Yield and Quality

Australian Macadamia Code of Sound Orchard Practices

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Introduction to the Australian Macadamia Industry Code of Sound Orchard Practices (COSOP)

The Australian macadamia industry's reputation on world markets for nut quality and food safety is a major competitive advantage. This reputation could easily be jeopardised through the effects of unsound management practices on individual farms.

As suppliers of a raw material to processors, each grower is responsible for the quality and food safety of his or her nuts. Growers also need to strongly consider the effect of their farm practices not only on the quality of the nuts when they are delivered to the processor but also when they reach the final consumer.

There is an expectation by the community that growers will foster sustainable environmental custodianship of their farms. It is likely that the community focus on farm environmental management will continue to increase. Growers are responsible to ensure that their farm practices do not have adverse effects on farm natural resources, neighbours or the surrounding environment.

There is an obligation for growers to ensure they maintain a safe and healthy workplace for themselves, their employees, other persons in the workplace or members of the public. There is also a requirement for documentation by growers of their workplace health and safety compliance.

Nut Quality

Nut quality includes the delicate characteristic flavour, crunchy texture and freshness.

Macadamia farm management practices have a major effect on quality of the nuts reaching the final consumer. COSOP addresses the critical steps in macadamia production where nut quality may be affected. There are many farm management practices, such as harvesting, drying and storage that have a major effect on shelf life.

Food safety

Management of food safety risks is extremely important in the Australian macadamia industry. Purchasers of Australian macadamias should be confident they are buying a consistent product with no risk of any ill effects.

The major potential food safety hazards are:

- Chemical residues, such as from the use of unregistered/ unauthorised or poorly timed pesticides.
- Pathogens such as Salmonella and E. coli.
- Harmful foreign matter such as impacted shell or broken glass - The presence of broken glass has led to the dumping of entire consignments of other horticultural crops.

Contamination by any of these food safety hazards would have major repercussions on the reputation of Australian macadamias. The code addresses key steps in macadamia production to ensure that the risk of contamination is properly managed.

Some processors require their grower suppliers to have in place an audited food safety program in order to satisfy the requirements of the processor's customers e.g. Freshcare® or other industry recognised programs such as the Macadamia Industry Approved Supplier Program (MIASP). These programs give growers the skills to identify on-farm food safety risks. They also detail good agricultural practices that eliminate or mitigate these risks to give customers the assurance that Australian grown macadamias are of acceptable quality and are safe to eat.

Details about the Freshcare program can be found on the Freshcare web site.

Environmental management

Macadamia orchards need to be managed to ensure there are no adverse effects on farm natural resources, neighbours or the surrounding environment. This includes the management of issues such as soil and nutrient runoff, and the prevention of spray drift. Macadamia growers need to ensure they meet any legal obligations with regard to environmental management.

The code is designed to identify a number of key areas that need to be addressed in macadamia production rather than as a comprehensive guide to environmental management of macadamias in Australia.

Workplace health and safety

As employers or self-employed people, macadamia growers are responsible to ensure that their business does not cause a risk to the health and safety of themselves, their employees, other persons in the workplace or members of the public.

There are many areas in macadamia production where risks to health and safety can occur. This code addresses a number of key issues relating health and safety in the workplace.

Further information on workplace health and safety requirements can be found on the Queensland and New South Wales Workcover websites.

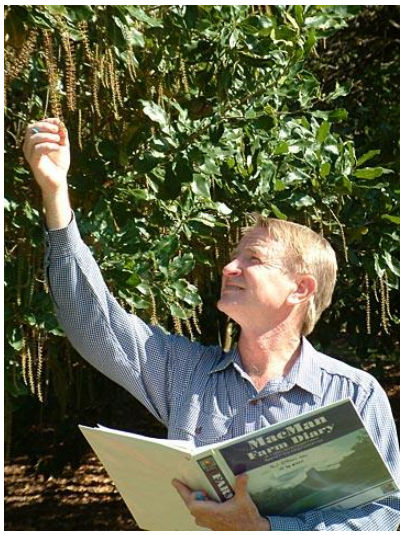
Agronomic best practice

Many of the practices outlined in the code are also aimed at maintaining healthy tree growth and orchard productivity.

Legislation

Macadamia growers must keep up-to-date with all relevant legislation affecting their farming operation. They also need to be aware of all relevant local government by-laws.

Record Keeping



Adequate record keeping is an essential part of any quality management system. Processors need to know how nuts have been handled on the farm to satisfy food safety and quality regulations and customer requirements. Record keeping also enables growers to identify areas in farm management where improvements in efficiency can be made.

Freshcare and other industry recognised food safety programs require growers to keep sufficient records to demonstrate that good agricultural practices are a fact of everyday operation. In Freshcare growers are audited annually by Freshcare accredited third party auditors. In other schemes the processors will periodically check that growers are carrying out the practices and keeping the required records.

The MacMan farm recording system is recommended as it is specifically designed to meet the needs of Australian macadamia growers. MacMan records can also be used to satisfy the requirements of food safety programs. It is simple to use and delivery reports can be produced to meet processors' food safety and quality needs.

Role of the code

The role of the code is to provide a guide to growers on managing their orchards to improve their nut quality and reduce potential hazards to food safety, sustainability and workplace health and safety. It is not designed as a recipe book on how to grow macadamias.

The original COSOP was published by the Australian Macadamia Society in 1992 as a guide to macadamia growers on managing nut quality on their farms and has since been regularly updated. It was based on the current knowledge at that time on the effect of management practices on macadamia nut quality.

Since the publication of the original code, research and development, as well as grower and processor experience, have led to major advances in the knowledge of how to manage nut quality in macadamias. Food safety, sustainable farm production practices, workplace health and safety, and legislation covering farming practices have also become increasingly important.

