause
Applying too much boron fertiliser or applying it unevenly.

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Boron & calcium: getting the balance right

Janus Erasmus, Gridfarm **E:** info@gridfarm.net



Boron imbalances — deficiency and toxicity — are one of the limiting factors in many macadamia orchards. Maintaining soil boron levels and adequate foliar boron will significantly contribute to the overall production of macadamias.

Boron is an essential trace element

The major role of boron is to provide structural integrity to the cell walls of plants. Boron is needed for the formation of new cells at growing tips: root tips, the ends of stems and flower buds. In the timber industry, boron is used to improve timber quality and strength.

The other very important role of boron is ensuring pollination translates into successful fertilisation. If boron is deficient during flowering, pollen tube growth is severely affected to the point where fertilisation does not occur.

It is common practice in macadamia orchards to apply foliar boron near flowering to ensure pollination, but if we miss this application due to weather, crop losses occur. Put simply: no boron, no nuts.

While it is important to ensure enough boron during flowering, boron is also a common nutrient toxicity symptom observed in plant production. It is easy to over-apply boron in lighter soils, especially if the calcium levels are low in the soil.

Understanding calcium to boron ratio

Understanding the availability of boron in our soils and having a way to manipulate boron levels is key to achieving the best outcomes.

It has long been known in plant and soil science that boron availability and uptake is linked to available calcium. Research published in 1941[1] described a correlation between available calcium in the soil and boron starvation in plants.

Later, in 2007[2], another interesting article discussed the effect of different ratios of calcium to boron. Towards one end of the ratio plants were deficient and towards the other end of the ratio they started showing toxicity symptoms.

During this same time a colleague, Johan Prinsloo, and I investigated the soil ratios of calcium to boron and recorded our findings in the field on various crops.

It was clear that plants started to show a boron deficiency if the soil calcium to boron ratio was more than 1000 parts per million calcium to 1 part per million boron. Both plant tissue tests and sap tests confirmed these observations. When the ratio reached over 2000:1, severe boron deficiency resulted and pollination was dramatically reduced. In various crops the amount of pollination and thus production increased significantly when this ratio was corrected in the soil.

The same was found in areas where boron has been over-supplied to the soil. Boron starts being toxic to plants if the calcium to boron ratio starts dropping below 600:1, with severe toxic symptoms at 300:1. We have investigated numerous macadamia orchards with boron toxicity and all were found to have a calcium to boron ratio of less than 600:1.

Correcting boron levels

Growers need to be very cautious when correcting soil boron levels because boron is toxic to plants in the wrong ratios, and if applied to soils with low calcium levels it can easily cause damage and reduce productivity. Boron is also an anion thus will not bind to the soil colloids. It is held in the soil, to a lesser extent, by the organic matter, but more so by calcium. Understanding soil texture is essential before making any soil corrections.

Choosing the correct boron ameliorant is important. Most commercial boron products are sodium borates which are very soluble and good for use in foliar applications. But when applied to the soil they tend to upset the calcium to boron ratio in the short term, and can then leach out with the first water that moves through the profile, making them unsuitable for correcting soil boron levels.

Some slow-release boron products on the market are pure calcium borates. They are not soluble and can take a very long time to become soil-available.

We have found that the best form to correct soil calcium to boron ratios is a magnesium–calcium borate. With a 5% water solubility and the rest citric acid soluble, it makes for the ideal release characteristics to supply small amounts of boron to the plants while at the same time altering the soil calcium to boron ratio.

Calcium and boron levels vary across orchards

It would be very easy to achieve an optimal calcium to boron ratio if the soil in an orchard was all even and homogenous. But the texture and nutrients in all soils vary dramatically over the topography.

The series of maps below illustrate how variable calcium and boron levels can be over an 11-hectare macadamia orchard.

Soil calcium levels can easily vary from 200 ppm to over 1500 ppm in the same orchard as illustrated in Figure 1. The lighter green areas are areas low in calcium, and the dark green and grey areas are high in calcium.

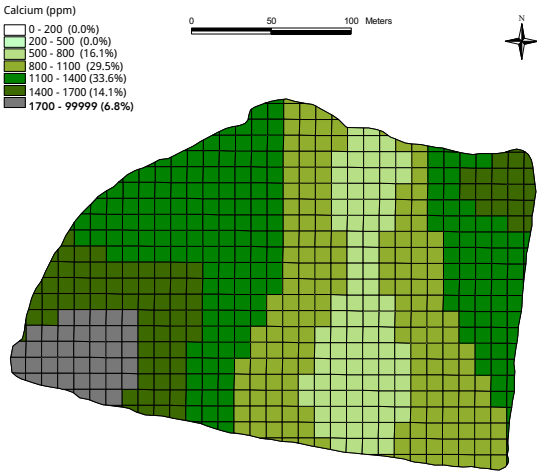

Figure 1. Calcium levels in a macadamia orchard vary from low (200 ppm, light green areas) to very high (>1700 ppm, grey areas).

Boron levels in that same orchard also vary from 0 to 2 ppm (Figure 2). The white and light blue areas are low and the dark blue and black areas are high.

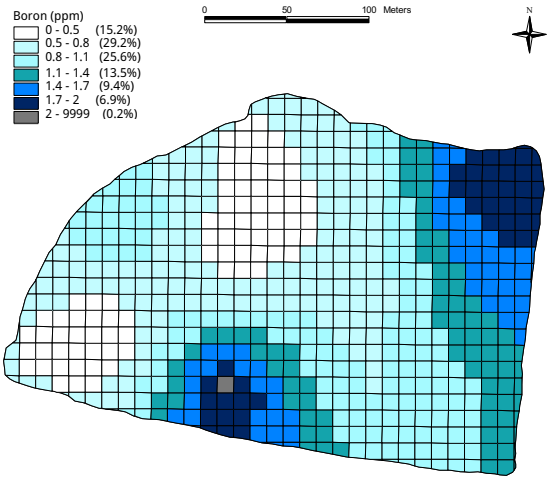

Figure 2. Boron levels in the same macadamia orchard vary from 0 to 2 ppm.

Looking at the calcium to boron ratio map (Figure 3) it is clear where the problem areas in the orchard are and a correction can be calculated. Blue and grey are in the very high, toxic range and the red and yellow areas are deficient. The green areas are those parts of the orchard where the calcium to boron ratio is in balance.

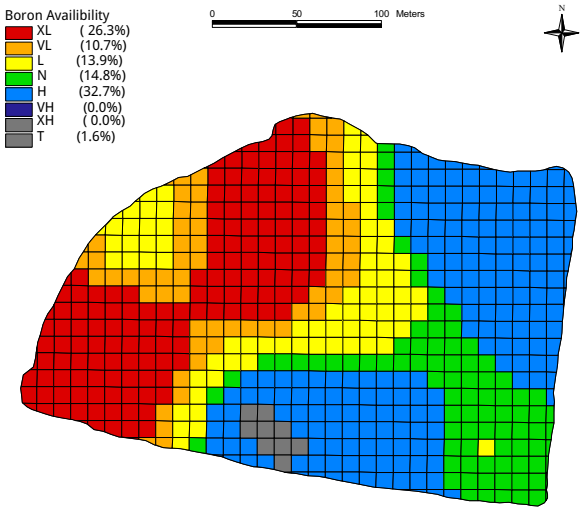

Figure 3. Boron availability levels showing areas in the orchard where boron is deficient (red and yellow), and areas where boron levels are too high or toxic (blue and grey areas).

In this 11-hectare orchard, ideal rates of magnesium–calcium borate required to address the imbalance vary from 25 kg/ha to 100 kg/ha.

Boron deficiency is still one of the most misunderstood trace element deficiencies in plants around the world, and a contributing cause of major crop losses and quality issues.

Getting the calcium to boron ratio right in your orchard for your specific soil type will give you the best chance of successful fertilisation of flowers and improved nut yields.

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1. Drake M, Sieling DH & Scarsetu D 1941, 'Calcium-boron ratio as an important factor in controlling the boron starvation of plants', *Journal of the American Society of Agronomy,* https://doi.org/10.2134/agronj1941.00021962003300050008x.
2. Tariq M & Mott CJB 2007, 'Effect of applied calcium-boron ratio on the accumulation of nutrient-elements by radish', *Journal of Agricultural and Biological Science*, vol. 2, no. 2.



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5 tips to help you find the right financial advice

Many of us may have considered getting financial advice from time to time – but many of us get stuck before we start – because we just don't know where to begin. Research shows that 80% of people who get financial advice believe it gives them more confidence in making financial decisions and makes them feel more financially secure[1].



Anne Fuchs, Head of Advice and Retirement at Sunsuper, explains some of the considerations when deciding what kind of advice you might need and how to find the right financial adviser.

Here are Anne's top 5 tips when it comes to financial advice.

1. Talk to your super fund – they may offer advice at no additional cost

Many profit-for-members or industry super funds offer financial advice to their members at no additional cost above their membership administration fee. Some funds may charge a small fee which is deducted from your super account. This advice is generally fairly simple around how to make the most of your super to achieve your best retirement outcome. If you have no other major assets other than your home and your super, then this type of advice could be all you need.

If you need advice about more complex financial issues such as Centrelink entitlements, an investment property, estate planning or whether a self-managed super fund might be right for you, then you'll most likely need comprehensive advice. This service comes at a cost and you will be required to pay a fee to your super fund or to an external adviser that they may recommend to you.

2. Consider your payment options

Most super funds will allow a fee-for-service advice fee to be deducted from your super account for any advice that is directly related to your superannuation and retirement planning.

This is important, as it means you won't have to pay the cost of the advice upfront. Fees vary, however, in my experience, around $3,000 seems to be the average, which is not a small sum by any means.

3. Only pay for what you need at the time

You may only need "moment-in-time" advice for a particular life stage or event. But it may be worth investing in ongoing advice (and therefore ongoing fees) if your situation warrants it.

4. Shop around

Meet with at least two advisers before you commit. Most people have had little exposure to financial advisers and don't know what to expect. Going to a couple of initial fact-finding meetings will help you enormously when deciding what you like and don't like about an adviser, and what you need in terms of the scope of financial advice.

These initial appointments are generally complimentary, and only require you to give as much information as you feel comfortable in giving.

Make sure you ask questions about the types of clients the adviser helps, and ask them to provide a couple of client case studies about how they've helped people like you. Most importantly, make sure you get a defined quote for the cost of the advice they propose to provide.

At Sunsuper we do very thorough background checks of any advisers we refer our members to. So if you need comprehensive advice, ask your super fund if they can refer you to an adviser they have pre-vetted.

5. Take action!

Do something to get you started – pick any one of the above options as a first step. Research has shown that a young couple that gets financial advice today could be up to $240,000 better off in retirement[1]. A financial adviser is like a personal trainer, they'll hold you accountable to the goals you've set yourself – and will help you to make sure you follow through.

