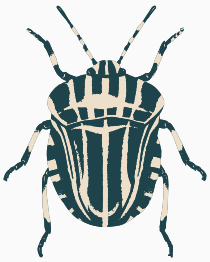
SAMAC
Macadamias South Africa NPC

Active Projects

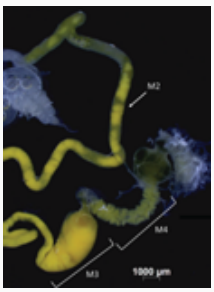
2024

Risk Mitigation

STINK BUGS



Analysis of the two-spotted stink bug's gut content



Stink bugs are currently the greatest threat to South Africa's macadamia industry. As stink bug numbers are primarily controlled using insecticides there is a growing need for the development of alternative control methods. The first objective of this study will be to identify the plant DNA found in the gut. Alternative plant hosts identified in this manner can be used as trap crops and will provide further understanding of alternative breeding hosts. These plants can also potentially be exploited to increase the attractiveness of lures for macadamia pests. The second objective is focussed on evaluating the efficacy of micronutrient fertilizers to remove the bacterial symbionts of stink bugs. Bacterial symbionts are essential for development and survival of the insect. Micronutrient fertilizers can potentially be used to successfully surface sterilize stink bug egg capsules and disrupting the life cycle of stink bugs.

The evaluation of essential oils for controlling stink bugs

The two-spotted stink bug (Bathycoelia distincta) is considered the most dominant and damaging pest in the South African macadamia orchards. The adults are responsible for causing severe yield losses of up to R200 million annually. Stink bugs have been primarily controlled using synthetic pesticides and the need for alternative control methods necessitates this study. Recent research has shown plant essential oils to have satisfactory antimicrobial and pesticidal effects. The aim of this study is to evaluate the pesticidal activity of essential oils from Artemisia afra (African wormwood), Lippia javanica (Fever tea), Eucalyptus smithii (Gully gum), Tagetes minuta (khaki bush) and neem oil (Azadirachta indica) on the two-spotted stink bug. The results of this project will provide knowledge about the potential use of the selected essential oils to improve the pest management program against an important pest species in the South African macadamia orchards.

NUT BORER COMPLEX

Establishing a laboratory-maintained colony of the macadamia nut borer

Moths pose significant economic threats to global food crops. Among them, the macadamia nut borer (MNB), *Thaumatotibia batrachopa* (Meyrick) (Lepidoptera: Tortricidae), has emerged as a prominent menace to macadamias. This research initiative aims to establish a laboratory-reared colony of the MNB, a crucial step in advancing integrated pest management (IPM) strategies for combating this pest. The project's objectives include formulating and disseminating a specialized diet for the MNB, accompanied by a comprehensive procedure for successful captive rearing. The work further encompasses a meticulous scientific investigation into the pest's performance, contributing valuable insights to the development of effective pest control measures. By addressing the complexities of MNB management through scientific inquiry, this project aims to enhance our understanding and mitigation capabilities in safeguarding susceptible food crops.

MACADAMIA FELTED COCCID

Biological control, development time and reproductive rate of the invasive macadamia felted coccid

The macadamia felted coccid (MFC) was first reported in South Africa on macadamia in 2017. This scale insect feeds on the branches, leaves, and nuts and has significant effects on yield and tree health. Insecticidal oils and insect growth regulators may provide some control, however an integrated pest management programme (IPM) that includes biological control needs to be developed. A survey to identify native predators and parasitoids will therefore be conducted and potential candidates will be tested to evaluate their potential use. During these surveys, MFC will also be collected and will be used to study the genetic diversity of these scales on different farms. Since information regarding the life cycle of MFC is currently limited, development time from egg to adult, sex ratio and adult longevity at different temperatures will also be investigated. This can be used to determine the number of generations MFC can undergo per season which will help to develop an IPM framework.

Importation and host-range testing of the parasitoid wasp, *Metaphycus macadamiae* for the biological control of the macadamia felted coccid on macadamia in South Africa

As the macadamia felted coccid (MFC) is of little consequence to macadamia growers in Australia, biological control using specialist host-specific natural enemies imported from there holds much promise for a long-term management solution for MFC in South Africa. Research under the current project seeks to import the parasitoid wasp, *Metaphycus macadamiae*, to conduct its host-range testing using indigenous South African scale insects, with the goal of releasing it as a biocontrol agent against MFC. A successful biological control programme using host-specific natural enemies like *M. macadamiae* will reduce dependence on insecticides, making a valuable contribution to the sustainability of pest management in macadamia in South Africa.