In developing this document, the authors are also aware that no two orchards are the same. Many orchardists have different methods of completing the same task without compromising quality, food safety, the environment and workplace health and safety.

COSOP should be used in conjunction with the food safety programs, workplace health and safety guidelines and other relevant codes of practice and best practice guidelines.

Orchard establishment

Site selection

Avoid poorly drained soils, excessively steep slopes and contaminated sites.

Macadamias perform best on deep, well-drained soils, rich in organic matter. Trees planted in poorly drained soils are more prone to poor growth and performance, tree decline and trunk canker.

Steep slopes are susceptible to unsustainable levels of soil erosion, leading to reduced tree performance and possible tree decline. Soil erosion can also lead to an increase in foreign matter adhering to the nuts. Close attention needs to be paid to soil erosion management. Measures such as surface drains and vegetative ground cover are required on sloping ground.

Harvesting, pesticide application and other management operations are more difficult on steep slopes and can be delayed, particularly during wet weather. It is also more costly to manage macadamia orchards on steep slopes.

Contaminated sites (e.g. old cattle dips or dumps used for agricultural chemicals) increase the risk of chemical contamination of the nuts, as well as posing a health risk to workers.

Orchard layout

Key recommendation - Develop a whole farm plan.

A whole farm plan is a very important tool in the establishment and management of the orchard and the optimum use of natural resources. A whole farm plan should include:

- A map of the farm,
- neighbouring properties (including future neighbours) and sensitive areas (e.g. houses, waterways etc),
- potential hazards (e.g. power lines),
- a drainage management plan,
- a strategic plan for the farming enterprise.

Growers should also check prior to planting if there are any requirements with regard to planting distances from sensitive areas such as waterways or hazards such as power lines.

Further information is available in the NSW DPI publication Living and working with macadamias – answers to common questions.

Plan orchards so that water flow is managed to minimise soil erosion and nutrient runoff.

Do not plant trees where water runoff concentrates or in natural drainage lines and depressions. Plan and manage orchards to ensure sufficient light will reach the orchard floor throughout the life of the orchard to maintain the growth of vegetative ground covers.

Uncontrolled water flow on bare soil can lead to soil erosion and nutrient runoff. Closely planted, mature orchards where shading has reduced vegetative ground cover need careful management to ensure this does not occur.

Establish surface drains and maintain vegetative ground cover in the orchard to control water flow. It is particularly important to maintain a stable ground cover in all surface drains or anywhere else water runoff concentrates.

A video produced by NSW Department of Primary Industries and supported by the macadamia industry levy through Horticulture Australia Ltd provides an excellent overview of the problem of water flow in macadamia orchards water flow in macadamia orchards and the measures that can be taken to minimise soil erosion and maintain effective ground covers.

Plan the orchards to avoid spray drift onto neighbouring properties.

The best way to cut down the chance of off-target spraying is to ensure the efficient and careful application of chemicals. Buffer zones can also reduce the potential impacts of spray drift. Consider likely prevalent wind directions and the proximity of neighbouring properties when planning the orchard. Consider also planting varieties that are more pest and disease tolerant in parts of the orchard adjacent to neighbouring properties and sensitive areas.

Further information on the application of chemicals in macadamia orchards, including controlling spray drift is available in the AMS publication *Best practice guidelines for the application of chemicals in macadamia orchards*.

Plan the position of dehusking shed and silos to avoid noise complaints from neighbours.

Position dehusking sheds and silos well away from neighbouring residential properties. Openings to any sheds should be placed in the opposite directions to residential neighbours. Topographical features can be utilised as natural acoustic barriers.

Further information on noise control is available in the AMS publication *Code of practice for noise management of on-farm processing of macadamia nuts*.

Consider machinery requirements when designing the orchard.

Ensure easy and safe machinery access and use. On slopes greater than 8%, run the rows up and down the slope for safe machinery use.

Row length is a compromise between efficient machinery operation and water flow management. Short rows are less efficient for machinery operation but enable improved water flow management. Access at regular intervals is required for unloading harvest bins or refilling spray tanks with very long rows. Allow sufficient access at the end of the rows for safe machinery use, particularly on steeper slopes.

Select varieties based on their production and quality characteristics that perform well in your region. Plant at least two varieties on your farm to spread the risk that a particular variety will not perform well and to aid cross pollination. Do not plant more than one variety in the same row.

Research has shown that varieties perform differently in different regions.

Adverse weather or seasonal conditions at critical times (e.g. flowering) may impact on production with specific varieties. Planting at least two varieties helps spread the risk of production losses.

Layout of varieties in a block is a compromise between the benefits of cross-pollination and maximising harvest and orchard management efficiency. Cross-pollination between selected varieties increases the number of nuts, the percentage of first grade kernel, kernel recovery and nut size.

Planting different varieties in the same row can lead to problems with harvesting times and crop protection requirements. Mixing early season and late season varieties in the same row will result in inefficient labour and machinery operations, as extra harvests may be required. Different varieties also have different tolerances of pests and diseases, and may need different spray programs.

Nursery trees

Select healthy, pest, disease and weed free nursery trees.

Macadamia trees are a long term investment. Poor quality nursery trees will cost you more in reduced production and increased management costs in the long term. Inspect nursery trees prior to purchase to avoid planting with:

- Stem damage or trunk canker,
- Damaged, root bound or deformed root systems,
- Bent or deformed stems,
- Insect pests such as felted coccid or latania scale, or
- Infestations of weeds such as tropical chickweed.

Further information is available in the NSW DPI publication Buying quality macadamia trees.

Orchard management

Animal management

Key recommendation - Domestic grazing animals should be excluded from the orchard during and in the four months prior to harvest. Vermin in the orchard should be constantly managed to be kept at minimum levels.