For more information on financial advice options through Sunsuper, visit www.sunsuper.com.au/advice-options or call us on 13 11 84 between 8am and 6.30pm, Monday to Friday to find out more.

1. Research conducted by CoreData on behalf of Sunsuper, December 2016. Visit www.sunsuper.com.au/thedreamproject/value-of-advice to find out more. See also *AMS News Bulletin* summer 2019 article p. 46

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Nambucca Macnuts now processing organic macadamias

Nambucca Macnuts has been in the macadamia processing industry since 1998, supporting the growers of the NSW Mid North Coast area. Recently they started processing organic in-shell from local NSW Mid North Coast growers and are believed to be the largest organic macadamia processor in Australia, processing around 120 tonnes of organic nut each year.

As Vince Collins, General Manager of Macnuts explains, "We were processing conventional macadamias until 2013 but decided to outsource the cracking of in-shell nuts to Stahmann Farm Enterprises. Due to economies of scale Stahmanns were able to do it more cheaply than Macnuts.

"We continued to receive in-shell from local growers, sorting using the popular Multiscan, drying down and value-adding at the Macnuts factory."

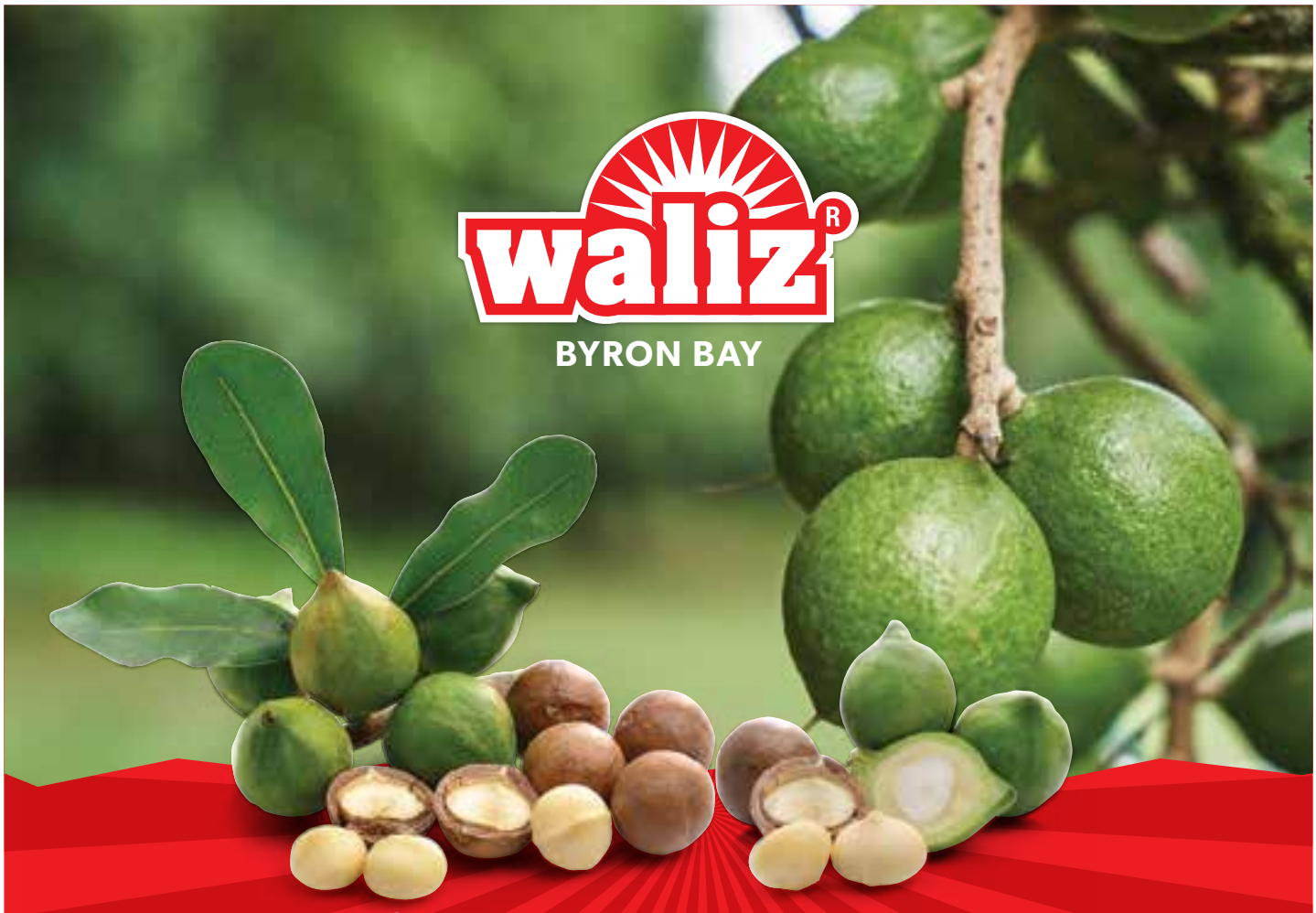
Several years ago, half a dozen local growers decided to go organic and now produce most of the organic in-shell in Australia. Stahmanns were processing this organic nut, however with the relatively small quantities involved and as Macnuts was the only supplier of organic in-shell to them, Macnuts decided to purchase updated processing equipment and commence processing again.

"The purchase, installation and testing of the organic processing line has now been completed and processing has begun. Our factory has HACCP accreditation, is ACO certified and has an AMS accredited laboratory", says Vince .

The Macnuts factory can now process organic and conventional in-shell, along with value-adding products such as their popular honey roasted nuts.

Vince says, "While Macnuts cannot compete with the larger processors in processing conventional in-shell, we are able to receive and process smaller consignments, guaranteeing growers have their own produce returned to them. The cost is still reasonable and the quality is excellent ."





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Simple but effective fertigation system a winner

Donella Andersen, AMS News Bulletin Editor

The AMS spoke to Bundaberg growers, Peter and Janet Anderson, about a simple system they use to ensure they are applying the right amount of nutrients through their fertigation system.

Orchard: Jubilee Macadamia

Owner: Peter Anderson

Location: Farnsfield, Queensland

Total size: 41 ha with 12,700 trees

Varieties: 344, A203 and 741; all 2½ years old planted at 8.9 m x 3.5 m spacing

Topography and soils: Ex-cane land, forest soils of variable quality and depth



Peter and Janet Anderson are new macadamia growers, having taken over Peter's father's sugar cane farm 3 years ago and converting it to macadamias. The whole orchard is irrigated in three separate blocks, and there is a fertigation system in place to distribute soluble nutrients.

As Peter explains, "The orchard is gently sloping and some of the soils are quite good, in that they're fairly deep; but some, especially in low-lying areas, are quite shallow with a clay subsoil. In the reasonably good soils the water table is probably about three foot below the surface, but there are areas where it goes into clay about 10 inches down. It's these areas that are our biggest concern."

To help address the high water table in the problem block, Peter has mounded the rows and planted the hardy 344 variety. He says, "The 344s aren't known for their good kernel recovery, but they do very well on poorer soils. They look just as good as the A203s up on the good soil here so I think we made the right choice."

Due to the shallow soils in the low-lying areas of the orchard, Peter was concerned that he may be over-irrigating and over-fertilising these areas. "I don't want to be over-watering and washing fertiliser into the water table. That's not very good for the environment, and it's not good for my pocket," he says.

"I wanted to be putting the minimum amount of water on with the fertigation product in it. Also, it is important to be able to know that all the fertigation water is making it out onto the orchard, and have a sense of how long that takes. So I came up with the idea of putting red dye in the fertigation tank with the fertiliser mix," says Peter.

"With the system I devised, once the fertigation tank is ready to go, we open the end of the irrigation lines and let the clear water run out. As soon as we see the red, fertigated water coming through, we shut the ends of the lines down and let the fertigated water push through the drippers.

"When the water runs clear out of the drippers we know that all the fertiliser has gone out so we turn the system off. It was a bit of trial and error, but it usually takes about an hour for the fertigated water to run out."

Peter is currently changing his drippers over to sprinklers and positioning them half-way between each tree to maximise the area he is wetting and fertilising. The sprinklers will let him get a lot more water on in a short period of time and will help with washing in granular fertiliser when that's needed, but most fertiliser will continue to be applied through the fertigation system.

So it will be back to the drawing board to get his fertiliser rates and timing right for the new system, but he's keen to increase his production levels by providing the right amounts of water and fertiliser at key times in the phenological cycle.

Peter's simple but effective solution is reducing environmental impacts, improving our social licence and contributing to ongoing reef care.

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Regenerative nut production: a case study

Ray O'Grady, O'Grady Rural **M:** 0429 200 492

The primary focus of regenerative macadamia production is increasing profits and accumulating natural capital on the farm. In this article, regenerative agriculture consultant Ray O'Grady shares his knowledge and experience at 'Picadilly Park' near Bangalow.

A more holistic approach to food production and farm management, encompassing a whole-of-systems approach is referred to as 'regenerative agriculture' and has been increasingly adopted by growers in the macadamia industry.

"It is not about organic, niche markets or a new cottage industry. Internationally, regenerative farming is quickly becoming part of mainstream agriculture. Some researchers are moving away from their reductionist past to more cost-effective, ecologically driven systems analysis," says Lorraine Gordon, the director of the Regenerative Agriculture Alliance for Australia. The Alliance has played a pivotal role in promoting and guiding the Southern Cross University's new degree in regenerative agriculture.

Our industry is fortunate to have an innovative and open-minded regenerative producer in Rex Harris, principal of the 60-hectare Harris family macadamia farm 'Piccadilly Park', near Bangalow.

Rex has been pushing the boundaries to find practical ways to transition from conventional monoculture to regenerative growing. His focus is fixed on increasing profit and building natural capital, not solely yield per hectare.

By the end of the 2020 harvest, following years of tree removal, half the rows in his orchard will have been replaced with interrow plantings of cover crops as well as under-tree broadcast plantings of ryegrass and hairy vetch. Earlier this year Rex's summer interrow crop included sunflower, sorghum, lablab, cowpea, mung bean, lucern, sula, buckwheat, flax and chickory.

Rex explains that these cover crops are his "solar panels that capture sunlight and carbon dioxide, and through photosynthesis, water and minerals are converted into complex organic acids and sugars. A large percentage of these carbon-rich compounds are exudated by the roots into the soil to feed the microbial communities."

Up to three times a year Rex uses a roller-crimper to flatten the cover crop, then follows up immediately with a direct driller to seed the new crop.

The most significant inputs at 'Piccadilly Park' are free: sunlight and rainfall.

Below the ground, the exudates and roots of the cover crops feed and connect the soil's microbiome and orchard yields soon recover from the tree removal. Above the ground, the good news is the cover crop provides habitat and food for predators and pollinators as shown in BioResource's recent findings on 'Picadilly Park'[1]. See box opposite.