Laboratory screening of entomopathogenic fungal isolates for virulence against the macadamia felted coccid

The macadamia felted coccid was introduced into South Africa during 2017 and has since spread throughout most of the Mpumalanga Lowveld, as well as to a location on the north coast of KwaZulu-Natal. During 2021, the macadamia felted coccid colony at the ARC died because of the possible introduction of an entomopathogenic fungus with macadamia cuttings. In field trials, commercially available entomopathogenic fungi have also performed well. This project is focussed on identifying the possible entomopathogenic fungus associated with the macadamia felted coccid in Mpumalanga, as well as screening known entomopathogenic fungi from the ARC Culture Collection against the macadamia felted coccid.

Laboratory screening of insecticides for control of the macadamia felted coccid

In 2017, *Eriococcus ironsidei* (Macadamia Felted Coccid - MFC) was reported in South Africa on macadamia for the first time. The pest is regarded as a significant threat to the macadamia industry and an integrated pest management (IPM) programme, that include the use of insecticides, should be developed. To obtain knowledge regarding the toxicity of insecticides, *in vitro* (laboratory) screening will be conducted which will also serve as a baseline study to monitor insecticide resistance development over time. To determine if this sap-sucking insect obtains nutrients from phloem or xylem tissue, the feeding behavior of MFC will be studied by means of scanning electron microscopy. The latter will determine if systemic insecticides can be used for control since they are usually translocated through the plants vascular system via xylem tissue.

Macadamia felted coccid surveillance

Macadamia felted coccid surveillance of nurseries and their corresponding mother blocks was introduced into the audit standard for macadamias by the Seedlings Growers Association of South Africa (SGASA) in 2022. In this project, SAMAC supports SGASA-accredited nurseries through coordination of these inspections through Cropwatch Africa.

THRIPS

Diversity, agroecology, and management of thrips in the Levubu region of Limpopo province, South Africa

Thrips are tiny insects that can lead to losses in the production and value of avocados and macadamias, reducing the capacity to generate wealth and support the communities where these crops are grown. Accurate identification of thrips is a necessary step for establishing the species that may damage avocados and macadamias. Also needed is knowledge of where, when, and why thrips are present. This project is identifying drivers of thrips damage and ways in which it can be prevented in the Levubu region of Limpopo province, South Africa. By doing so, the researchers will provide advice on the avocado and macadamia varieties and stages of development susceptible to thrips damage, and whether fertilizer application regimes can improve levels of resistance. Maps of thrips 'hotspots' in the Levubu region will be generated, and conditions that promote high thrips abundance will be identified, which can be used to target areas needing control interventions. This project is co-funded with the South African Avocado Growers Association.

BARK BORERS

Fungal symbionts of bark borers

Bark and ambrosia beetles are wood boring insects. They typically cause minimal economic damage in their native range since most species live in dead or dying trees, or their numbers are controlled by natural enemies. Numerous outbreaks of these insects and their fungal mutualists have however been reported in recent years. This is also true for macadamia in South Africa where high numbers of *Xylosandrus crassiusculus, Premnobius cavipennis* and *Ambrosoidum tachyraphus species* were recorded in baited traps placed in orchards. Fungal symbionts of bark and ambrosia beetles mostly belong to the orders: *Ophiostomatales, Microscales and Hypocreales.* The most common pathogenic genera within these orders include *Raffaelea, Ambrosiella* and *Fusarium*. Currently, information regarding the fungal symbionts of the beetles recorded in high number in macadamia orchards are not known. A research project to identify the fungi and to determine their impact towards macadamia is therefore needed.

Exploratory research into the biological control of polyphagous shot-hole borer, using phoretic mites and entomopathogenic fungi

The polyphagous shot-hole borer is a beetle that attacks living trees (including macadamia, pecans and deciduous fruit), establishing a symbiotic plant pathogenic fungus (Fusarium) in the wood. The beetle and *Fusarium* can kill branches and even entire trees. Bark beetles are often associated with mites, which use the beetle to hitch a ride to new habitats and are frequently found in the beetle galleries. These mites can potentially be used to vector biological control agents of the beetle and *Fusarium* into beetle galleries, where they are difficult to reach using conventional methods. This project, in collaboration with the pecan (SAPPA) and deciduous fruit (Hortgro Science) industries will collect and identify mites associated with polyphagous shot-hole borer, investigate the use of biological control agents against the beetle and Fusarium, and establish whether the mites can potentially be used to vector these biocontrol agents into the beetle galleries.

