SAMAC
Macadamias South Africa NPC

What have we learned

2025

RISK MITIGATION

STINK BUGS

Stink bugs and egg parasitoids in macadamia orchards in South Africa	Twenty stink bugs species were identified in three provinces, with the two-spotted stink bug dominant, but *Boerias* species also prevalent in KZN. A molecular diagnostic test capable of distinguishing between the 20 stink bug species was developed, as well as a photographic database. Stink bugs and especially their nymphal stages can now be identified more accurately and rapidly. Two parasitic wasps of stink bug eggs were identified.	The damage potential of *Boerias* species and the other lesser-known species must be determined. The two stink bug egg parasitoids will be studied further. 
Evaluation of potential entomopatho-genic fungi as biocontrol options against stink bugs	Several different fungal groups (*Aspergillus, Fusarium, Bionectria, Purpureocillium, Chaetonium* and *Scopulariopsis*) known to contain species which act as entomopathogenic fungi were tested against stink bugs. None performed better than a *Beauvaria bassiana* isolate identified in a SAMAC project. The ARC is currently engaging with commercial companies for commercialization of this isolate.	These alternative entomopathogenic fungi will not form part of further studies.
Sampling and evaluation of entomopathogenic fungi for the control of the two-spotted stink bug	The isolate of Beauvaria bassiana isolated from stink bugs performed better than commercially available products. Although chemical insecticides had a quicker knock-down effect, the entomopathogenic fungus was able to achieve the same level of control 12 to 18 days after inoculation.	Future work includes optimizing factors such as UV intensity, registration trials and compatibility tests with registered insecticides for an integrated pest management strategy. 

Alternative hosts and gut symbionts of the two-spotted stink bug	A DNA-based diagnostic tool able to identify the plant material present in the stink bug's gut was developed. These plant species can be used as trap crops, can be removed to prevent them from acting as reservoirs for the introduction of stink bugs into orchards or exploited to increase the attractiveness of pheromone lures. A bacterial species shown to be associated with all developmental stages of the two-spotted stink bug was identified, and removal of this bacteria affected stink bug survival. The removal of the bacterial symbiont required by the two-spotted stink bug for development and survival may be an additional biological control option against the two-spotted stink bug.	Stink bug fly-ins will be evaluated on a large scale to identify the plant species they feed on in the absence of macadamia nuts. The best chemicals and sterilization times for the removal of bacterial symbionts from the egg surfaces will be investigated. The survival of treated eggs and untreated eggs will be compared to identify an additional control option for growers.
Ecology and management of the two-spotted stink bug associated with macadamia orchards in South Africa	The study confirmed that the two-spotted stink bug can disperse over large areas if conditions are suitable, and that area wide management can be considered. The amount of genetic diversity between populations was low, implying that management tools can be applied uniformly across different regions. Acephate was the most lethal to two-spotted stink bug individuals, and a potential loss of sensitivity to pyrethroids was observed. Lambda cyhalothrin accelerated the development of the first generation. Three compounds of the two-spotted stink bug's alarm pheromone were identified to induce an alarm response in the two-spotted stink bug.	More work on the potential loss of sensitivity to pyrethroids and a role for pyrethroids in increased dispersal of the two-spotted stink bug should be done. The role of the alarm pheromone in push and pull strategies with the aggregation pheromone in orchards needs to be investigated further. 
Understanding the thermal biology of the two-spotted stink bug	The effect of temperature on the development, reproduction and survival of the two-spotted stink bug was characterized. The number of temperature units required for each life stage to progress to the next was identified, as well as minimum and maximum temperature thresholds, and sensitivity to extreme temperatures.	Incorporation of prediction models based on degree days into SAMAC Integrator.

The use of semiochemicals (pheromones and kairomones) for management of the two-spotted stink bug

Plant semiochemicals (kairomones) are used by insects to locate their food sources and can be exploited to manipulate pest behaviour. Kairomones combined with pheromones can greatly increase the effectiveness of synthetic pheromone lure traps. The aim of the project was to establish a system that allows for nut volatile sampling to identify plant semiochemicals (kairomones). Few volatiles were obtained from nuts sampled in the field compared to nuts exposed to stink bugs as well as nuts that were mechanically damaged. Various compounds, such as 2-ethylhaxan-1-ol, phenylethyl alcohol, and 2-hexadecanol were isolated from nuts and are known insect attractants. One compound identified, namely isopropyl myristate, is regarded as an insect repellent.

Sampling of nuts exposed to stink bugs and mechanically damaged nuts is recommended for future plant volatile sampling. Future studies should investigate the response of stink bugs towards the compounds tested, starting with Y-tube choice test analysis followed by GC-EAD.