This property had a long history of farming including 7 years of irrigated maize and potato growing, extensive soil degradation caused by high rainfall, erosion, cultivation and heavy grazing. Ten years ago many trees were in various stages of dieback, having soils with low CEC, crop limiting phosphorus, calcium and boron availability; and high levels of aluminium in the surface 150 mm as well as toxic levels below 300 mm.

In conventional plantations with constant chemical applications, the soil biology is supressed and becomes collateral damage. Soil biology is the driver of soil health, regulating biochemical cycles that control soil function and productivity.

Extract from BioResources report on 'Picadilly Park' interrow project report:

"Overall abundance of arthropods in the Piccadilly Park cover crop block was double that of the complete close mow block. We have found that there is numerical increase in beneficial insects without corresponding increases in herbivores or macadamia pests.

Most notably parasitoids were three times more abundant in the cover crop inter row and more than double in number in the cover crop macadamia trees compared to the close mow treatment. Similarly, predators were almost three times as abundant in the cover crop block, and nearly double in number in the cover crop macadamia trees.

Most insect orders were higher in the cover crop block in both the inter row and macadamia tree habitats. Thrips are the one exception, which were four times more abundant in the close mow block.

When comparing the cover crop with the complete close mow proportionally, predators and parasitoids were more abundant in a ratio of 80:20 in the inter row and nectivores (potential pollinators) had a ratio of 60:40 in the inter row and trees.

Overall, there were more insect families represented in the cover crop block in both the inter row and the macadamia trees."

At 'Piccadilly Park', inorganic NPK fertilisers have rarely been used in the last decade, but soil amendments such as lime flour, microfine gypsum and granular slow release boron are applied to correct mineral balance. Foliar applications of plant bio-stimulants are also used on a monthly basis.

Feedlot manure, compost and broadcast cover crops enhance the under-tree microbial communities.

The soil organic matter is now over 100 t/ha. Water infiltration rates have improved and there is virtually no runoff under intense rainfall. The interrow is less compacted and acts as a water reservoir during dry spells, having the potential to hold up to 3.6 ML/ha.

BioResource's findings on the benefits of regenerative nut production at 'Piccadilly Park' are similar to the results from a recent creditable California almond study due for publication before the end of 2020.

Compared to the conventional almond farms, the regenerative farms had:

- six times higher insect biodiversity
- 30% higher soil organic carbon
- six times higher water infiltration
- equivalent or better yields
- profits that were twice as high
- far fewer insect pests (conventional farms surprisingly had five times the number of insect pests).

In the 1500s Leonardo da Vinci mused, *"We know more about the movement of the celestial bodies than about the soil underfoot"*. In 2020 we owe it to our children and the planet to take a closer look at regenerative growing of macadamias.

References

1. BioResources 2020, "Picadilly Park" – Macadamia inter row project results, Final report prepared by A Makim and C Carr for Hort Innovation project MC16008 The IPDM program for the macadamia industry – BioResources.



Vetch and annual rye broadcast sown under the dripline of trees straight after harvest in Rex's orchard.

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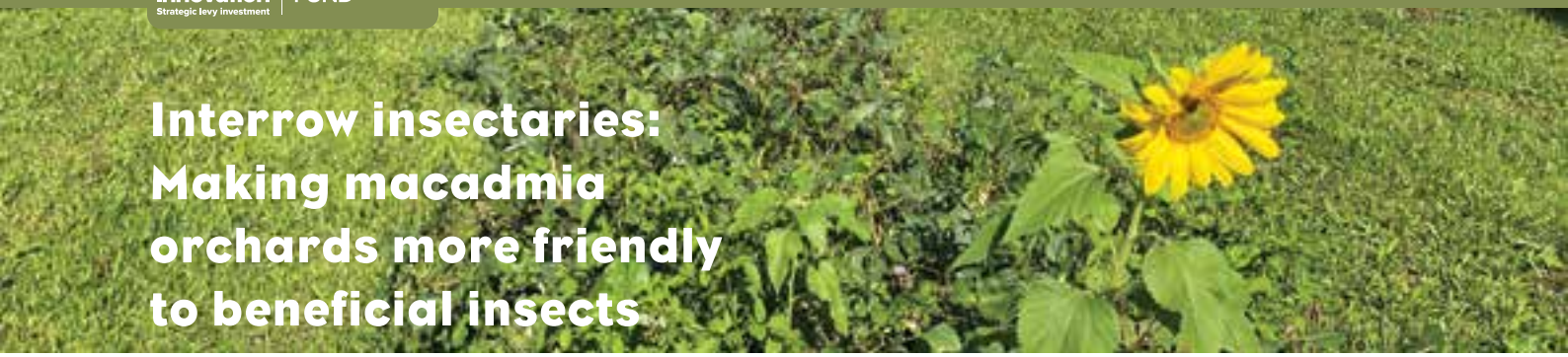

Interrow insectaries: Making macadmia orchards more friendly to beneficial insects

Dr Abigail Makim, Dr Christopher Carr, Dr Alana Govender & Richard Llewellyn, all BioResources **M: 0427 696 408**

AUSTRALIAN MACADAMIA SOCIETY
AusMac2021
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The BioResources research team will be hosting the **Cover crop and interrow workshop** at AusMac2021 on Tuesday 9 February.

Come along to find out how to improve the condition and health of your soils and take advantage of the balanced control that biodiversity brings. You'll hear about on-farm innovations and learn practical management principles to apply in your orchard.

Tickets on sale now via the AMS website.

An interrow insectary:

- consists of a diverse suite of flowering plants that are either self-seeded or purposefully and selectively planted within the interrow
- needs to be monitored and managed
- requires minimal disturbance to maintain populations of beneficial arthropods (which can be done using alternate row mowing)
- can be designed, with careful plant selection, to improve farm productivity, profitability and sustainability by improving both soil health and increasing the 'ready army' of beneficial insects within the orchard.

What is an interrow insectary?

An interrow insectary is a place of increased plant species diversity with increased, year-round floral resources, reduced physical disturbance and improved habitat complexity. An interrow insectary provides beneficial insects with the resources and shelter they need to maintain healthy populations within the orchard.

These beneficials include insects that predate on or parasitise macadamia pest species. The presence of beneficial insects means that this predation and parasitism (i.e. pest suppression) is occurring all the time. It is estimated that beneficial insects provide 5–10 times the pest control in agricultural ecosystems compared to chemical applications[1].

The increase in biodiversity provided by an insectary and other on-farm vegetation has the potential to provide multiple ecosystem services. These include a range of insect services such as increased crop pollination services because of the increased number and diversity of pollinators present; and alternative prey for important generalist predators such as spiders, which will keep them viable during low pressure periods from pests[2].

Beyond insect services, managed vegetative diversity can improve soil structure, soil microbiology, nutrient cycling, water storage, carbon sequestration and biodiversity[3].

An interrow insectary can be grown in most orchards, providing there is sufficient light within the interrow for plant photosynthesis.



Photo 1. *Example of alternate row mowing. This is a young orchard and unmown strips could span the majority of the interrow.*

Different strategies to suit

There are different strategies that can be used to achieve an insectary in a macadamia orchard. The strategy adopted will depend on many factors, including the maturity of trees, row width, available light, available machinery, budget and time to manage the insectary. The most important factor for growing an interrow insectary is the willingness of the grower/manager to change existing management practices. Fortunately, this can be done to different degrees.

Use existing vegetation for insectaries

Insectaries can be as basic as allowing the existing interrow vegetation to grow and maintain it as an unmown strip down the centre of the interrow. This strategy relies on naturally present weed, grass and native plant species establishing in the absence of regular mowing.

This can work well depending on the composition of the naturally present seed bank, and the willingness of the grower/manager to monitor the strip so as not to allow one or two plant species to dominate. One option to manage this is to mow alternate rows as needed. See photo 1.

Plant seeds for insectaries and cover crops

The interrow insectary can also be designed and managed with more ambitious objectives and results for ecosystem services in mind. This approach selects specific seed mixes based on a number of factors including and not limited to season, farm management capability, targeted ecosystem services, soil type, average annual rainfall/irrigation, regional climate and so on.

Depending on the availability of suitable machinery, seeds are either direct drilled or hand cast over prepared ground in the interrow. Seeding is incorporated into existing interrow vegetation and can be done to differing degrees depending on budget and need.

Cover cropping is a further option, which will completely replace conventional interrow vegetation types. Cover cropping can yield substantially greater benefits for beneficial insects and overall orchard and soil health compared to reduced mowing and/or seeding. However, there are practical and logistical considerations in establishing and maintaining cover crops that need to be worked through.

Interrow insectary options

The following table provides various methods for establishing interrow insectaries within an orchard. These options are neither extensive nor exclusive and combinations of options may be used within the one orchard. For example, alternative row mowing (at a reduced rate) can be used in conjunction with cover cropping or unmown interrow insectaries to provide a place of reduced disturbance for insects.

Mow option	Description
Unmown	**Reduced mowing leaves a central unmown strip down the interrow, with more regular mowing under the drip-line of the trees.** An unmown strip can be retained year-round, including throughout harvest. Row width of minimum 10 m is recommended. Strip width to be calibrated against width of harvester, slasher and mower.
Alternate row mow	**Mow every second row on a rotating schedule. Allow all rows to 'grow out' somewhat across the year. Mow all rows alternately outside of harvest.** This approach provides opportunities to more regularly encourage rejuvenation and flowering of vegetation in the interrow while managing dominant vegetation and areas of potential rat activity. A good option for young tree blocks where there is very limited ongoing access and management. It is also a good option where row width is less than 10 m and during non-harvest.
Reduced mowing with seeding	**Decide on a preferred reduced mowing strategy. Incorporate seeding into the interrow to improve vegetative diversity.** Intermittent seeding with seed mixes suitable specifically for the macadamia interrow to improve quality of the insectary and other ecosystem services.
Cover cropping	**Intensive management of the interrow with cover crops that improve multiple ecosystem services including insect pest suppression and crop pollination, nutrient cycling and soil health, carbon sequestration, and water and erosion control.** This is a dedicated system and detailed recommendations are beyond the scope of the HI project (MC16008). Further information with be available from BioResources in 2020–21. A valuable management approach for new blocks, young tree blocks, and blocks where row removal is underway. Also suitable in mature orchards where row width is greater than 10 m and good light is available.





Photos 2 & 3. *Interrow cover cropping in a macadamia orchard in northern NSW; (left) emerging cover crop seeded August 2019 including smart radish; (right) alternate adjacent row with cover crop at maturity September 2019 including smart radish, ryecorn, oats, chicory, red clover and other species.*

Will interrow insectaries lead to other problems?

Rats

The idea of growing an interrow insectary can be challenging for growers who have had rat problems in the past. The industry standard close mown orchard is promoted to alleviate rat problems, yet for many growers who follow these guidelines rats are still an issue.

For growers who have rat issues, increased monitoring and targeted action is undertaken and this same systematic approach applies to growers who have interrow vegetation.