Pathogenicity of fungal symbionts associated with ambrosia beetles

Bark and ambrosia beetles typically cause minimal economic damage in their native range since most species live in either dead or dying trees, or their numbers are controlled by natural enemies. Numerous new outbreaks of these insects and their fungal mutualists have however been reported from forest ecosystems as well as agricultural environments. A recent beetle survey identified several bark and ambrosia species present in high numbers in commercial macadamia orchards and this is of growing concern. Knowledge regarding their fungal symbionts is however limited. These symbionts should be studied since some of these fungi may also act as plant pathogens. To identify fungal symbionts, direct isolations from live beetles and beetle galleries will therefore be conducted. Thereafter their potential role in causing disease in macadamia will be investigated by means of pathogenicity trials on different macadamia cultivars.

Exploratory research into the biological control of polyphagous shot-hole borer, using phoretic mites and entomopathogenic fungi

The polyphagous shot-hole borer is a beetle that attacks living trees (including macadamia, pecans and deciduous fruit), establishing a symbiotic plant pathogenic fungus (Fusarium) in the wood. The beetle and Fusarium can kill branches and even entire trees. Bark beetles are often associated with mites, which use the beetle to hitch a ride to new habitats and are frequently found in the beetle galleries. These mites can potentially be used to vector biological control agents of the beetle and Fusarium into beetle galleries, where they are difficult to reach using conventional methods. This project, in collaboration with the pecan (SAPPA) and deciduous fruit (Hortgro Science) industries will collect and identify mites associated with polyphagous shot-hole borer, investigate the use of biological control agents against the beetle and Fusarium, and establish whether the mites can potentially be used to vector these biocontrol agents into the beetle galleries.

FLOWER BLIGHTS

Molecular diagnostic tools to detect the causative agents of macadamia dry flower disease in South Africa

Dry flower disease of macadamia is of growing concern in South Africa and there is a lack of molecular diagnostic tools for the streamlined identification of the dry flower pathogens. In this project, genetic tools will be used to determine the presence of dry flower causative agents on macadamia leaves and flowers at different flowering stages. Genomes of fungal species associated with dry flower disease will be used to develop a rapid diagnostic tool which can be performed with ease and without the need for expensive, advanced equipment or experts. The diagnostic tool can be combined with on-site DNA extraction methods, allowing for detection of dry flower pathogens directly in the field. The flowering periods of different cultivars and the conducive climatic conditions associated with dry flower disease will also be determined in field. This knowledge will contribute towards informed disease management practices and the timing of fungicide applications.

Flower blight causal agent identification and laboratory fungicide screening

Flower blight is a fungal disease affecting macadamia flowers. *Neopestalotiopsis* and *Pestalotiopsis* cause a disease known as dry flower disease, *Cladosporium cladosporioides* causes green mould of flowers and grey mould is caused by *Botrytis cinerea*. Little is currently known regarding the prevalence and impact of the different flower blight pathogens in South Africa. This research is therefore centred around identifying fungi obtained from diseased flowers. During surveys weather data was documented. Once we know which fungi are present and have confirmed that they are flower blight causal agents, laboratory assays with fungicides to test their efficacy against the pathogens will be performed. Correlation of weather data with the presence of specific pathogens in field and knowledge regarding fungicide efficacy will provide the industry with advice pertaining to fungicide application time windows. Maximising effectivity of fungicide application will reduce the number of sprays, allowing for greater cost efficiency.

The epidemiology of dry flower disease on macadamia in South Africa

Dry flower disease potentially poses a threat to macadamia production in South Africa. Economic losses due to the disease have not been documented in South Africa. No studies have been conducted to show which flower development stages are susceptible and it is unclear how prevailing weather conditions in the field affect infection and subsequent disease development. Understanding the epidemiology of the pathogens is important for the development and implementation of effective disease control strategies. The overall aim of this study is to investigate the epidemiology of *Neopestalotiopsis* and *Pestalotiopsis* spp causing dry flower disease in South Africa. The specific objectives are (1) to determine the effect of temperature on colony growth of the dry flower disease pathogens in the laboratory, (2) to determine the time of infection of macadamia flowers by Neopestalotiopsis and Pestalotiopsis spp. and (3) to evaluate the impact of climatic conditions on the relative abundance of conidia (spores) under field conditions.

Macadamia leaves as a source of inoculum for dry flower disease

A recent study from Australia suggested that the causal agent of yellow halo leaf spot can also infect flowers and cause dry flower disease. Leaf disease should therefore be managed in orchards with a history of dry flower disease to reduce the risk of dry flower disease occurring in the next season. In terms of South Africa, very little is known regarding leaf diseases. In fact, leaf diseases are often not present in well managed orchards. It is also not known which *Neopestalotiopsis* species commonly occur on infected leaves and if any of these are known dry flower pathogens. It is therefore not known if leaves can act as an alternative plant tissue where dry flower causal agents can grow on and then serve as a source of inoculum of the next season. This should however be investigated and is the overall aim of the current study.