Non-insecticidal pest management options for stink bugs in South Africa's macadamia orchards

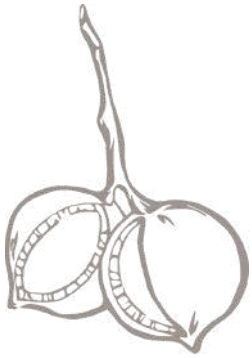
A total of 29 plant species were identified as alternative hosts of the two-spotted stink bug. Surface sterilisation of stinkbug eggs with micronutrient fertilisers reduced the number of bacterial symbionts present significantly. Nymphal survival to adulthood was also reduced significantly after treating egg capsules with micronutrient fertilisers.

The same micronutrient fertilizers will be tested using field friendly methodology. The efficacy of two egg parasitoids as biological control agents will also be investigated.

NUT BORER COMPLEX

The effect of artificial damage to macadamia nuts on the egg-laying preference of nut borers	There was no significant difference in the number of eggs present between nuts which were not damaged artificially, nuts damaged lightly, and nuts damaged heavily. The average number of eggs was the highest on nuts damaged lightly, followed by the undamaged nuts, and lastly nuts damaged heavily. Nuts damaged heavily did not develop any further and either died or were weaned. Heavy damage to nuts may sever the vascular tissue, disrupting the supply of nutrients and water to the husk.	The absence of significant differences in egg-laying suggests that macadamia trees may not produce a chemical cue upon wounding which attracts nut borers, and thus this will not be pursued further.
Nut borers associated with macadamias in South Africa	The macadamia nut borer was the dominant species found in macadamia nuts, but these results did not always correspond to what was found in pheromone traps. Macadamia nut borer populations from different provinces are not separated genetically, thus the specificity of pheromone blends is likely not affected by the presence of genetically diverse populations. A diagnostic tool capable of differentiating between the four species in the nut borer complex was developed, which decreases turnaround times for nut borer identification.	Future research should focus on characterizing the sex pheromone of the macadamia nut borer, and testing different pheromone baited traps. 
Characterisation of chemosensation genes and the sex pheromone in the macadamia nut borer	The whole genome sequence of the macadamia nut borer was determined, which will serve as a resource for future work on the genes involved in pheromone production and detection. Using gland extractions, Z8-12Ac was identified as the major sex pheromone component but minor components were not identified as the macadamia nut borer did not call for mates in captivity.	Work on characterizing the sex pheromone of the macadamia nut borer should continue once a breeding laboratory colony can be established.

Understanding the basic thermal biology of the macadamia nut borer	The effect of temperature on the development, reproduction and survival of the macadamia nut borer (MNB) was characterized. 95% of the MNB larvae died at 45.2 ± 0.2°C. The later larval instars (instar 3 and 4) are most cold and heat tolerant, and they can acclimate to perform better under cold and hot conditions. MNB females do not lay a lot of eggs, the average number of eggs laid over the lifespan was 6-9 eggs/female. With a newly developed rearing technique, 21% of the eggs laid is viable (hatching to result in neonate larvae that bore into the nuts). Eggs are laid up to 12 days after mating, from day 1, peaking at 4.5 days of adult female age. MNB pupae take an average of 11.6 days to complete this life stage, then the adult moths emerge at a ratio of 56% females and 44% males in general. 100% of the MNB pupae emerged as adults in the laboratory, suggesting a very low, if at all, natural mortality rate.	Once a protocol for breeding the macadamia nut borer routinely in the laboratory has been developed, research on aspects such as increasing the specificity of pheromones can be undertaken once again.
Macadamia nut borer and false codling moth pheromone trap specificity	The specificity of pheromone based sticky traps for the macadamia nut borer and false codling moth was evaluated by species identification of different moth species in traps. Most of the moths found on the macadamia nut borer traps were the intended species but the macadamia nut borer and false codling moth can both be found on the same sticky trap. False codling moth sticky traps showed higher proportions of macadamia nut borer and may thus overestimate the amount of false codling moth present in orchards.	Work on characterizing the sex pheromone of the macadamia nut borer should continue once a breeding laboratory colony can be established. 



MACADAMIA FELTED COCCID

Macadamia felted coccid surveillance in Mpumalanga and KwaZulu-Natal	243 farms and 7 953.6 hectares were inspected in the Mpumalanga Lowveld and KZN in 2020/2021. The macadamia felted coccid was present on 23 farms and absent on 220 farms. 19 commercial nurseries and 13 grower nurseries were inspected, and the macadamia felted coccid was not present in any commercial or grower nurseries. The macadamia felted coccid has not spread uncontrollably from sites where SAMAC were aware of infestations in 2020 / 2021.	To date the macadamia felted coccid has spread to most locations in the Mpumalanga Lowveld.