Managed vegetative diversity is the key and spot mowing and herbicide spraying within the interrow vegetation are additional tools that can be used if necessary.

During the research project (MC16008), the presence of an interrow insectary was not found to exacerbate rat problems on the majority of trial farms that had existing issues with rats, and by the end of the project any rat problems within insectaries had been resolved. Those growers who had initial concerns regarding insectaries exacerbating rats quickly gained confidence in their ability to manage rat problems if and when they emerged.

Weeds and plant dominance

Within an interrow insectary, locally present (and occasionally seeded) insectary plant species can become dominant in some situations where management of the insectary is not undertaken or is left too long between monitoring. During the project, some of the participating farms who grew unmown type insectaries from existing seed banks observed that one locally present species had become very dominant (mostly setaria grass, kikuyu grass, Rhodes grass, cobbler's pegs and Paddy's lucerne). In all these cases, this was easily managed with either intermittent mowing/slashing or spot herbicide applications. Alternate row mowing is a good way to minimise issues with weedy species.

Insect pest reservoir

In this project arthropods were sampled using yellow sticky traps, which are particularly attractive to wasps, flies, thrips and some of the smaller true bugs (hemiptera). While the yellow sticky traps were not targeted at monitoring pest insect populations, we did not find any major macadamia insect pests in the interrow vegetation. This was not unsurprising as macadamia pests are tree and nut pests as opposed to herbaceous plant pests.

Problems during harvest

Where macadamia orchards are on sloping land, harvestable nut may roll into interrow insectaries, making it difficult to harvest. In these cases, interrow vegetation should either by reduced in width or entirely removed during the harvest period.

More information

The project run by BioResources has produced a wealth of data on the diversity, abundance and composition of insects in the interrow insectaries compared to the complete mown control rows at participating farms. These results will be presented in the project's final report and summarised in an upcoming edition of the *AMS News Bulletin*. In the meantime, there are a range of summary reports, cases studies and other publications available on the BioResources website interrow management page www.bioresources.com.au/inter_row_project/index.html.

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Acknowledgements

The research was funded by Hort Innovation using the macadamia research and development levy and funds from the Australian Government, project number MC16008.



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Understand the limiting factors in your orchard

Kevin Quinlan, Marquis Macadamias **M:** 0408 243 028

Kevin's key message: For growers wanting to improve their orchard's health, the first step is to identify what factors are limiting orchard health on your farm. Every farm is different, and the issues are likely to vary from block to block. Undertake an assessment on a block by block basis and determine the specific issues you have, and then develop a plan to address them.

IOM: the foundation of a healthy orchard

The orchard health issues I commonly see relate to the three pillars of integrated orchard management (drainage, orchard floor and canopy), and pests and diseases. There are other issues, but these are the most common ones.

The 'red flags' for macadamia orchards described in the *Integrated Orchard Management Practice Guide* provide a sound framework to assess the health of your orchard.

When I'm assessing orchard health, I look at drainage first, then the orchard floor and then the canopy. The basis of a healthy orchard is healthy soil, and a critical part of achieving this is to have effective orchard drainage. I think that if you address drainage issues first it will ensure your orchard floor is in good condition, you will save soil from erosion and stop major root exposure.

The interactions between drainage, orchard floor and canopy are complex, so it's important to consider these. An example of this is dead 'sticky tops' in trees. The dead tops are usually an indication of an insufficient feeder root network that can't support the canopy. If you address your orchard floor issues (e.g. by applying organic matter such as mulch) you'll regrow and rejuvenate your root system. This will in turn regrow the top of your canopy. Once you have addressed this, you'll move into canopy management. The focus here will be whether there is enough leaf or whether the canopy is closed in and causing internal shading within the tree – limiting light interception and distribution.

Assess your orchard block by block

Planning ahead gives you time and certainty – for this year, next year and longer term. It allows you to break the works up into manageable pieces, to address the most important issues first, and also means that subsequent works you do become easier as each part builds on the last one.

The first step is to assess your orchard, block by block, and identify the issues on each individual block. Ideally, you'd do this assessment with an agronomist or your consultant. Use this assessment to determine your priorities, which order you will address them in and how long it will take. This will depend on a number of things, like when the best time is to undertake the works (with respect to the growing cycle) and the availability of funds to pay for the works.

It can be a juggle fitting it all in, but a good plan will make it easier. In your plan you may have identified the need to do major drainage works on a particular block; but how do you harvest and install the drains before the storm season starts? A way to do it could be to use ethephon to bring your crop down early in that block, finish the harvest and then have enough time to install the drains and stabilise them before the storm season (October onwards).

Having an orchard management plan based on a thorough assessment of your blocks and backed up with good mapping, such as a drainage management plan, is not just good for you as an individual grower, but from an industry point of view it demonstrates to the community that we are serious about sustainability.



Key drivers of family farm succession

Kim Lee, Rabobank



Successful family succession planning is something that farming families across Australia strive for. It is also something that can make or break families. In this article Rabobank succession planning facilitator Kim Lee explains the importance of family culture, family farming goals, and the need to ensure open and transparent discussions about succession.

In family farm succession planning it is important to understand what you need, what the family needs and what factors influence these needs and expectations. Each family works within their own set of issues, so there is no uniform approach to this process and no template that fits every family business.

Family businesses are different from other businesses, and family farming businesses are unique again. Work and home are often intimately connected on farms, and lifestyle can play an important role in decision-making and succession.

In coastal areas where macadamias are farmed, lifestyle can often be a significant factor in the desire to continue to farm.

The rules of family business are often confused with the rules around how a family operates, and this can be the source of conflict due to potential power imbalances and communication issues. Legacy can often play a crucial role, as what has been built by preceding generations is often highly valued when deciding what assets will go forward, and how they are to be treated.

History, and the stories passed through generations, also impact on how the land and the business are viewed.

Access to the farming assets is often considered a given, and great value is placed on this, including by those family members no longer involved in the farming business.

It's important when a family discusses the process of succession or inevitable change, that it allows family members time, takes good advice and embraces a process that enables them to safely explore, discuss and negotiate the factors leading to an outcome that everyone can be comfortable with.

Some of the key points in family farm succession planning are:

- make sure the process allows for transparent communication
- establish rules that enable open communication
- ensure everyone has a chance to be heard
- include all family members in the process
- seek input from your business adviser to check the feasibility of implementing your plan
- consider engaging a professional to facilitate your family meeting, to help initiate and streamline the process.

Agricultural industries that are relatively new, like macadamia farming, tend to have a young demographic profile and/or have people who were previously employed in other industries and tend to be more receptive to succession planning factors.

These industries tend to exhibit a propensity to make use of new technology, take on external advice, understand the importance of good financial literacy, and – thanks to a deeper understanding of profit drivers – are more adept at handling the process of change well.

Good business governance procedures, including the clear separation of family from business, and clear rules for entering and operating in the business, are more likely to result in a proactive approach to succession planning. This is especially true in the area of management succession.

If planning does not occur until there is a family or economic crisis, the options available tend to shrink, and tensions can run high.

It is important to start family succession planning discussions early and embrace the process as a normal part of business planning. In this way there can be many options available for each family.

To find out more about succession planning and to listen to the podcast series exploring the succession process, go to Rabobank.com.au/succession.

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Europe embraces more adventurous snack product flavours

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Watching new flavour combinations emerge is always fascinating, especially when macadamias are involved. Our industry's research into macadamias and the snack category revealed that macadamias offer excellent flavour potential for manufactured food products.



Macadamias' versatile taste makes them an ideal flavour carrier and a safe and luxurious way of introducing new tastes to market. Three European food manufacturers have recently demonstrated this, launching new products that marry macadamias with a range of unique flavours.

1. **German manufacturer Kern Energie** is a popular producer of individual snack mixes with nuts, seeds and fruits. Its 2020 Easter collection featured two macadamia products – their Raspberry-Thyme Bubble and Strawberry-Rosemary Roasted Bubble. The blush coloured products consist of macadamia kernel coated in a raspberry or strawberry dust with a hint of thyme or rosemary. Both are described as "a combination of the buttery soft macadamia, and the slightly acidic coating of the freeze-dried fruits and herbs". Their taste and texture are "fruity sweet, spicy and wonderfully crisp", which is said to make them an ideal accompaniment to a gin and tonic. We'll drink to that!



2. **The nucao company GmbH** is a social food start-up which plants a tree with every product sold. Specialising in cereal and chocolate bars, and natural protein shakes (all in plastic-free packaging), they recently launched the nucao Macadamia Chai chocolate bar, featuring a marriage of macadamia nuts and spices including cinnamon, cardamom and cloves. The brand describes its chocolate as "the first candy bar that you can enjoy with a clear conscience". It features 65% less sugar than regular chocolate, appealing to consumers seeking sustainable and healthy products that deliver on indulgence.



3. **Guillaume Vincent Chocolatier,** a high-end French chocolate brand, recently launched a decadent Coffee & Irish Cream Caramel spread, described as a "fusion of smooth caramel and macadamias that delivers a fine flavour reminiscent of coconut and vanilla bourbon". Delivering an "incomparable fragrance and exquisite taste" it also contains a natural chicory extract that gives it a lower fat content than many classic spreads.



More adventurous flavours replacing salt across Europe

According to Innova Market Insights[1], Europe ranked second for new product development in both the snack nuts (34%) and snacks categories (27%) last year, behind Asia which represented 39% and 44% respectively.

Germany launched the most new snack nut products of all European countries, with growth driven by packaging innovation, portion control, smoked and roasted flavours, fruit additions and indulgent sweet flavours such as caramel and maple.

While salt was the top flavour seen in new European snack nut products last year, its share has dropped from 20% in 2017 to just 5% in 2019, amid rising consumer interest in more novel flavours, and concerns about the health implications of salt consumption.

Chilli, honey and paprika were the next most popular flavours last year; with bacon, barbecue, coconut, soy sauce, rosemary, berry, matcha tea, Japanese miso and turmeric flavours also becoming more prevalent.

Has COVID cancelled flavour innovation?

Asian fusion foods and health-convenience were hallmarks of 2019's food product innovation and Innova Market Insights[2] says that while "wilder and stranger novelty flavours" were predicted to emerge in 2020, the script is being rewritten by the social restrictions and economic disruption of COVID-19.

Four effects of the pandemic have been identified as having an impact on flavour trends and innovation in the next few years.

1. **Household incomes and dining out:** the hospitality sector has been hit hard by the pandemic. Even with restaurants reopening, the economic strain many are enduring may compromise people's financial capacity to eat out. The catering and high-end restaurant trades have traditionally been initiators of new cuisines and flavours that gain mass appeal, and influence flavour in new product development.
2. **Travel bans:** travel has long inspired the search for "exotic and way out flavours and formats". Being unable to travel in search of new tastes and cultures may see exotic flavour innovation slow.
3. **Supply chain disruption:** product developers may need to alter innovation plans to account for the strain the pandemic has placed on some ingredient supply chains.
4. **Olympic Games postponement:** the 2020 Tokyo Olympic Games were expected to trigger increased interest in Japanese flavours. This will now be delayed until 2021.