DIEBACK

Identification of the causal agent of macadamia dieback in South Africa

Macadamia trees are potentially at risk of being infected by many diseases due to ongoing climate change, particularly those caused by latent pathogens. *Botryosphaeriaceae* species are among the most important latent pathogens, with a widespread distribution across many climatic zones and regions. Recently there have been many reports of dieback on macadamia trees in KwaZulu-Natal and Mpumalanga. This project will examine the affected orchards, attempting to understand and evaluate the disease caused by *Botryosphaeriaceae* on macadamia in South Africa. Objectives of this project are to: (1) determine the cause of dieback, (2) examine the virulence of all the *Botryosphaeriaceae* species found, (3) evaluate the tolerance and susceptibility of different macadamia varieties against the most virulent species of *Botryosphaeriaceae;* (4) evaluate fungicides against the fungal species; and (5) track the method by which *Botryosphaeriaceae* was introduced into the orchards. Rootstocks in the nursery, mature asymptomatic trees the orchards, as well as the common woody plants growing in close proximity to the orchards will be investigated.

ROOT ROT

Managing oomycete pathogens in macadamia nurseries

Several oomycete species *(Phytophthora cinnamomi, Phytophthora parvispora, Pythium ultimum and Phytopythium vexans)* were recently identified in a SAMAC project as being pathogenic toward macadamia. It is thus important that these pathogens should be absent from macadamia nursery trees to ensure the establishment of healthy orchards. The project aims to improve the laboratory methods used for detecting oomycete pathogens in nurseries and to investigate whether biocontrol agents are effective at excluding the pathogens from nursery tree roots when applied in nurseries. A better understanding of how biocontrol agents function in suppressing oomycete pathogens on macadamia will also be obtained. The project will improve the quality of macadamia nursery trees by reducing the probability of introducing oomycete pathogens with nursery trees into orchards, which can result in a decrease in the profitability of orchards.

Characterization of oomycete species associated with macadamia trees

Oomycete species from the genus *Phytophthora* are known to be harmful to macadamia. In 2007, a survey of oomycetes associated with macadamia nursery trees in South Africa indicated that species within the genus *Phytopythium* may also be damaging to macadamia. The first aim of the study is to conduct a survey of oomycete species associated with macadamia tree roots in nurseries, young orchards, and older orchards. The identified species will be evaluated for their ability to cause root rot and stem cankers on Beaumont seedlings. Species that are identified as causing root rot and/or stem canker on macadamia will be used to determine whether rootstocks (Beaumont, H2, A16 and *Nelmak2*) differ in susceptibility to the pathogens. Knowledge generated in this project will allow us to determine which oomycete species must be regulated in nurseries and which rootstocks are best utilised in regions where oomycete species are known to be problematic.

Establishing baseline sensitivities for new actives against *Phytophthora cinnamomi* and *Phytopythium vexans* on macadamia

Root rot and stem cankers caused by *Phytophthora cinnamomi* and *Phytopythium vexans* cause economic losses in macadamia. Although phosphonate registration trials are in progress, the registration of more fungicide actives are required. Based on the results from other tree fruit crops, actives with good efficacy against *Phytophthora* include oxathiapiprolin, fluoxapiproline, fluopicolide and propamocarb hydrochloride. Orchard efficacy trials are being established on macadamia for some of the actives, whereas for others, trials are in the pipeline. The aims of the project are to establish fungicide sensitivity testing protocols for the four actives as well as baseline sensitivities. This is important since most of the actives have a single site mode of action and are thus prone to resistance development. Mefenoxam sensitivity testing will also be conducted since some of the actives will be co-formulated with mefenoxam, and mefenoxam has long been used in macadamia nurseries to combat oomycete diseases.

HUSK ROT

Laboratory fungicide screening of husk rot causal agents and development of tools to detect and quantify causal agents in the field

Husk rot is a fungal disease of the pericarp that results in premature nut drop and may cause internal discoloration. Husk rot has been classified into three different types: Phomopsis husk rot caused by *Diaporthe* spp., Anthracnose husk rot caused by *Colletotrichum* spp. and Calonectria husk rot caused by *Calonectria* spp. Management of husk rot typically involve the application of fungicides, however, only two products are currently registered for use. Laboratory testing of various fungicides and other biological control products will therefore be conducted. In addition to knowledge regarding the effectiveness of fungicides, knowledge regarding appropriate timing of fungicide application is also important. A rapid diagnostic (real-time molecular marker) will therefore be developed to study the presence and/or movement of these causal agents throughout the growing season.