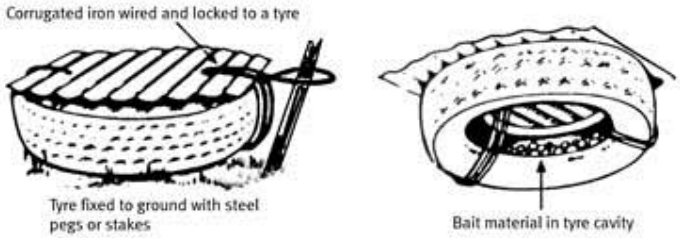
Grazing domestic animals in the orchard in the four months prior to and during harvest can increase the risk of contamination of the macadamia kernel with pathogens such as Salmonella and E. coli.

Vermin, such as rats (rat damage pictured at right), are less easy to exclude totally from the orchard. Steps should also be taken to minimise their presence in the orchard to lessen the risk of microbial contamination. These steps include:

- Remove any harbourage for rats within or close to the orchard,
- Maintain a wide mown strip around the orchard perimeter,
- Ensure as few nuts as possible are left on the ground after harvesting is completed, and
- Avoid dumping nut waste from grading and sorting in and around the orchard.
- Monitor vermin levels and maintain an active control program.

Key recommendation - Any baits used for rat control in macadamias should be monitored regularly and used only in approved bait stations to avoid contamination of nuts.

The use of rat baits in macadamia orchards presents a potential chemical contamination hazard to the nuts and the environment. They are also a threat to wildlife if they are not used correctly. Rat baits registered for use in macadamias must be used in an approved bait station.



Rats prefer the seclusion of covered stations and it also protects the bait from rain. All stations must retain the bait so that it does not spill on the ground or be able to be picked up during mechanical harvesting. Stations must also contain the bait to prevent access by children and non-target species such as birds. Baits must not come in contact with the ground or water.

Anyone handling baits and bait stations must ensure that they are wearing the appropriate personal protective equipment (PPE).

Further information on rat management and the use of baits is available in the AMS best practice information sheet on *rat management*.

Fertiliser Management

Monitor soil and leaf nutrient levels and correct any deficiencies and imbalances. Use standard sampling procedures and quality assured laboratories for analysis. It is recommended to maintain consistency in sampling sites, timing and laboratories to better understand and manage crop nutritional trends in the orchard.

Soil and leaf analyses provide guides to the availability of nutrients in the soil and uptake by the tree. Comparisons can be made with optimum levels set for healthy, bearing trees. Nutrient deficiencies and imbalances can lead to poor tree performance and reduced kernel quality.

It is important that the analysis interpretation and fertiliser recommendations are clearly linked to an understanding of the soil test, soil type, crop agronomy and the timing of growth cycle events (for example nut growth and oil accumulation) under local climatic conditions. Recommendations should also consider nutrient replacement requirements from crop removal and allowances for tree growth and other losses. It is recommended to seek advice from someone with appropriate qualifications and a sound knowledge of local conditions and macadamia management in developing a fertiliser schedule.

Sampling, analysis, interpretation of results and the development of recommendations are all critical steps in developing an appropriate fertiliser schedule.

A nutrient management plan is important, particularly near sensitive areas such as waterways.

Avoid excessive fertiliser use.

Fertiliser can be applied in macadamias using a number of different methods, including

broadcasting or banding, in sprays applied to the foliage or ground, or through an irrigation system. Whichever methods are used, monitoring of nutrient application and uptake is required to avoid too much or too little fertiliser being used. The fertiliser content of organic products such as animal manures also needs to be considered when calculating and monitoring nutrient applications.

Over use of fertiliser is an unnecessary cost, can induce deficiencies of other nutrients and can lead to environmental problems such as high levels of nitrogen and phosphorus in watercourses.

Timing of fertiliser application is also important to maximise the benefit to yield and quality of the fertiliser and to reduce the risk of losses to the environment through volatilisation, leaching and runoff.

Key recommendation – Split your fertiliser applications into at least four applications per year.

Smaller more frequent nutrient applications are more likely to result in more even nutrient availability to the trees and less likelihood of off-site movement of crop nutrients such as nitrogen.

Key recommendation – Do not apply animal manures that have not been properly composted or nut husk from heaps at least four months prior to mature nut drop until the completion of harvest.

Salmonella has been found to persist in animal manures that have not been properly composted for up to four months and has also been found in nut husk heaps. Applying animal manure or nut husk that has not been properly composted, in the period four months before mature nut drop until the end of harvest is a food safety risk. Proper composting of animal manures involves temperature and moisture management and regular turning prior to application.

Further information on composting is available in NSW DPI publications Using compost in macadamia orchards and How to compost on farm.

Locate stockpiles of animal manures and fertilisers to avoid runoff into orchards or sensitive areas such as watercourses.

Runoff from fertiliser and animal manure stockpiles can lead to high levels of nutrients such as nitrogen and phosphorus going into sensitive areas such as watercourses.

Runoff from stockpiles of animal manures into watercourses or orchards also presents a risk of spreading pathogens such as Salmonella.

Stockpiles should also be located to avoid wind-blown contamination of harvested nuts.

Maintain records of the fertiliser program.

Accurate records are an important part of monitoring the effects of fertiliser applications on yield and quality. This also includes application records of animal manures, composts, mulches and other soil amendments. They also provide a basis for decision-making for future applications. Farm recording systems such as MacMan are designed to enable macadamia growers to quickly and easily keep records of fertiliser products, rates and timing.

Irrigation management

If irrigating, ensure the irrigation water is of good quality.

Unsanitary irrigation water poses a risk of microbial contamination to the nuts. Water may need to be tested to assess the risk of contamination. If the water is used for spraying, the water quality should be measured and adjusted if required. Maintain records of any test results.

Irrigation water with excessive salt levels may also result in poor tree performance and reduced kernel quality.

Further information on water quality and food safety can be found in Freshcare.