Despite this, Innova Market Insights predicts new product and flavour formulations will continue, with new flavour development remaining one of the most effective ways for a brand to broaden its appeal or refresh a range.

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1. Innova Market Insights, Snack Nuts & Seeds in Europe 2019, Analysis of Snack Nuts & Seeds subcategory NPD in Europe.
2. Innova Market Insights 2020, "Out There" Flavors: Has the Future Been Postponed?





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Leaf diseases in macadamia

Femi Akinsanmi, The University of Queensland, Queensland Alliance for Agriculture and Food Innovation & **Chris Searle**, MacAvo Consulting

Leaf disease symptoms are often mistaken for symptoms and disorders caused by nutrient imbalances, deficiency, excess and phytotoxicity. It is important to be able to distinguish between leaf symptoms caused by pathogens and those caused by nutrient imbalances. However, it should be noted that nutrient imbalances may predispose macadamia leaves to pathogen infection and leaf diseases.

This article provides information on key distinguishing features of macadamia leaf diseases, which may help with field diagnostics and improve management decisions.

While yellowish or brown spots, lesions, blotches and blights are often observed on macadamia leaves, they are often mistaken for nutrient imbalances, chemical burn or physical damage. **Leaf spots that progressively spread, coalesce to form a 'patch' or give a blight appearance are often indications of pathogen infection.**

The incidence and severity of leaf diseases that affect macadamia in Australia have increased over the last few years and should be taken seriously. While mild infections can reduce the photosynthetic capacity of the tree, severe infections can result in moderate to complete leaf loss over consecutive growing seasons. In addition, severe leaf loss may increase susceptibility of the tree to pests and other diseases. Leaf disease can affect the tree at all stages from the nursery through to mature orchards. When examining unthrifty trees, leaf diseases should always be considered as a primary cause of tree decline.

Four types of leaf diseases in macadamia in Australia

1. **Black leaf blight** (Alternaria leaf blight) caused by *Alternaria* species.
2. **Brown leaf blight** most likely caused by fungi from the genus *Neofusicoccum* from the family Botryosphaeriaceae. These are the same fungi that cause Botryosphaeria branch dieback.
3. **Leaf anthracnose** (Colletotrichum leaf spot) caused by *Colletotrichum siamense.*
4. **Yellow halo leaf blight** (Pestalotiopsis leaf spot) caused by two similar fungal pathogens, *Pestalotiopsis versicolor* and *Neopestalotiopsis clavispora.*

Black leaf blight (Alternaria leaf blight)

Black leaf blight occurs on young leaf flushes when conditions are continuously wet. It can occur in both the nursery and orchard. Infected apical leaves die from the tip, appear blackened or dark brown and wilt from the petiole (Figure 1). Complete collapse, where the infected black/brown tissue becomes paper thin and disintegrates on being touched, is common. In the nursery the disease can easily be controlled by reducing the period of leaf wetness.



Figure 1. Young, immature macadamia leaves in the nursery with black leaf blight (Alternaria leaf blight).

Brown leaf blight (Botryosphaeria leaf blight)

Symptoms appear on mature, full-sized leaves as extensive brown blotches which have a **distinct dark brown margin** between the brown blotch and the heathy green leaf tissue (Figure 2). This dark brown region, which is the advancing front of the disease, makes it easily distinguishable from yellow halo leaf blight where the advancing fungus produces a yellow margin or halo (Figure 2).

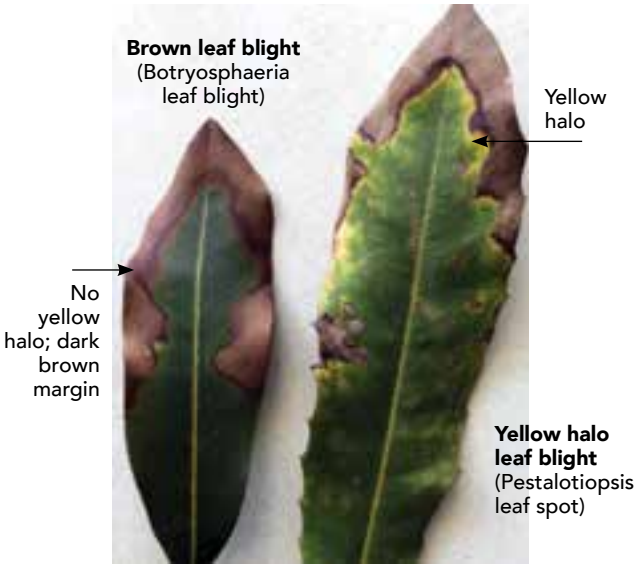

Figure 2. Key differences between brown leaf blight (Botryosphaeria leaf blight) and yellow halo leaf blight (Pestalotiopsis leaf spot) in macadamia.

Leaf anthracnose (Colletotrichum leaf spot)
Leaf anthracnose can either appear as distinct spots on the leaf or may occur as irregular brown patches along the leaf blade or at the leaf tip (Figure 3). Several leaf spots may merge to form brown-coloured patches on the leaf. The advancing **brownish lesion may appear water-soaked** at the junction between the brown lesion and the healthy green leaf tissues (Figure 3). As the disease progresses, black **fungal structures** often appear on the diseased leaf tissue. These fungal spores may be dispersed, by rain-splash, to the surrounding leaves.



Figure 3. Symptoms of leaf anthracnose (Colletotrichum leaf spot):
(a) Irregular shaped brown lesions on potted macadamia plant.
(b) Diseased tissue along leaf margin with dark to brownish water-soaked necrosis (thick arrow) and black structures of the fungus (thin arrows).
(c) Spots and blight symptoms on macadamia leaves.
(d) Close-up of diseased leaf at the tip with brownish water-soaked (thick arrow) margin advancing between the brown and green healthy part of the leaf.

Yellow halo leaf blight (Pestalotiopsis leaf spot)
Symptoms of yellow halo leaf blight are usually circular, dark brown spots with a characteristic **yellow halo.** The yellow halo is caused by the advancing fungus attacking the healthy leaf tissue (Figure 4). As the infection progresses, the dead necrotic centre of the spots may fall out to give a shot hole appearance (Figure 4c). Infections on the leaf tip or margin appear as brownish patches with distinct yellowish halo between the necrotic and green healthy part of the leaf. In the advanced stage, the tan-coloured lesions may turn **whitish and the dead leaf may become paper-thin** (Figure 4e). Leaf anthracnose can be distinguished from Pestalotiopsis leaf spot by the absence of a yellow halo around the diseased part of the leaf (Figure 5).

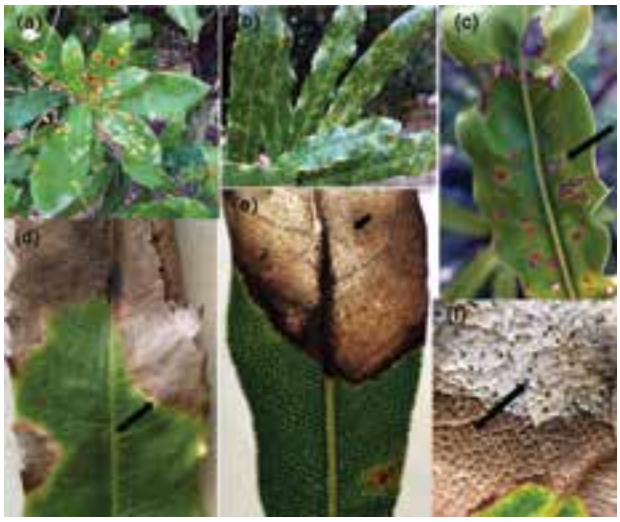

Figure 4. Yellow halo leaf blight (Pestalotiopsis leaf spot).
(a-b) Spots symptoms are circular with distinct yellowish halo surrounding the necrotic centre.
(c) Spot with shot-hole appearance (arrow).
(d) Close-up of diseased leaf tip showing brownish with distinct yellowish halo advancing between the brown and green healthy part of the leaf (arrow).
(e) Symptoms in advanced stage showing the tan-coloured lesions may turn the leaf blade paper-thin (arrow).
(f) Black structures of the fungus on diseased tissue (arrow).



Figure 5. Key differences between leaf anthracnose (Colletotrichum leaf spot) and yellow halo leaf blight (Pestalotiopsis leaf spot) in macadamia.

Incidence and spread of leaf diseases in macadamia

Yellow halo leaf blight (Pestalotiopsis leaf spot) and leaf anthracnose (Colletotrichum leaf spot) have been described as diseases of potential economic significance in macadamia in Australia[1]. Overseas, similar fungal leaf spot diseases have also been reported in macadamia: one caused by *Pestalotiopsis versicolor* in India[2] and another caused by *Neopestalotiopsis clavispora* in Brazil[3].

Wet leaf blight (Phytophthora blight), while not reported in Australia, is known to occur on high altitude plantations in Keaau, Hawaii, where it infects tender, expanding young leaves, resulting in extensive dark necrosis of irregular shape during prolonged wet periods. The foliar pathogens *Phytophthora capsici* and *Phytophthora palmivora* have been reported as the causal agents of Phytophthora blight in macadamia[4].

While a recent survey of commercial Australian macadamia orchards and nurseries[5] was unable to find these two *Phytophthora* species, they are present in Australia and are known to cause diseases in crops such as custard apples and nursery plants. In addition, the study was able to show that under laboratory conditions these two *Phytophthora* species are capable of causing macadamia leaf blight.

Managing leaf diseases in macadamia

The pathogens that cause leaf spot diseases can survive in infected leaves. These pathogens may serve as a source of inoculum for other diseases affecting flowers, nuts and young twigs. Spores of the pathogens are easily dispersed to other plant parts by splashing rain, hence the disease may easily spread throughout the canopy. Leaf diseases, such as Alternaria and Phytophthora leaf blights need water consistently on the leaves for a prolonged period of time. Disease development may continue unrestricted if wet conditions prevail.

There is currently no registered fungicide for the control of leaf diseases in macadamia orchards in Australia. The general cultural practices listed below should be adaptable for orchards and nurseries. These practices will minimise the risk of infection and underpin a sustainable control strategy. Options include:

- Adequate nutrition is essential, avoid excess or insufficient fertilisation, which may predispose the plants or trees to infection.
- Good sanitation practices are essential to the management of leaf spot diseases.
- Minimise leaf wetness with overhead irrigation by watering early in the day.
- Manage tree canopy to provide good air circulation within the canopy.
- Remove and destroy any heavily infected plants.

In the nursery, there are registered fungicides which may control the fungal leaf diseases of macadamia. When using these fungicides please follow label directions carefully.

What's next?

Future studies on leaf diseases should determine their prevalence in the Australian industry, and the impact and susceptibility of existing and new cultivars. Direct economic effects of leaf diseases should be estimated.