VIRUSES

Investigating the association of a phytoplasma or virus with witches' broom disease in the Mpumalanga Lowveld

Malformed shoots growing in clusters giving infected branches a witches' broom appearance were noticed around the Mpumalanga Lowveld during 2021/2022. Additionally, the leaves which formed from these shoots were elongated and rugose. Witches' broom disease (WBD) can be caused by several organisms including phytoplasmas and viruses. Phytoplasmas have previously been reported from macadamia in Cuba and China causing WBD. Different viruses found in association with WBD have been described from the USA and Vietnam. As the malformed shoots do not form flowers, WBD is of concern due to yield losses. The current study will investigate whether a phytoplasma or virus can be identified from malformed shoots. If either a virus or phytoplasma is found, a diagnostic assay will be developed for the identification of the causal organism and subsequent studies can be conducted to aid in the control of this disease. However, should a virus or phytoplasma not be identified, the study is still of significance, as it is important to rule out as many factors as possible that may be associated with witches' broom symptom of macadamia in South Africa.

NURSERIES

Managing oomycete pathogens in macadamia nurseries

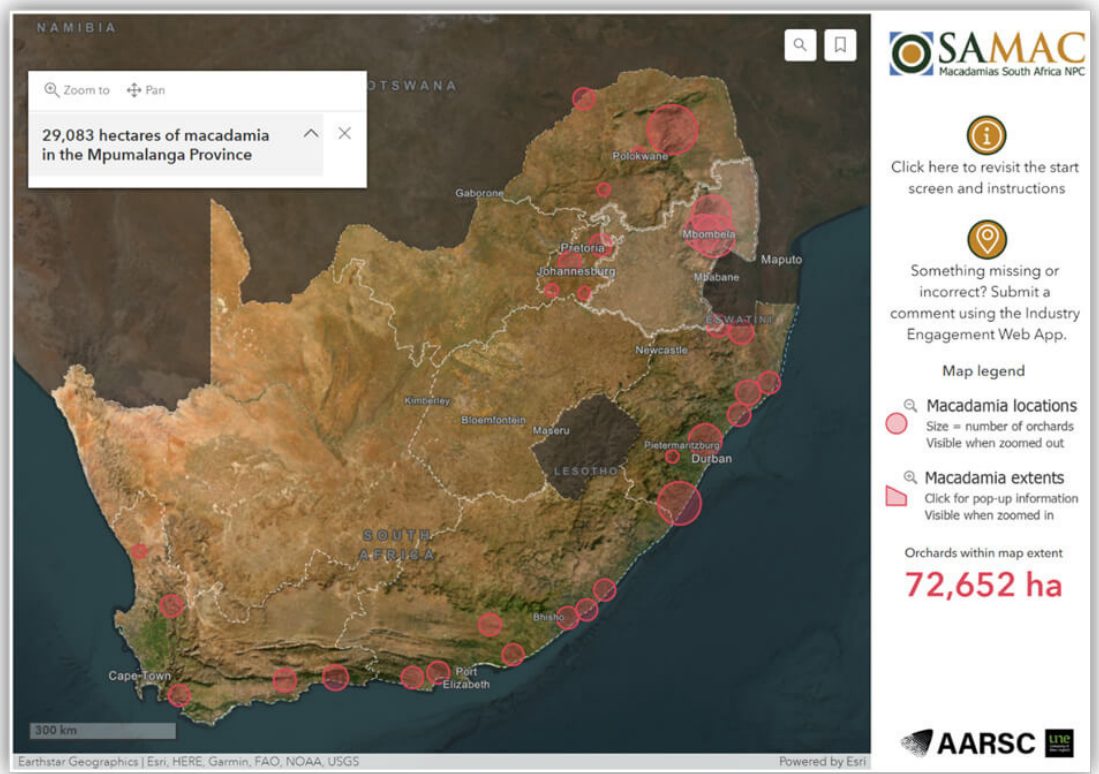
Several oomycete species (*Phytophthora cinnamomi, Phytophthora parvispora, Pythium ultimum and Phytopythium vexans)* were recently identified in a SAMAC project as being pathogenic toward macadamia. It is thus important that these pathogens should be absent from macadamia nursery trees to ensure the establishment of healthy orchards. The project aims to improve the laboratory methods used for detecting oomycete pathogens in nurseries and to investigate whether biocontrol agents are effective at excluding the pathogens from nursery tree roots when applied in nurseries. A better understanding of how biocontrol agents function in suppressing oomycete pathogens on macadamia will also be obtained. The project will improve the quality of macadamia nursery trees by reducing the probability of introducing oomycete pathogens with nursery trees into orchards, which can result in a decrease in the profitability of orchards.