BARK AND AMBROSIA BEETLES

Screening for tolerance against polyphagous shot hole borer-associated *Fusarium euwallaceae* in macadamias	The fungal symbiont spread by the polyphagous shot hole borer, *Fusarium euwallaceae* can cause disease in macadamias. However, the severity of disease is low, and the restricted growth of the fungus in macadamias means that the polyphagous shot hole borer likely only reproduces in macadamias under stress conditions. Heavily invested trees should be cut down and disposed of by burning/solarizing and chipping, while minimising movement of infected plant material in orchards.	Monitoring for the presence of the polyphagous shot hole borer in macadamia orchards is ongoing through the Disease Diagnostic Clinic and Cropwatch Africa. The reproductive status of the polyphagous shot hole borer should be reassessed from time to time as hosts initially not regarded as reproductive have become reproductive hosts in other industries.
Bark and ambrosia beetle survey	7123 (2022) and 8278 (2023) beetles were collected and identified. A wide variety of beetle species were obtained, some of which are not cause of concern (*Hypothenemus* species, *Premnobius cavipennis, Bostrichidae* species), while others will be monitored closely (*Ambrosoidum tachyraphus, Xylosandrus crassiuculus*, polyphagous shot hole borer). *Euplatypus paralellus* was recovered from moribund trees but was not found in any of the traps.	A second survey was conducted early in 2023, and the fungal symbionts of beetle species of concern identified. Research into control options is ongoing at FABI. Removal of infected trees and solarization is currently recommended to limit population numbers in orchards. 
Characterisation of fungal symbionts associated with bark and ambrosia beetles in macadamia orchards in South Africa	Three potential fungal symbionts were identified as *Ambrosiella* sp., *Geosmithia* sp., and *Ceratocystiopsis* sp., isolated from *Xylosandrus crassiusculus, Xyloborus ferrugineus* and *Euplatypus parallelus,* respectively. All three symbionts were able to produce bark lesions on cultivars 695, 816, A4 and Nelmak 2 when artificially inoculated.	Biological control of bark borers through the introduction of entomopathogenic fungi and other biological control agents into tunnels by phoretic mites is being investigated.

DIEBACK

Identification of dieback causal agents on macadamia	*Botryosphaeria* species occur widely as latent pathogens or endophytes in macadamia orchards. Five active ingredients were identified which show promise for dieback control. Nurseries and surrounding vegetation can serve as inoculation sources for dieback.	Future research projects will focus on preventative treatments using the active ingredients that showed promise, as well as biostimulants.
***Botryosphaeriaceae* in the macadamia canopy in South Africa**	Eleven fungal species of three genera, *Diplodia, Lasiodiplodia* and *Neofusicoccum* were obtained from healthy and symptomatic branches, leaves, racemes, and nuts. *Lasiodiplodia pseudotheobromae* was most frequently isolated, *Neofusicoccum luteum* was the most aggressive on stems, *Neofusicoccum parvumwas* most aggressive to leaves and *Lasiodiplodia euphorbicola* was most aggressive to nuts. *Botryosphaeria* fungi were also confirmed as causal agents of brown leaf blight and husk rot in macadamia orchards. Seedlings infected with dieback pathogens remained healthy under no stress scenarios, but disease developed as soon as seedlings were placed under water or drought stress, highlighting the importance of limiting stress in orchards.	Further studies with new generation plant resistance activators are suggested as well as early detection with remote sensing technology. The incidence of this disease in the nursery as well as possible transmission from surrounding host plants is currently underway.

THRIPS

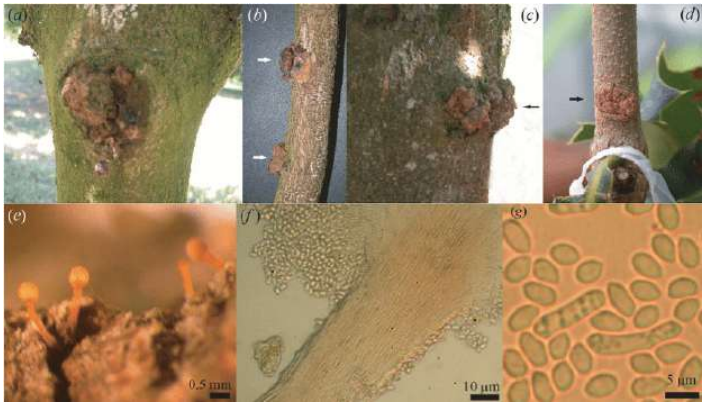
Evaluation of different integrated pest management strategies for the management of thrips in macadamia orchards in South Africa	The results from this work on thrips in the macadamia industry showed that thrips damage and numbers were higher in the drier climate zones compared to the wettest climate zone in this study. Thrips larvae and total thrips counts were important predictors of damage on flush and the numbers should be kept below 25 and 45 respectively to prevent losses higher than 10%. Thrips control, especially in the driest climate zone, was possible by implementing integrated pest management strategies that included predatory mite releases, entomopathogenic nematode releases and a strategic formetanate intervention, statistically reducing flush damage as a result.	The impact of these insects on tree carbohydrate reserves and subsequent yield losses is stilll acking. 
Correlation of sucking insect levels on macadamias to nitrogen and calcium in the macadamia leaf	The objective of this study was to do a preliminary study on the relationship, if any, between sucking insect damage on macadamias to nitrogen, calcium, and possibly other nutrients in the macadamia leaf. Results showed a positive association between orchards with high thrips pressure and high levels of ammonium (+77.08%) as measured in the young leaves.	A formal, longer-term research project was initiated. Higher insect pressure is normally associated with soft green leaves and the integration of this knowledge into a practical IPM program will be an important subsequent step.

