Appendix 2. NIASA Guidelines APPENDIX 15 - Macadamia Nursery Stock Specifications & Audit checklist

This project has been funded by Hort Innovation using the macadamia and nursery levy and funds from the Australian Government (Project MC17001).

APPENDIX 15 MACADAMIA NURSERY STOCK SPECIFICATIONS

A.15.1 Introduction

Nursery production of high-quality macadamia trees is recognised within Australia and abroad as playing an important role in supporting the macadamia nut production industry.

Purchasers of macadamia nursery stock require assurance that stock purchased meets an industry standard, is true to type, and that appropriate steps have been taken to reduce the chance of introduction of serious pathogens into the production environment.

In order for a production nursery to be eligible to be accredited as meeting Macadamia Nursery Stock Specifications, the production nursery ***must*** be:

- NIASA accredited; **AND**
- be found at audit to have implemented mandatory procedures (indicated through use of the term ***must***) within this Appendix to a **Satisfactory standard** (see Section A.15.9 Auditing for compliance and continual improvement and the MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST).

A.15.2 General production nursery requirements

The production nursery ***must*** take steps to mitigate the risk of human assisted entry and spread of plant pathogens into and within the production area. High risk entry pathways include water, growing media, and contamination of production areas through movement of people and equipment.

A.15.2.1 Water

Irrigation water ***must*** be managed in accordance with the requirements provided in NIASA Section 1.1.1 Water.

Key requirements – Water

- Water that is obtained from town suppliers, bores free of surface run-off or clean roof catchments does not require disinfestation.
- Other sources of irrigation water (creeks, dams, rivers etc.) ***must*** be disinfested using an approved NIASA disinfestation procedure.
- Subsequent storage of disinfested/clean water requires facilities and procedures ***must*** be established and implemented that do not allow for contamination by untreated water, soil, plant debris, dust and animal movement.
- The pH and EC (Electrical Conductivity) of all water sources ***must*** be checked and recorded at least once per month as even town water supplies can have variations in quality.
- Water from surface supplies, springs, effluents, or water testing positive for the presence of root-rot organisms ***must*** be disinfested using a NIASA approved method.
- Please note APPENDIX 5 NIASA PRODUCTION NURSERY CHECKLIST SECTION 1: Water and irrigation for a complete list of all audited criteria.

A.15.2.2 Growing media / propagating media

Growing media ***must*** be managed in accordance with the requirements provided in NIASA Section1.1.2 Growing media/propagating media.

Further information

- Production of macadamia trees occurs over a longer duration than most other nut/fruit trees - on average 12 to 24 months. As a result, it is important to ensure that high quality potting media is used to avoid breakdown of the media over this extended time period. The long time period also has the potential to cause problems in other areas such as nutrition and irrigation management.
- A good quality long lasting media designed for macadamias is essential if root health, and therefore tree health, is to be maintained. Of particular importance is air-filled porosity as this will decline over time as the media degrades.

Key requirements – Growing media / propagating media

- Growing media/propagating media that is sourced from a NIASA accredited growing media supplier does not require additional pathogen testing and treatment prior to use.
- Growing media/propagating media that is sourced from a non-NIASA accredited growing media supplier ***must*** undergo treatment or pathogen testing, and where pathogens are detected – treatment, prior to use.
- Growing media/propagating media prepared on-site which includes components that pose a risk of contamination, for example river sand, ***must*** be disinfested using an approved NIASA disinfestation procedure.
- Each batch of growing media ***must*** be tested for EC (Electrical Conductivity) and pH using suitable equipment. Adequate records of all growing media ***must*** be maintained, including pH and EC.
- Growing media/propagating media ***must*** be stored in a manner to prevent contamination prior to use.
- Please also note APPENDIX 5 NIASA PRODUCTION NURSERY CHECKLIST SECTION 2: Growing media for a complete list of all audited criteria.

A.15.2.3 Beds and benching

Beds and benching ***must*** be managed in accordance with the requirements provided in NIASA Section 1.1.16 Beds and benching.

Key requirements – Beds and benching

- **Ground level propagating beds**. Beds ***must*** be totally isolated from soil (e.g. with the use of black plastic) and ***must*** be free draining. Beds ***must*** not be subject to flooding during periods of heavy rain.
- **Production beds for containerised stock**. The surface of the bed and the pathways adjacent to it ***must*** prevent contact of the plant, the plant roots or the container, with soil or water contaminated by soil (or growing media) or water draining from other containers or from any other possibly contaminated sources (e.g. road base). Pooling of water is not permitted.

Coarse gravel or crushed rock covered surfaces ***must*** be well drained and the gravel aggregate (screenings of 10mm to 25mm diameter) ***must*** be a minimum of 75mm deep and preferably deeper.

Concrete, polythene or bitumen is permitted where they are covering properly consolidated surfaces and exceptionally good drainage occurs, and all other hygiene practices are satisfactory. Beds with these surfaces ***must*** not pool water and ***must*** be separated as much as possible from adjacent production sites in terms of water runoff.

- Benches spanning or adjacent to either properly sealed or aggregate surfaced floors and paths need not be higher than 30cm. However, where splash and other methods of contamination are likely to occur, a suitable bench height is 75cm or higher.
- Please also note APPENDIX 5 NIASA PRODUCTION NURSERY CHECKLIST SECTION 3: Propagation for a complete list of all audited criteria.