Production

NATIONAL MAPPING OF ORCHARDS

National mapping of macadamia orchards

This project involves the annual revision of all macadamia orchards in the national map (update currency) and mapping new plantings. The project also includes maintenance of the Industry Engagement web tool and industry dashboard for the next three years (available in the member section of the SAMAC website (http://samac.org.za/national-map-of-orchards/), and very importantly annual update of tree age models. The team are also providing input and guidance to the Integrator team where needed.



CULTIVARS AND BREEDING

Selection and evaluation of new cultivars for the South African macadamia industry

The South African macadamia industry relies primarily on imported cultivars – of the current commercial cultivars only Nelmak 2 and Nelmak 26 are local selections. Except for A203 and A268, all other current cultivars are more than 30 years old in South Africa and much older in their country of origin. To determine whether there are more profitable cultivars for adoption, 14 open source and 5 protected varieties have been imported from Australia and are being tested along with 4 standard South African cultivars, A203, A268 and 10 cultivars from the ARC germplasm collection. These trials are being conducted at four locations with different climates and will focus on factors such as yield, kernel recovery, kernel size and style split as well as monitor kernel defects which may reduce marketability. The objective is to release new cultivars which enhance profitability through increased production and/or quality.

Genomic technologies for macadamia tree improvement

The Macadamia Genomics Project aims to develop innovative technologies for accelerated macadamia tree improvement. This project of the Forest Molecular Genetics Programme and the Macadamia Protection Programme in FABI will assist the South African macadamia industry to move into the genomics era by using expertise and infrastructure developed by the forestry sector. The first step is to develop DNA fingerprinting technologies that will allow the industry to conduct routine cultivar identification, clonal confirmation, and parentage analysis. Next is to develop genetic linkage maps using whole-genome sequencing approaches to identify DNA markers located throughout the genome. The linkage maps together with morphological trait data will allow us to identify genomic regions and DNA markers associated with growth, flowering, nut yield, nut quality and resilience to biotic and abiotic stress. These genomic technologies will be implemented in breeding programmes to ensure the sustainability and competitiveness of the South African macadamia industry.

NUTRITION

A comparison of crop removal figures for different cultivars in the South African and Australian macadamia industries

Crop nutrient replacement values, together with leaf and soil analyses, provide a basis for determining annual fertiliser recommendations, and should prevent both under- and overfertilizing. Current estimates of nutrients removed from macadamia orchards through nut in husk harvesting are based on limited data from Australian studies, and to date, there has been limited focus on macadamia fertiliser requirements in South Africa. The objective of this study is firstly, to determine crop removal figures in both the Nelspruit/Barberton area and the KZN South Coast for the following varieties: Nelmak 2, 695, 788, 814, 816, 842, A4 and A16 and this should aid in future fertiliser recommendations. The second research objective is to compare these varieties' crop removal figures to those of varieties widely planted in Australia. The comparison of internal controls, used in both the South African and Australian legs of this study, will allow for the benchmarking of these results.

Evaluating the possibility of reducing thrips damage on macadamia by means of precision nutrient applications

This project was initiated to investigate the relationship between sucking insect damage on macadamias and nutrient levels in leaves. Any deficiencies or toxicities will be corrected, and the effect on thrips load will be monitored.

PHENOLOGY

Determining the seasonal root growth pattern and carbohydrate allocation in macadamia trees

In macadamia trees, vegetative and reproductive development must be balanced to ensure long-term productivity of trees. Sufficient vegetative growth is needed to provide the framework for future bearing sites, as well as foliage to support the crop requirements, while excessive vegetative growth will be in competition with and reduce the current crop. An understanding of growth patterns, in response to the local environment and farming inputs in the form of irrigation and nutrition, is needed to develop effective management strategies in macadamia trees. Current available phenological information is mostly based on work done in Australia, and it is important to update the calendar for the South African industry. The objective of this study is to update the macadamia phenological calendar with a specific focus on the timing of root flushes and determining fluctuations in trunk and leaf carbohydrate reserves across seasons, in A4, 816, 695 and Nelmak2.