WHITE ROOT ROT

White root rot in macadamias	White root rot *(Rosellinia necatrix)* can cause disease in macadamias. Root rot develops 4 weeks after infection, and leaf wilt and dieback by 6 weeks post infection. 	Although white root rot does not seem to be prevalent in macadamia orchards, monitoring is ongoing through the Disease Diagnostic Clinic. All samples tested for Phytophthora root rot also undergo testing for white root rot.

ROOT ROT

Optimising the management of Phytophthora root rot and stem canker on macadamia using phosphonates and seasonal Phytophthora root colonization patterns	Testing of trees for *Phytophthora cinnamomi* infection should be conducted between March and July as *P. cinnamomi* is present at higher levels during this period. When the infections which lead to these higher *P. cinnamomi* levels occur is unclear, but roots should be protected between February and July. Phosphonate treatment efficacy was evaluated in two production regions, and trial data showed that foliar sprays were effective. The effect of soil drenching and bark sprays were inconclusive.	A final effectivity trial, as well as residue and phytotoxicity analysis is required for the registration of a potassium phosphonate product, and SAMAC is engaging with the relevant company in this regard. The baseline sensitivity of *P. cinnamomi* to the alternative actives oxathiapiprolin, fluoxapiproline, fluopicolide, mefenoxam and propamocarb hydrochloride is being investigated in a new project. Orchard efficacy trials will also be conducted to support the registration of the actives.



HUSK ROT

Understanding fungal nut diseases of macadamia in South Africa	There are three causal agents of husk rot in South Africa: *Colletotrichum* species (Anthranose husk rot), *Diaporthe* species (Phomopsis husk rot) and *Calonectria* species (Calonectria husk rot). Phomopsis husk rot and Anthranose husk rot are present as latent infections throughout the year. Anthranose and Phompsis husk rot typically require wounding for infection, while one species of Calonectria did not require wounding for infection. Optimal growth temperatures were determined for all three groups. A4 appeared to be less susceptible to infection compared to 695 and Nelmak 2.	Development of husk rot risk models and field trials of control agents. 
Timing of infection of macadamia fruit by *Phomopsis* species and the role of insect damage and climatic conditions on disease incidence	The link between husk rot and damage was conclusively proved and corresponded with results from Australia. Nuts were susceptible when they were pea sized but also when they reached approximately 20 mm in medial diameter which also correspond with the main oviposition period of nut borers. Disease incidence was correlated with meteorological parameters and various models were presented.	Development of husk rot risk models and field trials of control agents.
Laboratory screening of fungicides against macadamia nut disease causal agents	Pyraclostrobin + boscalid (50/50) and difenoconazole + azoxystrobin (64/100) was effective against *Diaporthe* husk rot and Anthranose husk rot (*Colletotrichum* species). Azoxystrobin + tebuconazole (60/100) was most effective against Calonectria husk rot based on a growth inhibition in the laboratory.	Actives should be screened in the field. New chemistry as well as biological products such as *Trichoderma* species can also be investigated. Resistance should be monitored continuously as quinone outside inhibitors have a significant risk for cross-resistance.

DRY FLOWER DISEASE

Characterisation of macadamia flower blight in South Africa and efforts towards chemical control	The most dominant flower disease in South Africa is dry flower disease, followed by green mould. Optimal climatic conditions for DFD are 25-27°C, 70% RH, VPD > 0.7 kPa. Most of the currently registered products effectively inhibit mycelial growth and/or conidia growth of DFD.	Future research will focus on preventative and curative treatments in field trials using the active ingredients that showed the most promise.
Diversity and pathogenicity of *Neopestalotiopsis* spp. occurring on macadamia leaves in South African orchards	All isolates from leaves were identified as *Neopestalotiopsis* species, grouping into 5 different species clades. Four of the 22 isolates were pathogenic on leaves (caused wounds), but weakly so. The presence of dry flower causal agents on leaf tissue in commercial orchards confirms the theory that yellow halo leaf spot leaves can be a source of inoculum for dry flower disease.	Biological control options for DFD will be the next focus.