If irrigating, ensure the irrigation system is operating efficiently, monitor soil moisture and schedule irrigation to avoid wastage of water and nutrients.

Inefficient irrigation systems are wasteful of money and resources. Tensiometers, neutron probes, capacitance tools etc enable growers to monitor soil moisture levels and tree requirements. For maximum yield and quality, scheduling should match water supply with tree demand.

Soil management

Maintain sound cultural practices that sustain soil structure, minimise erosion and provide an environment for healthy root development. Monitor for soil erosion in the orchard and where necessary, take prompt steps to correct the problem.

Soil health includes the physical, chemical and biological characteristics of the soil.

Soil compaction and low levels of organic matter can impede root development leading to poor tree performance and reduced kernel quality. Avoid the overuse of heavy machinery on bare, wet ground, particularly in soils with high clay contents.

Water flowing along tree rows can:

- Remove nuts and soil from beneath trees,
- Expose tree roots,
- Interfere with harvesting,
- Increase the amount of foreign matter adhering to the nuts, and
- Increase the risk of microbial contamination.

Use surface drains and/or vegetative ground cover in the orchard to control water flow. Maintain vegetative ground cover in waterways to minimise soil erosion and nutrient loss. This may require the removal of trees from drainage lines. Techniques such as soil profiling, the creation of inter-row drains and the application of compost can help to remediate degraded orchard floors.

As part of the soil management program, Canopy management may be required in mature orchards to allow sufficient light to reach the orchard floor for ground cover establishment and maintenance.

Further information on sweet smother grass can be found in the NSW DPI publication "Establishing and managing sweet smother grass on macadamia orchard floors".

A video produced by NSW Department of Primary Industries and supported by the macadamia industry levy through Horticulture Australia Ltd provides an excellent overview of the problem of water flow in macadamia orchards and the measures that can be taken to minimise soil erosion and maintain effective ground covers.

Pest and disease management

It is important to note that COSOP is only a guide. Growers need to keep up-to-date with the most recent state and federal requirements for pesticide application as well as the most recent workplace health and safety requirements.

Further information on pesticide application can be found in the AMS publication *Best practice guidelines for the application of chemicals in macadamia orchards*.

Monitor regularly for pests and diseases. Pest management advisers should be well-trained and up-to-date with pest monitoring and management systems.

Pests and diseases can cause crop loss, increase reject kernel levels and induce premature nut drop. Damage by vermin such as rats can cause kernel loss and pose a potential risk of microbial contamination.

Pest monitoring and management systems are complex and are being continually fine-tuned. They require a detailed understanding of the pest, macadamias and available control measures.

Key recommendation – Only apply controls when threshold levels have been exceeded. Apply the most appropriate control strategy.

Thresholds have been developed for major macadamia pests and diseases. These thresholds determine when economic damage is likely to occur and when control is warranted.

A range of management strategies are often available for the control of pests and diseases in macadamias. Integrated pest management systems are preferred. All available forms of pest suppression (biological, physical, chemical etc) should be used to lower pest populations safely, economically and in an environmentally acceptable manner.

Key recommendation - Use only pesticides registered, or permitted to be used in macadamias, by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Follow label directions and observe withholding periods.

The use of pesticides not registered or permitted by the APVMA or the failure to follow the label or off-label permits or observe withholding periods is illegal and could lead to major consequences for individual growers and the macadamia industry. These consequences might include unacceptable chemical residues and the potential loss of key markets.

A withholding period is the minimum recommended time interval that should elapse between the last application of a chemical product to a crop and its harvest (APVMA Information for farmers – frequently asked questions).

Details of registered or permitted pesticides for use in macadamias can be found on the APVMA web site.

Pesticide users must be appropriately trained and accredited.

Users of all agricultural pesticides (including herbicides, rodenticides, insecticides and fungicides) in the macadamia industry must be appropriately trained and accredited to promote worker, food and environmental safety and efficient pest management). In NSW every person who applies a pesticide as part of their business or employment must have a current chemical use training card.

Further information on training and accreditation requirements can be found on the NSW Office of Environment and Heritage and Biosecurity Queensland.

Use suitable spray equipment that has been calibrated at least annually under field conditions by a suitably qualified person.

Unsuitable or improperly calibrated spray equipment can be inefficient, unsafe and wasteful. It can also result in poor pest control leading to a decrease in nut yield and quality. Spray equipment needs to be calibrated in the orchard to ensure sufficient coverage of the tree canopy for the situation. All of the following are important when calibrating spray equipment:

- Tractor speed,
- Pressure gauge settings,
- Air volume,
- Chemical rates,
- Nozzle selection, and
- Target pests or diseases.

Information on spray equipment and the conditions for its safe use must also be available to all equipment operators.

Do not spray near silos containing nuts when the fans are running.

Spraying near silos containing nuts when silo fans are operating may lead to contamination of nuts.

It is preferable to empty silos and to consign nuts prior to spraying. If this is not possible, turn the fans off prior to spraying.

Pesticide container labels, off-label permits and Material Safety Data Sheets must be available to anyone responsible for pesticide storage and use.

Any person with responsibility for the storage or use of pesticides requires the following information:

- Pesticide container labels. All pesticide containers must be labelled to ensure the contents of the container can be readily identified and used correctly.
- Off-label permits. Where a pesticide is not registered for use in macadamias but an off-label permit exists, a copy of the permit must be readily available to the person storing or using the pesticides.
- Material Safety Data Sheets (MSDS). These contain information on the hazards associated with a substance. A supplier must provide an MSDS for each hazardous substance supplied to you with the first supply and when you request it. Ensure that an MSDS for each hazardous substance is readily available for each person storing or using it.

Further information on the safe use and storage of chemicals macadamia orchards can be found in the AMS publication *Best practice guidelines for the application of chemicals in macadamia orchards*.