It is important to consider the role of diseased leaves in the canopy, in particular, in perpetuating the pathogens for other diseases of known economic significance. Studies to determine the identity and contribution of the pathogens to rapid establishment and spread of raceme blight and Botryosphaeria branch dieback diseases in macadamia are continuing at the University of Queensland as part of the integrated disease management research project (MC16018).

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Acknowledgements

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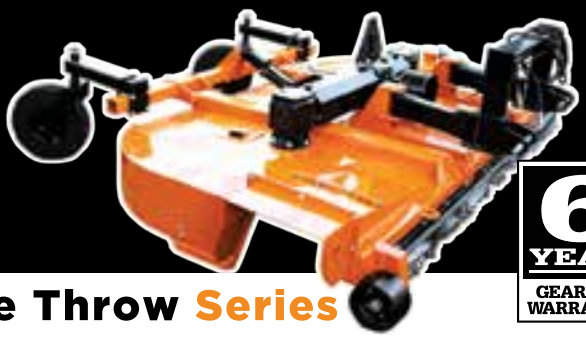

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Macadamia lace bug: orchard hygiene critical to reduce spread

Ryan Shofner, University of New South Wales

Project snapshot

One of the most vilified and least understood macadamia pests is the macadamia lace bug. As part of his PhD research, Ryan Shofner investigated various aspects of macadamia lace bug biology.

One of the main goals of the project, critical to developing better control methods, was to understand how individual lace bugs move between orchards.

The project found that *Ulonemia decoris* has a high dispersal rate between populations, low genetic diversity, and possible rapid asexual reproduction *.

This research was undertaken as part of the Horticulture Innovation project *Biology, species and genetic diversity of macadamia lace bugs* (MC13008), a joint project between Horticulture Innovation, the University of New South Wales, and NSW Department of Primary Industries.

* Asexual reproduction (or parthenogenesis) in animals means development of an embryo from an unfertilised egg cell.

Lace bugs emerged as a problem in the macadamia industry relatively recently, but immediately caused enormous economic losses[1]. 'Lace bug' is the common name for members of the family Tingidae, so-named for the lace-like structures found on the backs and wings of many species. The family Tingidae belongs to the insect order Hemiptera, the true bugs, and includes many well-known pest species: fruit spotting bug, green vegetable bug, felted coccids and aphids.

Different lace bugs have different hosts

An interesting aspect of lace bug biology is that most species have a close affinity with a narrow range of host plants. In other words, macadamia lace bugs are likely to only be found on macadamias or closely related species in the family Proteaceae.

This is important because it means that there is the potential for lace bugs that use other Proteaceae, like grevilleas or ivory curl, as hosts to 'jump' to macadamias. This has already happened at least once in Australia, with the olive lace bug (*Froggattia olivinia*) jumping from its native host, mock olive (*Notelaea longifolia*), to commercial olives, both of which are in the olive family (Oleaceae).

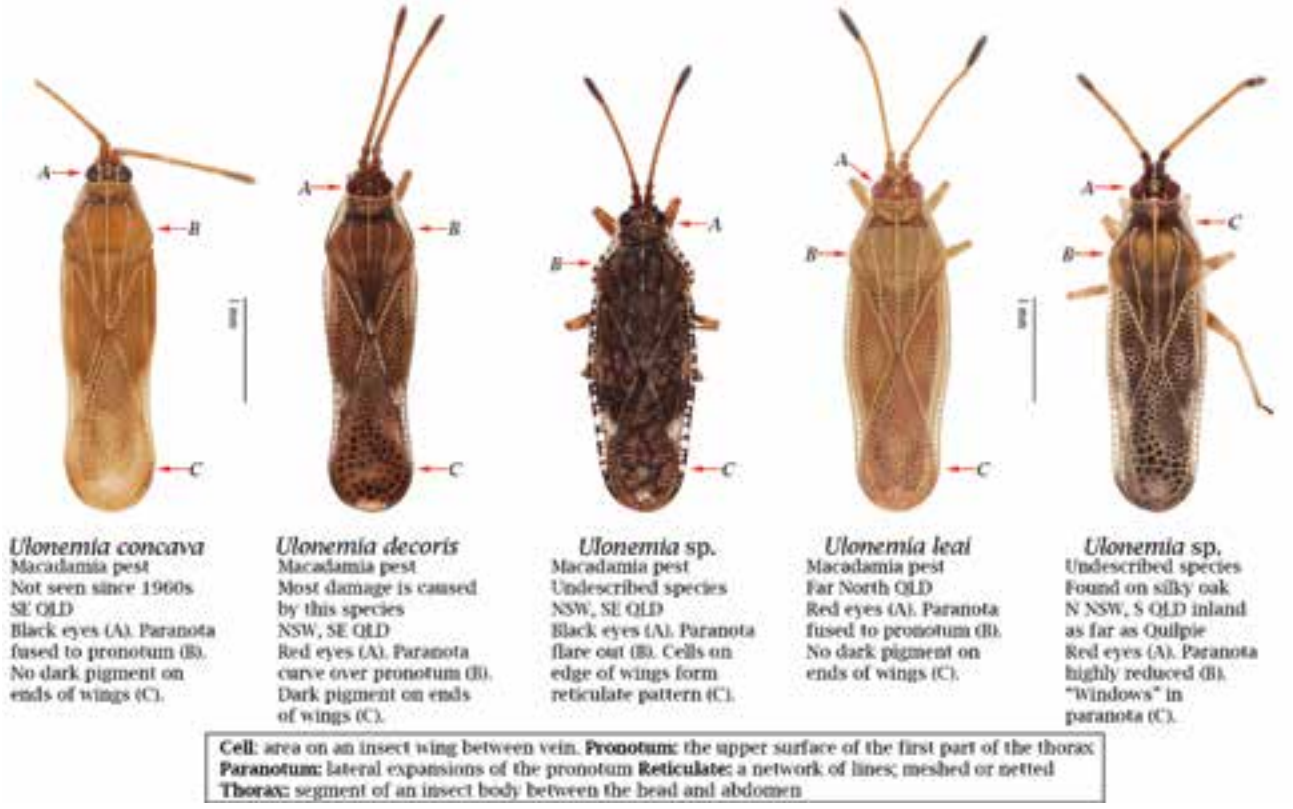

Figure 1. Identification guide for macadamia-associated lace bugs in Australia.

During the project, many growers expressed a concern that macadamia lace bugs were using tallowwoods (*Eucalyptus microcorys*) as a secondary host. This is extremely unlikely, as tallowwoods and macadamias are from two different families. We investigated and found no lace bugs on tallowwoods. In fact, no lace bug species has ever been found using any eucalypt as a host.

Four lace bugs use macadamias as hosts

We found four species of lace bugs using macadamias as hosts (Figure 1), and 13 other species that are obligate feeders of Proteaceae. Of the four species that occur on macadamias, three are serious pests. The fourth species, *Ulonemia concava*, was recorded from macadamia orchards in the 1960s, but I was unable to find any trace of this species either in the field or in museum specimens. The common name macadamia lace bug specifically applies to this 'missing' species, *U. concava*. The main pestiferous species, to which the name macadamia lace bug has subsequently been applied, is *U. decoris*. The remaining two species are *U. leai*, and an undescribed species which has been tentatively placed in *Ulonemia*.

Of these four species, three have been found exclusively on macadamias. However, *U. decoris* has also been collected from *Hicksbeachia pinnatifolia*, which is another member of the Proteaceae and closely related to macadamias. We can also infer that *U. leai* has a host other than macadamia, as the native ranges for *U. leai* and macadamias are separated by hundreds of kilometres. As such, *U. leai* would represent a second instance of host switching in Australia from a native species to an introduced one.

Another species of lace bug, also undescribed and also tentatively assigned to *Ulonemia*, occurs on silky oak (*Grevillea robusta*) within the macadamia growing region (Figure 1). This species could hypothetically switch hosts from silky oak to macadamia, though there is no record of such an event to date.

Lace bug life cycle

The four species of macadamia lace bugs all complete their life cycle on macadamia flowers. Adult females lay their eggs just under the surface of the flower raceme, and both nymphs and adults feed on the flower. This is surprising because most lace bug species feed on leaves. There is some overlap between species, with *U. decoris* and the undescribed species, both nymphs and adults, observed occupying the same flower.

Where are they found?

- ***U. decoris*** is found in New South Wales south to at least Nambucca and as far inland as Dunoon and Chillingham, and in Queensland north to Beerwah and inland to Mt Glorious. (See Figure 2)
- ***U. concava*** was last recorded in the 1960s from Mt Glorious and Maleny, Queensland.
- ***U. leai*** has only been recorded from the Atherton Plateau and around Cairns.
- ***Ulonemia* sp.**, the undescribed species, has been recorded in New South Wales from Alstonville through the Nightcap Mountains, and in Queensland from Lamington National Park north to Maleny and Beerwah. This undescribed species was the second most abundant in our study, and has caused total crop loss in some orchards, particularly in Queensland. (See Figure 2)

The geographic distribution for each of these species is approximate and based on museum collections, as well as specimens collected during this project. Their distributions are likely to be larger than indicated here, especially since lace bugs of unknown species have been collected in other macadamia growing regions that were outside the scope of this project. Collection of additional macadamia lace bug specimens is essential to fill in our knowledge gaps in their distribution.

Based on the physical features of these species, it is likely that the genus *Ulonemia* will be split into three, with only *U. leai* remaining in that genus[2]. The other two groups represent brand new genera, which will herald a name change for *U. decoris*. Unfortunately, due to the vagaries of describing new taxa, I cannot publish the new names here; they have to be published in a scientific journal first! Keep an eye out for these changes.

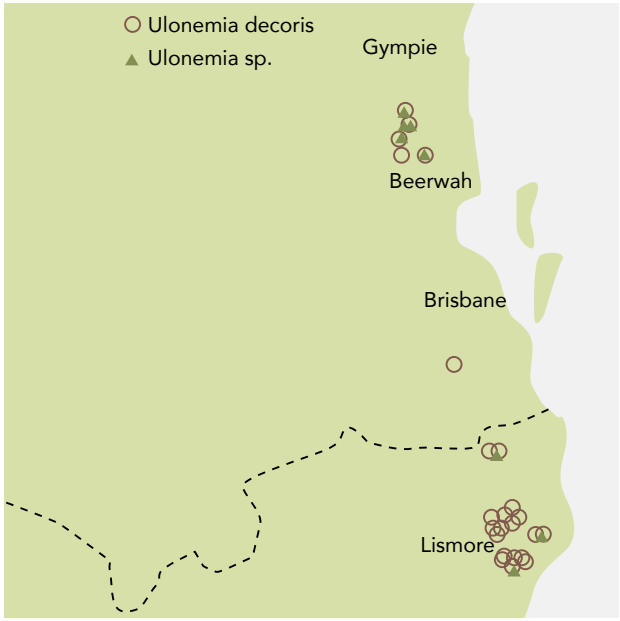

Figure 2. *Recorded distributions of Ulonemia decoris and an undescribed Ulonemia species found in association with macadamias.*

How do they spread so rapidly?