VIRUSES

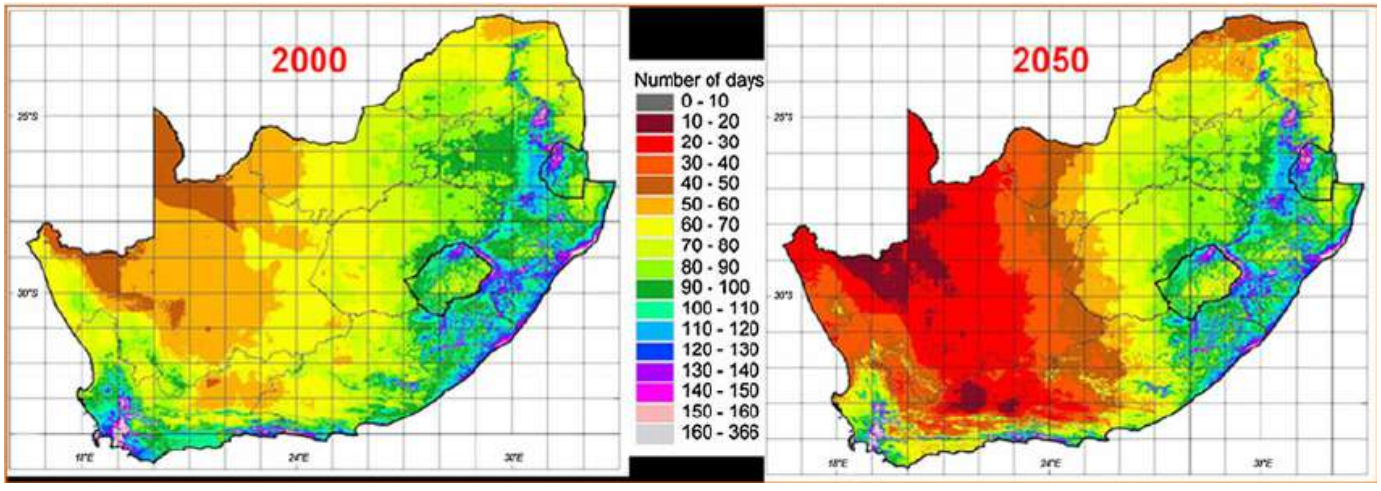
Detection of the causal agent associated with macadamia chlorosis disease	Yellow tree symptoms could not be linked to a virus, bacteria or phytoplasma. A new virus responsible for ringspot symptoms om several cultivars (695, Nelmak 2, 788 and 816) in Mpumalanga, Limpopo and KwaZulu-Natal was identified and provisionally named Macadamia ringspot virus.	The economic value of Macadamia ringspot virus (potential yield losses) is being established, as well as how it spreads within orchards.
Effect of Macadamia ringspot virus (MRSV) on yield	Provisional results indicate that there is no negative impact but it must be emphasised that data that was recorded should be regarded as baseline information and real impacts will only be measured during subsequent years of measurements.	

NURSERIES

Characterisation of nursery diseases	The most common above ground diseases across all surveyed nurseries were leaf diseases including yellow halo leaf spot, Alternaria leaf blight, brown leaf blight and ringspot virus. In addition to leaf diseases, *Phytophthora* was also detected. Finally, stem and graft dieback were also noted in some nurseries, although in very low frequencies.	Next steps should focus on disease - free mother blocks and nursery sanitation management practices.
Nursery based rootstock trials	For the scion and rootstock cultivars tested in this study, rootstock / scion compatibility was not the cause of tree losses, but rather nursery practices such as bag size, planting medium, transplanting practices, budwood preparation and grafting technique.	Best practices, especially for newer cultivars, may need to be investigated. Practices such as the timing between budwood cincturing and cutting, contact between the scion and the rootstock and matching the thickness of scions and rootstocks are important.