Exposure of people to hazardous substances must be eliminated or minimised. Personal protective equipment, as specified on the pesticide label or MSDS, must be available and worn. Observe re-entry periods into the orchard.

Control measures should be adopted that eliminate or minimise as far as practicable the exposure of any person to hazardous substances.

Personal Protective Equipment as specified on the chemical label and MSDS must be worn. It should be appropriate for the task, acceptable to the wearer, readily available, clean and in a fully operational condition. Chemical filters on air conditioned cabs in tractors also need to regularly maintained.

It is important to observe re-entry periods where contact with foliage and skin is unavoidable. Many pesticides are readily absorbed through the skin. As a minimum, re-entry by unprotected persons should not occur until dusts have settled or sprays have dried, where no re-entry period is stated.

Further information on the protection of workers involved with the application of chemicals in macadamia orchards can be found in the AMS publication *Best practice guidelines for the application of chemicals in macadamia orchards*.

Key recommendation – Eliminate the potential for off-target spray drift.

Off-site spray drift is illegal. It is the responsibility of the farm owner and the equipment operator to ensure that off-site spray drift does not occur. Preventing spray drift is an essential aspect of using pesticides responsibly.

The following are important considerations in assessing the potential risk of off-target spray drift and potential hazards to human health and safety and the environment:

- Spray equipment being used,
- Weather conditions, for example wind direction and speed,
- The distance from the application site to areas of potential risk, and
- Any barriers between the application site and areas of potential risk.

Further information on assessing the potential risk of off-target spray drift in macadamia orchards can be found in the AMS publication *Best practice guidelines for the application of chemicals in macadamia orchards*.

Store pesticides in a well-ventilated and well-lit shed. The store should have shelving and an impervious floor. It should also be kept locked and have a childproof latch. Store pesticides away from respirators, protective clothing and equipment, foodstuffs, animal feeds, fertilisers, seeds and other chemicals. Avoid storing pesticides in flood-prone areas and potential watercourses.

The amount of chemicals and their characteristics, the duration of storage, and the response to potential emergencies such as spillage or fire should be considered in designing chemical storage. Chemicals must be stored so they do not present a safety risk to people, animals or the environment or so that they cannot contaminate nuts or other foodstuffs. It is also important to ensure there is no risk of pesticides entering watercourses.

It is important, when using pesticides that poison drums are not left at water fill up points, particularly in flood-prone areas or near potential watercourses. Do not fill pesticide application equipment within 50 metres of a watercourse. Empty chemical drums should be triple rinsed and disposed of properly.

Further information on the safe storage of chemicals in macadamia orchards can be found in the AMS publication “Best practice guidelines for the application of chemicals in macadamia orchards”.

Further information on the disposal of empty chemical drums can be found on the Drum muster web site.

Maintain a stock inventory of the chemicals in storage and conduct an annual stocktake. Do not store more than one season’s chemical requirements.

Maintaining a stock inventory is a requirement of some food safety programs. A stock inventory is not only important for efficient farm management but also is necessary should an emergency occur. Reducing the amount of chemicals stored on the farm is an

important method in reducing chemical storage hazards. Many chemicals also have a limited shelf life.

Maintain records of pest and disease monitoring results and all pesticides applied.

Growers need to meet their legal obligations with maintaining pesticide application records.

Accurate records are a requirement of food safety programs such as Freshcare and an important part of monitoring the effectiveness of pesticide applications on yield and quality.

Farm recording systems such as MacMan are designed to enable macadamia growers to quickly and easily keep records of pests, diseases and pesticides applied.

A farm map identifying crop locations, sensitive areas and other key farm attributes is an important part of record keeping.

Further information on recording chemical applications in macadamia orchards can be found in the AMS publication *Best practice guidelines for the application of chemicals in macadamia orchards*.

Canopy management

Manage macadamia orchard canopies:

- **To ensure sufficient light reaches the orchard floor to promote inter-row vegetative ground cover growth.**
- **To provide sufficient light and ventilation at the orchard floor to help the ground dry after rain during the harvest season.**
- **To provide clearance for machinery access.**
- **To enable efficient spraying without off-target spray drift.**

There are a range of canopy management strategies aimed at improving light penetration to the lower parts of the canopy and orchard floor while maintaining yield and efficient orchard management.

Mature macadamia orchards can form a dense canopy that prevents light reaching the orchard floor. Even shade tolerant ground covers, such as sweet smother grass, (Dactyloctenium australe) require light for growth. Orchards with a closed canopy also dry out slowly after rain resulting in harvest delay and deterioration in nut quality.

Further information on sweet smother grass can be found in the NSW DPI publication establishing and managing sweet smother grass on macadamia orchard floors.

An alley width of at least two metres is generally considered the minimum for machinery access. A wider alley width will offset shading of the orchard floor caused by increasing tree height. Light interception models show that increasing alley width increased light penetration to the orchard floor more than reducing tree height.

Effective spray coverage with standard low-profile, ground-based air assisted sprayers is limited at tree heights greater than six metres.

Harvest management

Pre-harvest preparation

Key recommendation - Remove or finely chop unsound, old or immature nuts are removed or finely chopped before mature nut drop. Any impediments to harvest such as excessive leaf or foreign matter should also be removed or finely chopped.

Nuts from the previous season, immature nuts or insect damaged nuts reduce the kernel quality of the harvest if not cleared from under the trees prior to mature nut drop.

Inadequate orchard floor preparation can lead to harvesting difficulties and delays and an increase in unsound kernel.

Monitor maturity of nuts to determine the optimum time of pre-harvest clean up to ensure that only nut-in-shell that meets the required specification of your processor is consigned.

Most processors offer maturity testing as a service to their suppliers. Optimum timing of pre-harvest clean up can have significant economic benefits. Early in the season, both mature and immature nuts can fall. Timing the pre-harvest clean up too early can lead to excessive levels of immature nuts in the first harvest round. Late pre-harvest clean up can result in significant losses of good quality nuts.