Investigating the factors driving out of season flowering in macadamia

This project aims to understand out of season flowering in macadamia orchards in South Africa. Environmental stresses such as drought, temperature and low carbohydrate levels could potentially trigger irregular flowering events, causing difficulties in crop management. The study aims to determine the impact of drought stress and annual non-structural carbohydrate concentration on flowering intensity with a focus on out of season flowering. In addition, the study will analyse on a macro scale the potential impact of drought stress and temperature on flower induction using retrospective data. The anticipated outcomes include insights into stress-induced flowering, potential guidelines for growers, and improved orchard management strategies.

POLLINATION

Best pollination practices and guidelines for macadamias in South Africa

Development of mutually beneficial industry standards and guidelines for pollination, based on well-founded research and experience in pollination practices, is crucial. Growers pay substantial fees for pollination and have the right to ask questions about the quality of hives being brought in for pollination. Likewise, beekeepers insist on protection of their bees from pesticides and reasonable compensation for their services. This study aims to evaluate, through in field testing, current hive recommendations of 2-4 hives/ha and determine the best colony placement strategy for optimal and even foraging patterns. Placement will be based on tree age, cultivar, pruning and planting density, considering that bees can easily fly 300m along rows of 4-year-old trees but only 200m between rows. Both the macadamia and bee industries will benefit from sustainable beekeeping and pollination practices that are becoming more important in view of the growing macadamia industry and the consequent demand for pollination.

Cross pollination in macadamia cultivars

This project was commissioned by the R&D Committee to determine the cross-pollination potential of 12 cultivars, and their production potential when cross-pollinated with other cultivars. The value of specific cultivars as pollen donors will be determined, i.e. determining which combinations of cultivars has the highest yield, best quality, and nut size.

Pollen harvest and long-term viability of macadamia pollen

The research conducted highlights the significance of cross pollination in *Macadamia integrifolia* and *Macadamia tetraphylla* for improved nut set and yield. However, existing literature lacks information on the harvesting and long-term storage of macadamia pollen for large-scale pollination, given the plant's vector pollination nature. Artificial pollination becomes necessary in orchards where cross-pollination is insufficient, especially in older orchards unable to replant with new cultivars. To address this gap, the proposed study aims to explore the long-term storage capacity and viability of macadamia pollen from different cultivars, both in *vitro* and *in vivo*. The expected result is a thorough comprehension of how pollen viability evolves with time and how various storage conditions impact its effectiveness in pollination. This knowledge will be helpful for enhancing the management of macadamia orchards and potentially increasing yields.

IRRIGATION

Optimizing irrigation of macadamia orchards: transforming theory into practice

This project was commissioned by the R&D Committee in response to the project on macadamia water requirements which ended in March 2021. The previous project focussed on how much water macadamias need and when, with the new project focussed on how to deliver the required water most efficiently. The trials will focus on optimizing and comparing drip and micro sprinkler irrigation and will study the leaf anatomy of different cultivars to quantify possible differences in the water requirements of different cultivars. This will determine if field trials are required to compare the water requirements of different cultivars. Lastly, the water stress trial of the previous project, which focussed on the phenological stage at which macadamias are most sensitive to water stress did not provide conclusive results as the researchers struggled to induce adequate levels of stress in the study sites and yield losses couldn't be determined because of the national lockdown. That component will be repeated in another orchard in this new project.

NURSERIES

Field evaluation of micro-grafted trees against cuttings and traditionally grafted trees

In South Africa, nurseries supplying plants to growers traditionally use two methods of propagation namely, grafting and to a lesser extent, cuttings. More recently micro-grafted plants have become accessible to growers. Research out of Australia showed the feasibility and cost-effectiveness of using micro-grafted plants for propagation and field establishment. This research will provide a benchmark against which SAMAC can compare similar data against. The objective of this project is to test the field performance of cuttings and micro-grafted macadamia trees, against traditionally grafted trees, over a five-year period. The survival and growth parameters within the first two years after establishment will be funded by the Seedling Growers Association of South Africa (SGASA) (2023 – 2024). SAMAC will fund years three to five (2025-2027), which will provide both growth and yield data. A frost trial in KZN is being used which consists of six cultivars and three plant types of each cultivar i.e., traditional grafts; micro-grafts and cuttings.