CLIMATE CHANGE MODELLING

Determination of climatically suitable growth areas in South Africa for macadamias under present climatic and projected climate change conditions	There are four climate zones in South Africa suited to macadamia production: Am, Aw, Cfa and Cwa. Modelled changes include expansion of areas suited to macadamia production along the coast of the Eastern and Western Cape, an expansion inland in KZN and the Eastern Cape and the replacement of certain zones by others also suited to macadamia production in Mpumalanga, Limpopo and Eswatini.	Predictions will be updated periodically with the latest bias corrected climate models as they become available.
Update to climatically suitable growth areas in South Africa for macadamias under present climatic and projected climate change conditions	The climate change scenarios reflected short term (2050) and long term (2080) predictions under contrasting changes in anthropogenic greenhouse gas concentrations. Overall, the areas potentially suitable for productive macadamia orchards are likely to increase; a shift towards the interior part of the country is also evident in all four climate change scenarios examined. These changes are strongly linked to the increasing temperatures, resulting in decreased frost risk, a key limiting factor for growing macadamia trees.	Models will be revisited when new general circulation models are available.



PRODUCTION

BEES AND POLLINATION

Honeybees, pesticides & pollination	Cross-pollination increases yields by 52% when compared with open pollination. Honeybees remain active on macadamias throughout the flowering period, and although they forage for pollen as well, they are predominately nectar foragers. Colonies can be introduced at the beginning of flowering based on the number of open flowers and can remain in orchards for the duration of flowering. At least two hives per hectare is recommended to maximise cross-pollination, and in single cultivar blocks the introduction of cross-pollinizers through grafting can be considered.	The number of hives required per hectare, best cultivar combinations for cross-pollination and the role of in-hive pollen transfer in cross-pollination. 
Evaluation of floral rewards of different macadamia cultivars and the effect of honeybee pollination on crop yields in these trees	Cross-pollination increases yields by 48.5% and improves nut quality (size and kernel weight). The amount of nectar and nectar sugar concentrations in macadamias are sufficient and inside the preferences of bees.	A pollination standard for hives, hive placement and measuring pollination efficiencies.
Genotyping of macadamia kernel to determine pollen parents	A4 was highly outcrossing (97%), 695 was 64% outcrossed, 816 41% outcrossed and 814 showed 10% outcrossing. The low level of outcrossing in 814 might be the result of trees located at one end of an orchard, with bushland on one side and 695 on the other, and a lack of synchronous flowering between 814 and 695. The effects on nut quality are being finalised.	

How many bee colonies do I need?	Results demonstrated the critical role of honeybee colonies in macadamia orchards, with the absence of bees resulting in only 30% production in both cultivars. The study was hampered by the fact that large colonies decreased the number of foragers they sent out in response to the number of trees present in the netted cages. Large colonies, despite adjustments in foraging levels, increased production in the A16 cultivar compared to the open orchard. The size of honeybee colonies showed a correlation with overall nut production, particularly in the A16 cultivar.	These findings emphasize the need for greater understanding of honeybee stocking rates and their direct impact on pollination and nut production in macadamia orchards.
To Bee or not to Bee' – An analysis of pollen transfer efficiency, floral rewards and self-incompatibility in South African macadamias	This study confirmed that Beaumont macadamia trees are self-incompatible and require cross-pollination to produce nuts, although the exact mechanism of self-incompatibility remains unclear. Cultivars such as 695, 788, and A4 were identified as having superior floral rewards and accessibility, making them more attractive to pollinators. Additionally, managed bee hives significantly improved pollen transfer between flowers, highlighting their potential to enhance yields compared to relying solely on wild pollinators.	These findings suggest that mixed plantings and managed pollination strategies are vital for optimizing macadamia production.
Cross-pollination in macadamia cultivars	Cross-pollination is critical for maximizing macadamia yields and improving nut quality, significantly outperforming self-pollination and open pollination in most cultivars. The study highlights a substantial pollination deficit caused by limited insect activity and insufficient cross-pollen, emphasizing the need for better orchard designs and pollinator support. Effective hand-pollination methods demonstrated the potential for yield improvements, underscoring their value in research.	Further research is recommended to more thoroughly determine the cross-pollination requirements of macadamia cultivars presently being used in South Africa and the pollen donor suitability of these cultivars.

MACADAMIA WATER USAGE

Macadamia water usage	An average of 510 L of water is required to produce a kilogram of macadamias. The water use efficiency of macadamias is relatively low as they accumulate oils and not sugar and have a low water content compared to fleshy fruits. In contrast, the water use productivity is high due to the high prices of macadamias. Macadamias are conservative water users and can switch off transpiration under conditions where water loss through transpiration exceeds water supply from the roots. Evaporation can be high in macadamias, and this needs to be considered during irrigation scheduling. Macadamias appear to be less sensitive to water stress in comparison to other horticultural crops when considering yield but water stress during flowering and nut set can affect quality.	Evaluating the most efficient way to water trees (for example drip vs microjet) and differences between cultivars in terms of water use.