Macadamia kernel that is harvested, dried, cracked and packed as soon as maturity is reached tends to have a longer shelf life and lower rancidity levels than with kernel where delays are experienced in this process.

For varieties that have a propensity to develop stick tight nuts in the trees, strategies that promote early season nut drop can help maximise kernel shelf life. The application of ethephon is a potential tool for promoting nut drop once nuts are mature.

Harvest

Complete a harvest round at least every four weeks during the harvest season.

Kernel quality will deteriorate the longer the nuts are on the ground due to discolouration and rancidity, and increased germination during wet weather.

Harvesting needs to be a continual rather than a stop-start process. Once a harvest round is completed, continue harvesting rather than waiting for the end of the four week interval. This is important to maximise nut quality when using a single pass harvesting strategy. A single pass harvest strategy offers the potential to complete harvest rounds more quickly and to maximise the efficiency of your pickup and nut quality.

Harvest interval needs to be minimised where the nuts are exposed to direct sunlight or during wet weather. The risk of microbial contamination also increases the longer the

nuts are on the ground.

Keep nuts from different harvest rounds separate, particularly with early season harvests.

Early season harvests often have high levels of immature nuts and other quality problems. Mixing nuts from early season harvest rounds with later harvests can seriously reduce the quality of consignments.

Ensure efficient pick up when harvesting to avoid nuts being left on the ground until the next harvest round.

An inefficient harvest pick up will lead to excessive numbers of nuts left on the ground until the next harvest round. The deterioration in quality of these nuts will lead to an overall decrease in quality of the next harvest round. If mechanically harvesting, attention needs to be paid to the efficiency of harvesting machinery and the evenness of the soil surface.

There will be less deterioration in nut quality when you have shorter harvest intervals if some nuts are left on the ground. The shorter harvest intervals mean that you have more opportunity to pick up the nuts during the following harvest round before deterioration can occur.

Inspect harvest containers before use and clean if necessary. Maintain harvesting machinery in a sound, clean condition. Ensure harvest equipment and other machinery is clean when shifting between orchards.

It is a requirement of food safety programs such as Freshcare to ensure you clean harvest containers prior to the commencement of the season. Unclean harvest containers (bins, buckets etc) or machinery increase the risk of contamination of the nuts. Incorrectly maintained harvesting machinery can cause cracking of the shell increasing the risk of mould, microbial contamination and bruising of the kernels. Unclean harvest equipment also presents a risk of spreading diseases, weeds etc when shifting between orchards.

Post harvest handling

The aim in handling macadamias is to harvest, sort and deliver to the processor in the shortest possible time at the lowest possible cost and with the highest quality.

Delays from harvest through to delivery of the nuts to the processors, particularly at higher moisture contents, can lead to deterioration in nut quality through the development of rancidity and internal discolouration.

Effective on-farm drying and storage of macadamias relies on understanding the dehydration process and its effect on nut quality.

It is important to keep accurate records of nut storage and movements during post harvest handling. This is an important part of food safety programs such as Freshcare. Monitoring and recording nut handling is also important in preventing losses in nut quality.

Post harvest handling shed and equipment

Maintain the building in an orderly, sanitary condition and ensure all people handling nuts observe hygienic practices. Provide waste containers and frequently remove and properly dispose of waste, including reject nuts, from the working area. Monitor and take steps if necessary to prevent birds, rats or other animals entering the shed. Develop and implement a cleaning and vermin control plan.

Poor shed and personal hygiene increase the risk of nut contamination. Birds, rats and other animals in the shed also increase the risk of microbial contamination. Reject nuts can lead to an increase in rat and bird problems if they are not disposed of properly.

Food safety programs such as Freshcare require growers to have a cleaning and vermin control plan. This includes:

• Containers used for waste product need to be clearly identified and only used for the purpose of holding waste.
• Toilet and hand washing facilities must be available to staff and all people handling product.

Further information is available on the Freshcare website.

Install a monitoring system for recording daily movements through the shed of nut-in-shell and nut-in-husk.

It is important to record daily movements of nut-in-shell and nut-in-husk from the time of receival at the shed until delivery of nuts to the processor. This is to ensure that nuts are treated appropriately to maximise quality. Suitable systems include the MacMan farm recording system and nut handling and storage recording sheets in food safety programs. Food safety programs such as Freshcare require permanent records to allow traceability should it be required at a later date.

Provide sufficient guarding, lighting and ventilation to enable staff to work safely and efficiently.

Macadamia growers are responsible, as far as practicable, to ensure that their workplace does not cause a risk to the health and safety of themselves, their employees, other persons in the workplace or other members of the public.

Poorly lit and ventilated working conditions can result in staff being unable to work efficiently. Adequate lighting and ventilation is particularly important in ensuring sufficient and effective sorting.

Key recommendation – Ensure that there is no risk of contamination of the nuts by broken glass or other foreign matter.

Contamination by broken glass has had extremely severe repercussions in other horticultural industries and the loss of entire export consignments. It is important to take practical steps necessary to ensure that there is no risk of contamination of the nuts by broken glass from fluorescent bulbs etc or by other foreign matter. Lights should be protected to prevent breakage.

Ensure vermin are controlled in the shed and any rat baits used cannot contaminate the nuts.

Any rat baits used in or around farm buildings should be placed in covered bait stations in locations where there is a minimum risk of contamination of nuts. The stations should be inspected regularly and maintained, and their locations clearly identified in the shed and on the cleaning and vermin control plan.

Maintain equipment used for dehusking and sorting in a sound, clean condition. Sort rocks from nuts before dehusking.

Incorrectly set and maintained dehusking machinery can cause cracking of the shell. This increases the risk of mould, microbial contamination and bruising of kernels. Unsorted rocks can damage machinery leading to inefficient dehusking and damaged nuts.