SUSTAINABILITY

Carbon footprint benchmarking of the South African industry

The Confronting Climate Change (CCC) Initiative is a carbon footprinting project, developed to support the South African fruit and wine sectors by identifying and responding to the risks and opportunities associated with carbon emissions. The CCC Initiative includes an online carbon foot printing platform; industry engagement workshops; a range of commodity-specific industry benchmark reports; and relevant energy and emissions-related news and information. Based on 6 563 hectares, 2023 data showed macadamia farms produce on average 2.09 kilograms of CO_2 equivalent per kilogram of wet nut in shell, mostly attributed to electricity usage, fuel and fertiliser use. Processors emitted 0.26 kg CO_2 equivalent per kilogram of wet nut in husk, with emissions coupled mostly to electricity and fuel usage. The information provided in a carbon footprint report for an individual producer is extremely valuable in identifying the hotspots in their business and indicating to them where they should focus their efforts to reduce not only carbon emissions but to minimize input costs and ensure greater resource efficiency and ultimately long-term sustainability of business activities and operations.

Quantifying the effect of regular herbicide sprays on soil health, mineral availability, and mineral uptake in a macadamia orchard

The use of herbicide sprays in macadamia orchards are very common. They are mostly used from flowering through the active reproductive growth stage of the macadamia tree when nutrient needs are the highest. The question of how much damage herbicides are causing to the soil microbiome, nutrient availability, uptake, and tree health remains largely unanswered. The research project aims to determine whether regular glyphosate use has a quantifiable negative effect on soil health, the microbiome, and mineral availability to the macadamia tree when used as a weed killer under the tree in orchards. The second objective evaluates if a monetary value could be coupled to any such loss which would then assist producers in making calculated decisions in the use of herbicides.

POST-HARVEST

Addressing the issue of shell skin marks (skin adherence) on macadamia kernel

Skin adherence (the cause of skin marks on kernel) is one of the factors contributing to loss of premium grade kernel in the South African macadamia industry. This disorder tends to be associated with hybrid cultivars such as Beaumont, Nelmak 2 and A4. Although the losses due to this disorder are relatively low in general, some combinations of growing region and cultivar can lead to losses of up to 1.5% of kernel on a DIS basis where total unsound kernel varies from 2.5% to 4% on a DIS basis (SAMAC loss factor benchmark report, 2020). In 2020, the industry lost 1.31% on a DIS basis due to stink bug, placing this disorder on a similar scale to stink bug damage where it occurs. This project seeks to assess the possible factors such as nutrient deficiency and/or water availability which may contribute towards the development of the disorder and, if possible, to ameliorate it.

Cultivar and environment effect on fatty acid profiles and quality in macadamia kernel

Research funded by SAMAC regarding kernel shelf life has revealed that there is a significant intra-seasonal effect on kernel quality. Specifically, late season kernel appears to have a shorter shelf life. It has been hypothesised that this may be due to fundamental differences between kernel from early and late season cultivars. Since the double bonds in fatty acids determine whether oils oxidise, it is likely that late and early season cultivars have different fatty acid profiles and thus differ in shelf life. One objective of this study is to determine whether different cultivars do indeed have different fatty acid profiles. A second objective is to determine whether these profiles affect shelf life of kernel, while a third is to determine whether profiles and antioxidant levels vary during kernel storage. The resulting information should allow the industry to make allowances for these inherent cultivar differences and market kernel in a way that shelf life is optimised.

Determining the effect of ethephon application on Beaumont shelf life

Ethephon has been registered as a nut abscission agent for use on the Beaumont macadamia cultivar for some time and is efficacious when used at the correct concentration and with the correct timing. However, ethephon has effects other than abscission, one of these being to promote ripening in several fruits. This is seen as development of fruit colour associated with ripening as well as, for example, conversion of starch to sugars. This leads to the question of whether ethephon advances the maturity of treated macadamia kernels, and in so doing reduces their shelf life. The current work examines the quality of Beaumont kernels harvested with two ethephon concentrations (750ppm, 1000ppm) at two times in the season (May, July). Peroxide analysis and accelerated oxidation tests will be used to determine whether there is a decline in kernel quality, both at processing as well as one year after processing.

ORCHARDS OF THE FUTURE

Yellow trees: a systematic and teams' approach

Yellowing in the macadamia industry has been prevalent and widespread over the last decade. A clear answer to the problem of yellow trees in the South African macadamia industry has not been forthcoming. Previous research could not identify any obvious nutritional deficiency or toxicity in chlorotic trees. The presence of a virus, phytoplasma or bacteria was also ruled out as a cause. It is suspected that several different factors such as over-irrigation, poor soils, high phosphate levels etc, in isolation or in combination, can lead to the observed yellowing. The aim of this project is to identify affected blocks, and to systematically identify and/or exclude contributing factors and correct them. The second aim is to, through experience from project members and results from demonstration blocks, provide growers with recommendations of the most likely causes, i.e. where to "start". A holistic approach should be followed to evaluate all possible contributing factors, with necessary corrective actions implemented and progression/reversal of yellowing symptoms and yields monitored throughout.