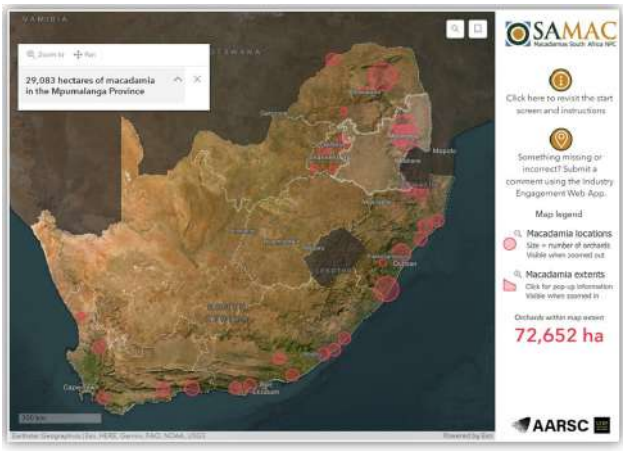
NUTRITION & PHENOLOGY

A comparison of the nutritional status of chlorotic versus healthy trees	Yellowing in macadamia trees is a complex issue with many potential factors. The study identified that soil and leaf nutrients alone aren't the main cause, and other factors need to be considered to understand why some trees turn yellow. Macadamia trees can be sensitive to high levels of phosphorus (P), and P-toxicity can present as leaf chlorosis. Other factors such as variation of overall soil nutrient levels or the interactions between nutrients could essentially be at play.	Investigation into other factors such as soil-borne pathogens, nematodes (root damage), or nursery practices (graft incompatibility) should be considered and ruled out as causes of tree yellowing. Further research is needed to draw clearer conclusions.
Response of macadamia nut yield, quality, and soil health parameters to the application of different rates of macadamia husk compost in the subtropical climatic zone of Vhembe District, South Africa	The husk compost improved the soil's physical, chemical, and biological properties. It increased soil organic matter, carbon content, and nutrient levels, making the soil more fertile and suitable for growing healthy macadamia trees. Applying husk compost helped reduce the occurrence of early nut germination and damage from insects. This resulted in fewer losses and higher nut yield. The application of husk compost further helped the soil retain more water, reducing the need for irrigation and potentially saving water resources. Macadamia trees treated with husk compost showed better growth, with more new leaf flushes and water shoots, indicating healthier and more vigorous trees.	The use of compost is a sustainable practice as it improves soil health, reduces chemical fertilizer dependency, and helps in water conservation. Future work can focus on a gradual transition to more sustainable practices 
Correlation of sucking insect levels on macadamias to nitrogen and calcium in the macadamia leaf	This preliminary study aimed at investigating the relationship between sucking insect damage and key nutrients in the leaves found a positive correlation between thrips damage and elevated levels of ammonium (+77.08%) in young leaves, while a notable negative association was observed with various minerals, with calcium showing a significant decrease (-45%). The strongest negative associations were identified with manganese (-96.01%), copper (-70.07%), cobalt (-66.15%), and molybdenum (-56.52%). This implies that nutrient concentration in young leaves may influence thrips occurrence. The study, while based solely on young leaf sap analysis, lays the groundwork for more comprehensive investigations.	A longer-term study was initiated and includes soil and old leaf analyses and investigating nutrient imbalances from diverse sources.

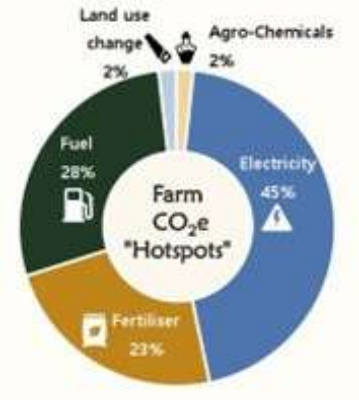
A comparison of crop removal figures for different cultivars in the South African and Australian macadamia industries	Nutrient removal in macadamia orchards varies significantly between cultivars and production regions. In South Africa, the amount of nutrients removed by husks, shells, and kernels differs between Mpumalanga and KwaZulu-Natal, with Mpumalanga generally removing more nutrients through husks. The comparison with Australian data highlighted further regional and varietal differences, emphasizing the complexity of fertiliser management.	Understanding crop nutrient removal specific to cultivars and regions is important. This will enable more accurate fertiliser recommendations, better resource management, and improved sustainability in macadamia orchards. This will be repeated to validate the results and update the phenology calendar.
Determining the seasonal root growth pattern and carbohydrate allocation in macadamia trees	Deeper root zones (30–45 cm) are vital in macadamia trees for root development, urging growers to take these layers into account with regard to orchard management practices. Vegetative growth peaks and flowering periods for specific cultivars, such as 816 and Nelmak 2 or 695 and A4, align well, presenting opportunities for co-planting to improve synchronization of orchard activities like pruning, spraying, and harvesting. Cultivars 695 and A4 also showed evidence of a chill requirement, suggesting they are better suited for colder areas or south-facing slopes in the Southern Hemisphere.	Update SAMAC's phenological calendar with these findings to guide the industry toward improved management practices.