One of the biggest questions about macadamia lace bugs is how they can spread so rapidly. The level of genetic variation between lace bug populations can be used to identify possible source populations, as well as the movement pattern of individuals between populations. We conducted a genetic analysis of

U. decoris populations across seven sites in the Northern Rivers. We concentrated on this species because it was the most numerous and widespread.

We found that *U. decoris* had a remarkably low level of genetic variation, both within and between populations, with pair of populations ranging from 200 m to 29 km apart[2]. There was so little variation that it appeared the *U. decoris* populations were inbred. This did not make sense, as lace bugs number into the millions or billions during an outbreak. Upon closer scrutiny, we discovered several asexually reproducing lineages of *U. decoris* in the Northern Rivers[2]. This is a common evolutionary strategy among pest species, allowing populations to exploit sudden resource availability. This fact, coupled with the low genetic diversity among sexually reproducing individuals, indicates that *U. decoris* can rapidly disperse, with no source population able to be identified.

Preliminary results from an expanded genetic dataset indicate that some lace bug populations in Queensland may have been introduced from New South Wales, though this data has yet to be verified.

Take home messages

- The biggest management implication is that proper **orchard hygiene is critical** in reducing the spread of lace bugs between orchards.
- Lace bugs are **transferred easily between orchards**, most likely on equipment or clothing. Ensure you and your equipment are pest free before moving between orchards to help reduce the impact of outbreaks.
- Pest scouts and orchard managers should also stay alert to the possibility of an additional lace bug species making an appearance. Each species may require different management practices, so proper **species identification is critical**.
- Optimal management of the species will likely require **region-wide coordination**.

Overall, we were able to generate a much more holistic picture of lace bugs in macadamia orchards, and the knowledge we generated can be used to further develop effective control measures.

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Under-tree nets providing soil health benefits

Dr Stuart Irvine-Brown, QDAF
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Macadamia growers James and Aimee Thomas of 'Falkirk Farm' have been using under-tree nets to divert falling nuts into the interrow for 4 years. They have seen increased yields and other orchard floor improvements. Recent agronomic testing by QDAF has shown the nets are indeed improving soil health and nutrient supply.

Last year James and Aimee Thomas of 'Falkirk Farm' worked with researchers from the Queensland Government Department of Agriculture and Fisheries (QDAF) to assess the effects of diversion netting on orchard floor soil health improvements and soil nutrient availability. The work also aimed to determine the economic benefits and water quality catchment management improvements that the nets may provide.

Previous research[2] found that soil loss from macadamia orchards due to stem flow and runoff during intense rainfall events occurred where insufficient ground cover levels left the soil vulnerable to erosion, particularly on sloping ground. Also, it has been found that soils in the root area of macadamia orchards are often lower in

Under-tree netting at Falkirk Farm: the story so far

About 4 years ago James and Aimee Thomas established an innovative under-tree netting system in their orchard in the Gympie area of the Mary River catchment. Their aim was to protect the 'magic metre' around the base of the tree where ground cover is often thinnest and where the critically important fine feeder roots are most dense. The idea was to protect the root zone from damage which happens each year around pre-harvest and harvest times[1].

James and Aimee have seen many positive benefits from the nets, including increased in-shell yields in the netted rows compared to the unnetted rows. There is now no disturbance under the trees, less interrow to prepare and manage prior to harvest, and fewer passes on the harvester and mowers are needed – reducing soil compaction and damage as well as operating costs[1].

Orchard floor management is one of the three pillars of integrated orchard management that growers are familiar with. Research has shown that soil loss and soil health are key management issues for macadamia orchards. Good orchard floor management results in improved soil organic matter and soil stability.



nutrients, microbial biomass and microbial activity than those in nearby comparable soils outside of orchards[3]. Additionally, it appears that the issue of soil depletion in macadamia orchards had been increasing over time[4] but is now under renewed focus with integrated orchard management. Therefore, any mechanism to streamline nut harvesting, improve soil organic matter retention and reduce soil disturbance of tree rows was predicted to be a win-win scenario.

It was expected that the under-tree diversion nets would increase the sustainability of production and enhance soil conservation within the orchard, as well as improving nut harvest efficiency.

Soil testing at 'Falkirk Farm'

The trial soil testing by QDAF was conducted from April to October 2019 within three adjacent rows in a block which were netted. In these rows, two 1.5 m wide nets run down the length of the rows on each side of the trunks, overlapping slightly across the middle of the tree row. The nets are tilted down towards the interrow alley at an angle of around 40° to divert falling nuts into the interrow for harvest. Three control rows on the eastern side of the netted rows were selected for comparison. The macadamia block was on a Ferrosol soil with a very slight slope (<3%) and a mixture of tree cultivars spaced at 9 m x 5m.

To assess the soil health benefits of the nets, a range of different tests were undertaken in the netted and unnetted rows, including: water holding capacity, electrical conductivity, depth of ground cover litter, soil organic matter, total organic carbon, and available soil nutrients.

The trial design (e.g. layout of the netted and unnetted rows tested) was not randomised, so robust statistical analyses were not possible. However, the results showed interesting and substantial differences between the netted and unnetted rows. Future studies using a fully replicated and robust sample are worthy of consideration.



Under-tree nets provide many benefits

Netted rows showed potential benefits and differences compared to unnetted rows, including benefits to the orchard floor, nutrition and yields.

Orchard floor benefits

- Improved drainage with lower water holding capacity (WHC) after saturation from a 12-hour irrigation event. This shows the **soils are more porous** due to more prolific rooting and biological activity.
- Greater water content when measured without saturation indicating the soil has a longer-term water holding capacity, i.e. **improved soil moisture availability.** Note that sampling was conducted throughout a significant drought period (April to October 2019).
- Much **deeper ground cover** litter (65 mm) and **greater soil organic matter** content with 50% increase in total organic carbon (TOC) in the surface soil (i.e. 0–5 cm depth).
- Substantially higher numbers of Ba3 **nematodes** were found under netted rows. These nematodes are a group of disturbance-sensitive nematodes, so their presence indicates a more stable soil system and greater soil food web interactions.
- **Roots growing up into the litter layers** were found consistently under the nets. They were sometimes found at the edge of the net, but never found in the interrow area.
- **Double the weight of roots** around trunks.

Nutritional benefits

- Increased biological capacity for **nutrient cycling** and breakdown of macadamia litter and roots.
- Large differences in functional nutrient cycling and **soil health biology** between netted row and adjacent interrow areas which was not found between conventional row to interrow areas.
- Over a third **greater electrical conductivity** (EC) in surface soil. This is related to the availability of conducting salts produced by decomposing litter and nutrient cycling of organic matter.
- Three times more **crop-available nitrate-N** (NO_3^-) in the upper soil (i.e. 0–10 cm depth), and considerably higher retention of nitrate-N.
- Twice as much available **calcium** (Ca) and three times more **boron** (B) in surface soil.
- 20% lower soil potassium (K) levels than in conventional unnetted rows, although leaf tests were not conducted to compare in-crop K status.

Greater yields

- Greater yields (5–6%) during 2018 and 2019 compared to conventional rows. James and Aimee think that their 2020 yields may show a greater increase even under drought.

Take home message

Findings from this research have shown an under-tree netting system can increase yields and provide nutrition and soil health benefits by reducing soil disturbance and increasing soil organic matter retention.

The results have shown effects above and beyond James and Aimee's initial expectations in what has been a relatively short timeframe for physical, chemical and biological soil changes to have occurred.

Greater depths of leaf litter under nets provide an environment conducive to fine root growth, with litter roots growing upwards to take advantage of nutrients released from organic matter cycling and decomposing leaves.

The relatively high levels of activity of microorganisms can be attributed to higher numbers of soil organisms specialising in life within the macadamia rhizosphere (i.e. the zone of chemical, biological and physical influence generated by root growth and activity). This microbial decomposition and nutrient cycling releases the building blocks of plant tissue into the soil, accounting for the higher levels of total organic carbon, nitrate, calcium, boron and conducting salts seen under the nets.

Additionally, the litter layer, total organic matter, and the presence of shading from nets all enhance the long-term water holding capacity of the soil.

"The past year was one of our worst on record for rainfall and the netted rows are showing improved yield compared to conventional rows. I see this system as something that really reduces our risk to the effects of dry years as opposed to something that increases good yields even higher," said James.

Given there is considerable value in exploring the ongoing benefits of nut diversion netting from various perspectives (including productivity, profitability, soil health and environmental sustainability), this trial will be of continued focus to 'Falkirk Farm' growers James and Aimee and the macadamia industry moving ahead.

An economic / cost-benefit assessment of using under-tree nets is planned and will be reported on in a later edition of the *News Bulletin*.

Acknowledgements

Agronomic research presented here was conducted by Dr Janine Conway and Dr Stuart Irvine-Brown of the Horticulture Systems Agronomy Team, and Dr Tony Pattison and Dr Hazel Gaza of the Soil Health Team from QDAF.

QDAF would like to thank James and Aimee Thomas for their collaboration and their willingness and ability to investigate and assist in presenting the findings of this trial. For more information please contact Stuart Irvine-Brown email: stuart.irvinebrown@daf.qld.gov.au.