All parts of the receival and dehusking and sorting line need to be regularly cleaned as per the cleaning and vermin control plan. Use only cleaning and vermin control chemicals that are approved for use in food premises.

Drying equipment and storage vessels should be kept clean and maintained in good order with records kept of when these tasks have been done. Ensure silo fans are working efficiently. Precautions should be taken to prevent contamination or wetting of nuts during handling, drying and storage.

Unclean and poorly maintained equipment, and unsecured containers increase the risk of contamination of nuts from insects, vermin and other pests, and from chemical or microbial contaminants or other substances.

Build up of dust on silo fans can reduce their efficiency. Old nuts not removed from equipment and containers before use can also lower the overall quality of consignments.

Holes in silo walls can allow air to escape leading to uneven drying of nut-in-shell and variable kernel moisture content.

Ensure the plenum and the silo floor is cleaned prior to and during the season to avoid physical or microbiological contamination and to ensure the air flow isn't restricted.

Condensation inside storage containers is an indicator that the drying system is not operating efficiently. Condensation can also promote food pathogens to breed and contaminate nuts and to encourage mould growth.

Dehusking

Key recommendation – Dehusk nuts on the same day as they were harvested. If dehusking cannot be accomplished within 24 hours, nut-in-husk must be stored in a vessel with adequate and even forced air ventilation or spread out in thin layers to allow sufficient airflow between them.

Nut-in-husk generates respiratory heat in storage, particularly where the husk is wet or fleshy and green. This can cause an increase in mould, rancidity, germination and internal discolouration.

Sorting of nut-in-shell

Key recommendation - Following dehusking, inspect the nuts and remove any foreign matter and nut-in-shell that is defective or less than the minimum size specified by your processor. Monitor your nut quality to determine if sorting is necessary and economical.

Insufficient or ineffective sorting will result in increased levels of unsound, immature or small nuts, or foreign matter being included in the consignment to the processor.

Monitoring rejected nuts during sorting and recording the reasons for rejection enables you to analyse your orchard management practices and their effect on macadamia nut quality. It also enables you to check sorting efficiency. Farm recording systems such as MacMan are designed to enable macadamia growers to quickly and easily keep records of rejected nuts during sorting.

It is easier to identify and sort defective nuts when they are dry. It may be necessary to conduct an initial sort immediately following dehusking to remove easily identifiable defects, such as rat damage.

Sorting may not always be necessary, particularly second sorting after the easily identifiable defects have already been removed. It can lead to a financial loss, particularly if excessive amounts of good quality nuts are also rejected. It is important to monitor nut quality prior to sorting to determine if it is necessary.

Further information on deciding if sorting is necessary can be found in the MPC publication The sorting table.

Nut-in-shell sorters should be adequately trained.

Training materials, such as the AMS Macadamia Sorting Guide (this is available in hard copy directly from AMS) can assist sorters to identify defective nut-in-shell. These should be readily available and visible, particularly for inexperienced sorters.

You should also contact your processor(s) for advice on which nuts to reject.

Key recommendation - If you use on-farm flotation sorting of nut-in-shell, empty and hose out the water bath at least every four hours. Empty and sanitise the water bath at the end of each day it is used. Leave the bath empty overnight.

On-farm flotation sorting of nut-in-shell presents a major risk of contamination by pathogens such as Salmonella. Increases in time and water temperature can cause a rapid multiplication of Salmonella in solution. The concentration of Salmonella can multiply by up to 150,000 times in a water bath at 20ºC in 24 hours.

If you add any sanitising agents, they need to be approved for food contact and their use monitored and recorded to ensure they are being correctly used.

If you are using air sorting of nut-in-shell, ensure that the waste air is either filtered or vented outside the shed in a safe manner.

Air coming off air sorters may contain fine particles of dust containing animal manures and other potential contaminants. Dust laden air from air sorters is a potential hazard for both worker health and safety and food safety. It is also important that vented dust does not contaminate roofs used for collecting water.

Monitor rejected nuts during all stages of sorting to ensure that sorting is working effectively by cracking a sample and recording the reasons for rejection.

Flotation sorting of nut-in-shell is only effective for removing immature nuts if the nuts are at the optimum moisture content. Similarly, air sorting of NIS will only be effective if nuts are of a similar moisture content. The optimum moisture content of nut-in-shell will vary depending on kernel recovery (this can be affected by variety, season etc).

Crack samples of nuts rejected during flotation sorting and monitor kernel quality. Record the amount of crop lost and the causes for crop loss to aid future management decisions.

Drying and storage of nut in shell

Key recommendation – Consign nut-in-shell to your processor as soon as possible.

Storage of nuts at high moisture contents will reduce shelf life and increase rancidity, off flavours and internal discolouration. Lower moisture contents and lower storage temperatures are required for longer term storage of NIS.

NIS should not be held on farm after harvest any longer than two weeks and preferably no longer than seven days.

There is also an increased risk of fracturing, chipping or bruising of the kernel during handling or transport at NIS moisture contents less than 8 to 10%.

Ensure there is sufficient storage with forced airflow available to hold the quantity of nuts from the largest harvest round. At least two storage vessels (e.g. silos or bins) are preferred.

It is recommended that growers have sufficient storage capacity available to hold at least the nuts from the largest harvest round.

Multiple storage vessels enable you to dry wet nuts prior to sorting, and avoid adding wet nuts to already partly dry nuts. They also assist with regular complete emptying of storage vessels to ensure nuts are not stored longer than necessary. If you are resorting NIS, you will need an empty storage vessel to hold the sorted NIS.

A larger number of small vessels can help you to achieve better air flow, higher nut quality and better drying efficiency than with a smaller number of larger vessels. It is also best to design your storage vessel size to match your transport and harvest requirements.