INDUSTRY RESOURCES

National mapping of commercial macadamia orchards in South Africa	The location and extent (hectares) of macadamia orchards in South Africa were mapped and is available on an online dashboard. By January 2025, 80 090 hectares of macadamias were mapped in South Africa.	The map will need to be updated continuously by growers.
Site classification for macadamia orchards in South Africa	Sites suitable for macadamia production in South Africa were predicted based on combinations of parameters such as mean annual temperature, frost, seasonal heat units, altitude, relative humidity etc. 1.2 % of the total surface area of South Africa was classified as optimal, while 7% was classified as sub-optimal. These geospatial layers will be available in an interactive industry dashboard through the project "Industry information to unlock the potential of future orchards".	Future work entails integrating the geospatial layers into the industry dashboard (SAMAC Integrator), as well as making necessary updates if parameters/assumptions change with new information.
Proposed methodology for the evaluation of spray deposition parameters quantity, quality and uniformity as influenced by spray application practices in macadamia nut trees	The results underscore the importance of tailoring spray application practices to specific orchard conditions. Pruning actions positively influenced deposition parameters, emphasizing the need for orchard management strategies. High variation in deposition uniformity highlights the complexity of spraying within macadamia canopies. The van Schalkwyk, Levings, and Ras model proved effective for determining optimal spray volume, providing a valuable tool for effective application in macadamia orchards, particularly when utilizing high-profile air-assisted sprayers.	Develop and implement comprehensive orchard management strategies that incorporate effective pruning techniques to enhance spray application outcomes.



SUSTAINABILITY

Carbon footprint benchmark	The 2024 carbon footprint benchmark included 15 909ha in Mpumalanga, Limpopo and KZN South. The average carbon footprint for macadamia farms is 1.91kg CO2e/kg wet nut-in-shell. Grid electricity (for pumping of water), direct fuel (diesel used in tractors) and fertiliser (synthetic nitrogen fertiliser) contribute most to a macadamia farm's carbon footprint. In 2023 this project was rolled out to processors and the average carbon footprint for macadamia processors was 0.22 kg CO2e/kg wet nut-in-shell. Grid electricity, fuel and packaging contribute most to a macadamia farm's carbon footprint.	The carbon footprint will be conducted annually. 

ORCHARDS OF THE FUTURE

Mechanical harvesting of macadamia nuts	A hybrid harvesting system can enhance efficiency, consistency, and reliability in the harvesting process, while also acknowledging socio-economic considerations. The strategic use of mechanical harvesters in orchard inter-rows, with a specific focus on safeguarding the root zone, presents a viable solution. This approach allows for most of the crop to be picked up mechanically, with additional labourers employed under the tree canopy and in challenging areas during adverse weather conditions or on steep slopes.	Upskilling labourers to efficiently operate within this system, without causing damage to the orchard floor or the machinery. Additionally, continuous research and development efforts by service providers should focus on improving the design and functionality of mechanical harvesters, considering the unique topography and conditions of South African orchards.
Industry information to unlock the potential of future orchards	SAMAC Integrator, an integrated industry information database and interactive platform was developed.	New modules will be rolled out in SAMAC Integrator in 2025.

POST-HARVEST

HEALTH RESEARCH

Macadamia nut oil supplementation	Macadamia nut oil supplementation significantly lowered lipase and CRP levels, which contributes to pancreatic health and reducing inflammation in the body, which has a cardioprotective effect. Macadamia nut oil supplementation showed more beneficial effects for human health when compared with coconut and olive oil.	
Macadamia nut effects on adiposity and cardiovascular risk factors	Consumption of macadamia nuts does not lead to changes in waist circumference, body mass or percentage body fat.	

LOSS FACTORS

Addressing the issue of shell skin marks (skin adherence) on macadamia kernel	Shell skin marks or skin adherence develop when the kernel comes into contact with the shell, with the brown shell membrane subsequently sticking to the kernel. This is associated with a loss in premium grade kernel, and is more prevalent in hybrid cultivars such as Beaumont, Nelmak 2 and A4. The effect of nutrient deficiencies, nut development and immaturity on the development and incidence was investigated. Potassium was consistently higher in leaf and shells of unaffected orchards, and potassium supplementation should be considered in future.	Other avenues for future work include improved calcium application, cation ratios and addressing the immaturity parameter through oil analysis of affected and non-affected nuts throughout the season.