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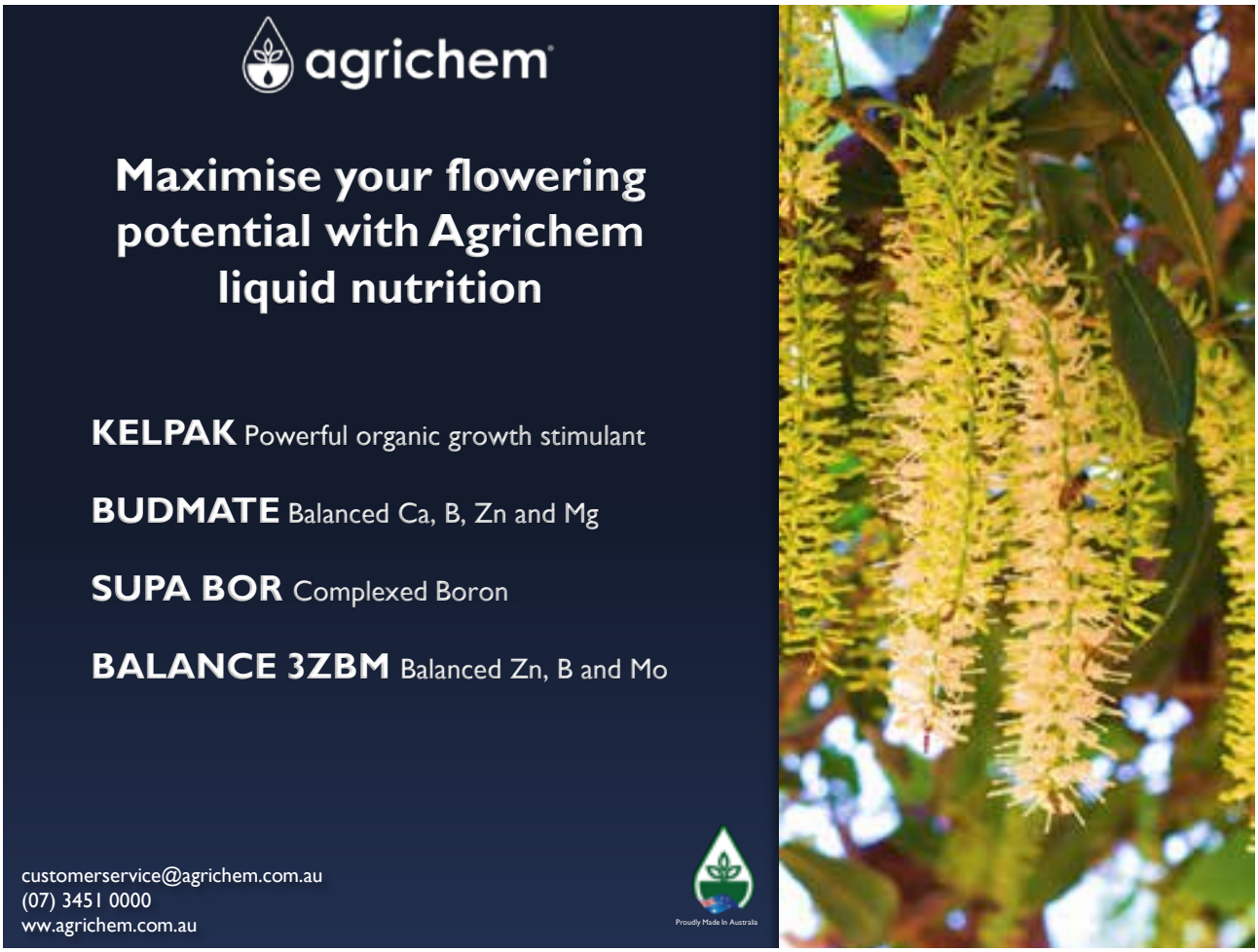

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Demand driven breeding of horticultural tree crops: proof of concept using macadamia

Stephane Kern, University of Queensland, Bruno Santos, Robyn Cave, Bruce Topp and Craig Hardner

Project snapshot

The Hort Innovation project, *National macadamia breeding and evaluation program* (MC19000) continues to progress genetic improvement for the Australian macadamia industry.

Breeding programs for tree crops require considerable resources and future demand is hard to predict due to the long breeding cycles. For macadamia, it is usually 20 years between determining breeding objectives and the ultimate release of the cultivar.

The project, undertaken by University of Queensland, aims to evaluate a new method to prioritise traits for breeding that are based on growers' preferences. This article describes a 'proof of concept' of the method using macadamia.

Tree crop breeding

Tree crop variability due to genetics and environment can influence the profitability of the supply chain and its competitiveness on foreign markets. However, different actors in the supply chain may place different values on different production traits. For example, in relation to macadamias, some growers may favour compact trees that are easier to manage, while other growers may focus more on yield. Processors may also value certain nut characteristics based on consumer preferences or processing costs.

While differences in value along the supply chain should theoretically be captured through pricing, this may not always occur in reality for a range of reasons, including the variability of inputs and commodity price, and the differences in cost structure between farms. Therefore, there is an opportunity to evaluate a methodology which engages industries in the definition of breeding objectives, and so deviating from strict economic approaches to include non-economic factors. Such a methodology would have a component which accounts for farmers' and stakeholders' opinions and preferences while still being driven by the economics of the production system and by market signals.

Methods to elicit farmers' opinions to derive breeding objectives are well established in animal industries which may also require lengthy breeding programs. AbacusBio (https://abacusbio.com/), a science and technology firm based in New Zealand, have developed a conjoint analysis combining bioeconomic modelling and choice analysis for multi-trait selection of livestock and plants. This method is currently being evaluated for macadamia due to the inherent long length of the breeding program for this crop.

Bioeconomic modelling for macadamia traits

A crucial step in a breeding program is to determine which traits should be targeted through selection, and the relative importance of such traits. This is an objective and transparent method to optimise profitability by combining all traits according to their economic value. The economic value is the impact of a unit change in trait on the profit of the production system.

In this project, 10 traits were investigated for this proof of concept model:

- in-shell yield
- kernel recovery
- canopy width
- precocity
- tree size
- percentage whole kernel
- nut size
- insect damage susceptibility
- sticktight susceptibility
- harvest length.

A bioeconomic model of a theoretical 30-hectare macadamia orchard in Queensland Central Coast has been developed using data collected by the Department of Agriculture and Fisheries (Queensland) to link the impact of variation of those traits with the profitability of macadamia production. Trait calculations were based on a bioeconomic model developed by David Bell that extended and modified previous models[1,2,3] and incorporated production data[4].

Choice analysis survey

A group of members of the Australian Macadamia Society were invited to participate on an online survey during July 2020. The survey used a pairwise comparison method using sociodemographic information and the '1000Minds' software to assess farmers' preferences for traits.

Each question presented the respondent with a trade-off between two traits based on the economic values derived through the bioeconomic model. This allowed growers' choice of trait to be made within the scope of orchard profitability.

Respondents also answered a demographic survey about their production system and a ranking of those traits will be derived from the survey results.

Model outputs

Breeding programs for tree crops require considerable resources and future demand is hard to predict due to the long breeding cycles. For macadamia, two decades separate the determination of breeding objectives from cultivar release. Used on a large scale and in the context of an industry consultation, this model will identify future trends. The derivation of clusters based on preference heterogeneity may assist with choice and selection of cultivars for specific types of growers. Understanding the relative importance of these traits to each type of grower would be valuable to inform future research paths in the macadamia breeding program.

Acknowledgements
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We acknowledge the contributions of Abacusbio, the Australian Macadamia Society, Queensland Department of Agriculture and Fisheries, Hidden Valley Plantations, Marquis Macadamias, the Queensland Alliance for Agriculture and Food Innovation and the University of Queensland.

For further information on this research please contact Stephane Kern on s.kern@uq.net.au.

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4. Mulo S 2018, *Benchmarking the macadamia industry 2015–2018,* Hort Innovation project final report, MC15005.




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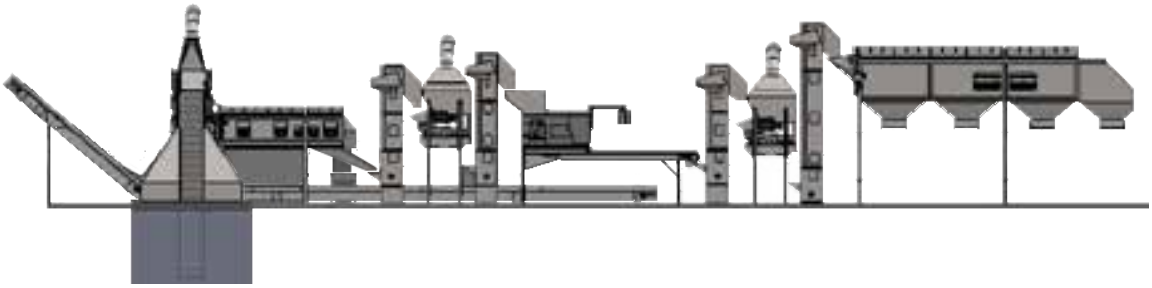



The Aspirator is used to separate out light debris and to grade nuts by weight. It is available in 24", 36" & 48" widths.



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



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



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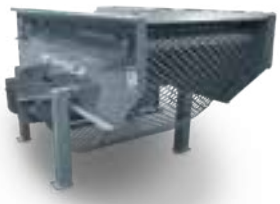
The Pit Elevator is the first stage of many cleaning plants. Savage makes them in several sizes.



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



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



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



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

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

Project no.	Project name	Delivery partner	Expected end date (subject to change)
Macadamia Fund investments: levy projects			
MCI3008	Biology, species and genetic diversity of macadamia lace bugs	University of New South Wales	May 2019
MCI4000	Macadamia second generation breeding and conservation	The University of Queensland	Dec 2019
MCI5004	Australian macadamia industry innovation and adoption program	Australian Macadamia Society	Feb 2021
MCI6000	Innovative rootstocks for the Australian macadamia industry	Qld Department of Agriculture and Fisheries	Dec 2021
MCI6002	Macadamia industry minor use program	Hort Innovation	Ongoing
MCI6004	IPM program for the Australian macadamia industry: NSW DPI	NSW Department of Primary Industries	Oct 2021
MCI6005	IPM program for the Australian macadamia industry: Qld DAF	Qld Department of Agriculture and Fisheries	Sep 2021
MCI6006	IPM program for the Australian macadamia industry: IPM Technologies	IPM Technologies	Oct 2021
MCI6007	IPM program for the Australian macadamia industry: University of Sunshine Coast	University of the Sunshine Coast	Jul 2021
MCI6008	IPM program for the Australian macadamia industry: BioResources	BioResources	Apr 2020
MCI6018	Macadamia integrated disease management	The University of Queensland	May 2022
MCI7001	Developing a macadamia industry tree stock standard	Nursery & Garden Industry Australia	Jun 2019
MCI7005	The effect of macadamia nuts on cardiometabolic risk factors and adiposity: a randomised intervention study	Loma Linda University	Jun 2020
MCI7006	Macadamia regional variety trials series 4	Qld Department of Agriculture and Fisheries	Aug 2026
MCI7007	Generation of pesticide data – *Sigastus weevil* [1]	Peracto	Jul 2019
MCI8000	Australian macadamia communication program	Australian Macadamia Society	Feb 2022
MCI8002	Benchmarking the macadamia industry 2019–2021	Qld Department of Agriculture and Fisheries	Mar 2022
MCI8003	Macadamia crop forecasting 2020–2022	Qld Department of Agriculture and Fisheries	Apr 2022
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
MTI7015	Consumer behavioural and retail data for fresh produce	Nielsen	Mar 2021
STI6006	Generation of residue, efficacy and crop safety data for pesticide applications in horticulture crops 2017	Eurofins Agrisearch	Feb 2020
Macadamia Fund investments: voluntary contribution projects			
MCI3014	Macadamia: propagation and precocity	Plant & Food Research Australia	Nov 2018
MCI5007	Still wild about macadamias: conserving Wa national icon	SEQ Catchments Limited	Apr 2019
MCI5008	Establishing an open-source platform for unravelling the genetics of macadamia: integration of linkage and genome maps	Southern Cross University	Apr 2019

[1] Now called macadamia seed weevil.

Hort Innovation Strategic levy investment | MACADAMIA FUND

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

Australian macadamia minor use and emergency permits

Current at August 2020

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	Maldison: Not required when used as directed
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.

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