If you have sufficient storage capacity, separate nuts with different quality attributes such as kernel colour or kernel recovery.

Additional storage vessels increase the capacity to handle the harvested crop. This can be very important during peak harvest periods.

Completely empty storage vessels when consigning nuts or transferring nuts to other storage vessels.

Complete emptying of storage vessels is necessary to ensure that nuts are not stored longer than desirable, resulting in a deterioration of quality. If storage vessels are not completely emptied, old nuts will mix with new nuts when the new nuts are added.

Commence drying immediately following dehusking and sorting.

Excess free water should be removed from the surface of the nuts, particularly following flotation grading, before being added to storage vessels.

It is important to reduce the heat of respiration and the initial NIS moisture content immediately after harvesting and dehusking. This needs to be done to prevent deterioration of quality, particularly with regard to increases in mould, rancidity, other off-flavours and internal discolouration and reduced shelf life.

It is important that there is an adequate air flow if wet nuts are being added to a storage vessel to ensure effective drying can occur.

Ensure you have adequate air flow through your nut bed to effectively remove moisture and the heat generated by respiring nuts.

Uneven or inadequate air flow and ventilation causes increased mould, rancidity, internal discolouration and reduced shelf life. Air velocity should be at least one metre per second through the nut bed. Ensure you have adequate ventilation out of your silo to remove moist air. You should have an air outlet area at least 1.5 times the size of your air inlet area.

Further information can be found in the AMS publication *Drying macadamia NIS on farm*.

The bed depth in silos should not exceed 2.5 metres. The top of the bed of nuts should be as parallel as possible to the base of the nut bed to ensure that there is an even flow of air through the NIS.

It is difficult to maintain even, adequate drying with silo bed depths greater than 2.5 metres. The deeper the bed depth, the longer the drying front takes to move through the nut bed. Nuts at the top of the bed may stay wet or be re-wet by moisture removed from the nuts at the bottom. This can extend the time to reach equilibrium moisture content and reduce kernel quality.

Key recommendation - If heating is used during drying, do not use temperatures greater than 25ºC or more than 5ºC above ambient temperature. Regulate temperatures closely and ensure that secondary controlling systems are in place to act as a fail-safe should the primary temperature controller fail. It is important that heating systems meet all legal safeguard and installation requirements and be installed by a properly qualified person.

Excessive temperatures during drying, particularly with nuts with high moisture contents, can cause internal browning and kernel discolouration during roasting and reduced shelf life. It is also not necessary to use temperatures greater than 25ºC or 5ºC above ambient temperature to achieve effective drying.

Secondary controlling systems need to be in place as entire silos of nuts can be ruined should the primary temperature controller fail and overheating occurs. Great care is also required to reduce the risk of fire damage if using heating. Consult relevant authorities with regard to legal requirements before installing heating.

Further information on the use of heat during drying can be found in the AMS publication *Drying macadamia NIS on farm*.

Key recommendation – Install fan controllers that operate on relative humidity and temperature.

Relative humidity based controllers have been proven to reduce NIS moisture faster and more efficiently than manual control or time clock systems. The controller should also have a temperature override to turn on fans if the respiration heat rises when the fans are not operating to ensure that the maximum temperature in the nut bed never exceeds 30 ºC. This could be either at night or during the day in extended periods of wet weather.

Avoid drop heights exceeding 2 metres.

Excessive drop heights cause increased fracturing and bruising of kernels. As the nut-in-shell moisture content decreases, it is more prone to damage and the acceptable drop height decreases. The maximum acceptable drop height at 10% nut-in-shell moisture content is 2 metres. Effective letdown measures need to be in place for drop heights greater than 2 m. Any easy let down systems need to be designed and constructed so that they do not constrict air flow or cause uneven air distribution through the NIS bed.

Transport of nut-in-shell

Assess kernel quality before consigning nuts. Ensure your processor is aware of the quality of NIS you are consigning.

Assessing kernel quality before consigning is important in deciding whether the nuts meet minimum standards to warrant consignment. This is also important in assisting future farm management decisions.

Minimise the time in transit of nuts to the processor once they have been removed from storage.

Delivery delays can lead to a reduction in kernel quality and shelf life. At higher moisture contents, this reduction in kernel quality and shelf life is accelerated.

Suitable precautions should be taken to prevent contamination of nut-in-shell during transit. Inspect the transport before loading and ensure it is clean, particularly of animal waste or husk. Secure and cover loads for long distance travel.

Unclean containers increase the risk of contamination.

Failure to secure or cover loads can lead to contamination of the consignment by dirt, gravel, broken glass etc. Covering of loads is also crucial to avoid rewetting of NIS.

Food safety programs such as Freshcare also require checking of transport prior to loading to ensure it is clean and free of contaminants.

Avoid drop heights greater than 2 m without effective letdown measures. Where possible, avoid uneven routes, rough handling and vehicles with excessive vibration.

Excessive drop heights cause increased bruising and fracturing of kernels. Rough road or vehicle conditions, or rough handling can also lead to increased fracturing.

Confirm with processors before consigning whether they will accept Macadamia tetraphylla nuts. Send Macadamia tetraphylla and Macadamia integrifolia nuts in separate consignments to the processor. Check also with processors which hybrids or seedlings are acceptable before consigning.

Macadamia tetraphylla nuts have a higher sugar content which leads to excessive browning if they are roasted at temperatures suitable for Macadamia integrifolia. The characteristics of hybrids vary across the range between the two species. Nut quality of seedlings is also variable.

Ensure adequate records are kept in order to complete processor delivery dockets. Ensure details on receival dockets are also correct.

Inadequate information to the processor can lead to inappropriate handling and processing of the consignment. Farm recording systems such as MacMan are designed to enable macadamia growers to quickly and easily keep adequate records to complete processor delivery docket requirements.

Record keeping is an important component of food safety programs such as Freshcare.