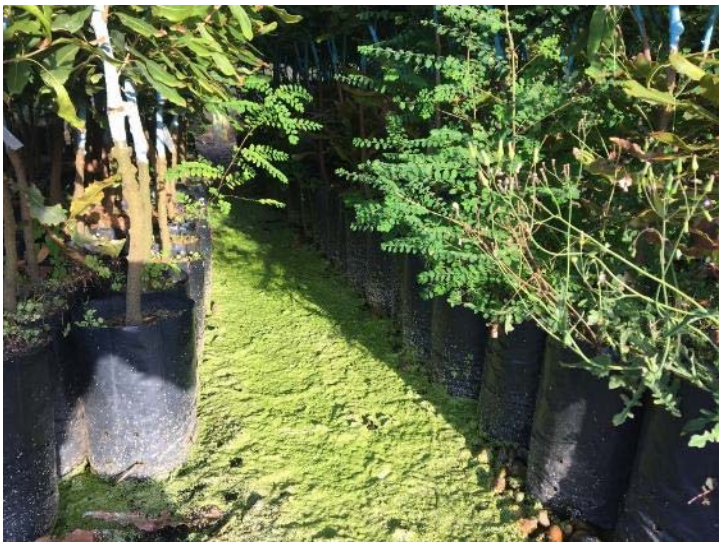

Image 1 – Poor drainage creates a serious risk to plant health and quality.

A.15.2.4 Disinfestation and hygiene

To minimise the risk of movement of plant pathogens into and within the production area, disinfestation and hygiene procedures are paramount in any production nursery.

Hygiene means taking steps to prevent things from becoming contaminated where possible. Hygiene steps include avoiding contact of items with potentially infested surfaces, for example keeping hose nozzles and hand tools off the nursery floor.

Disinfestation, or sanitation, means removing contamination from potentially infested items. Chemical disinfectants or detergents and heat treatments are still the most reliable methods for the control of most plant pathogens. When preparing disinfectant or detergent solutions:

- Follow all label requirements and safety precautions when handling chemicals.
- Only use freshly prepared disinfectant solutions.
- When using *chlorine* based chemicals, diluted chlorine solutions are particularly unstable and ***must*** be made up fresh daily. Use water for dilution with a pH of between 5.5 and 7.5. Undiluted chlorine ***must*** be stored out of direct sunlight preferably in a locked a cool room below 28°C. Chlorine should NOT be stored in areas with fertiliser or other farm chemicals.

Quaternary ammonium compounds (QUATs) are incompatible with most cleaners and detergents and have a low tolerance to hard water (increasing with calcium carbonate ($CaC0_3$) above 120mg/L). As a biocide the added benefit of using a QUAT is the ability to leave a residual anti-microbial film on surfaces. At concentrations greater than 1-10ppm they are regarded as highly toxic to some aquatic life forms. QUATs should NOT be stored in areas with fertiliser or other farm chemicals

Copper sulphate ($CuSO_4$) can be extremely toxic in water of low alkalinity and is ineffective at high pH. Use water for dilution with a pH of between 6.5 and 7.5. Its persistent nature makes it a good biocide however it can also be absorbed by soil and organic material. In working concentrations, it can also be lethal to some aquatic life forms.

The business ***must*** also:

- use chemicals responsibly as per the approved product label or permit conditions;
- dispose of spent disinfectant solutions responsibly as per the product label;
- if handling and storing bulk chemicals (e.g. chlorine) complete a risk assessment and develop an 'Emergency Response Plan' document.

NOTE: Some QUATS are highly toxic to plants and care **MUST** be taken to select an appropriate product when treating near crops.

Further information

- Hygiene & Sanitation of Working Surfaces in the Nursery (#2000/03)
- Hygiene in the Nursery – Disinfecting Production Surfaces; cement, gravel, capillary mats and sand beds (#2000/05)

A.15.2.4.1 Hand hygiene

High hygiene levels ***must*** be maintained in risk areas such as propagation, potting or staging operations.

The business ***must*** ensure that hands are washed thoroughly between operations using an approved hand disinfectant such as Sunlight soap, Savlon or Dettol antiseptic soap, or disposable gloves are used and changed between operations.

A.15.2.4.2 Footwear

Footwear disinfestation and hygiene ***must*** be undertaken in accordance with the requirements provided in NIASA Section 1.1.6 Footwear.

Further Information

- Care ***must*** be taken to address the risk of entry of potentially infested materials such as soil or plant material present on footwear being transferred onto the facility and then into production areas.
- On entry to the facility, footwear ***must*** be clean and ***must*** not carry excessive visible soil and/or plant material that could transfer pests and pathogens into the production areas. Excessively contaminated footwear ***must*** be scrubbed clean with a brush then treated with a suitable disinfectant or detergent solution prior to entry into the production area.
- The business may also install foot baths at all entrance points of production areas OR direct staff to change footwear and use only designated footwear in the production area.

- Alternatively, although not recommended, boot covers may be provided to contractors and visitors however these ***must*** be monitored, discarded and replaced should they show signs of damage.

A.15.2.4.3 Tools, knives and other instruments

Tool disinfestation and hygiene ***must*** be undertaken in accordance with the requirements provided in NIASA Section 1.1.5 Tools.

Cutting tools should be treated at a minimum between batches of propagated plants, and as frequently as between trees when collecting material from parent trees. Cutting tools are disinfected by first cleaning off any surface residue then treated using a suitable disinfectant.

A.15.2.4.4 Equipment

All equipment, including trolleys, barrows and trays that come into contact with vegetative propagation material or inputs such as growing media, should be routinely cleaned with a brush or pressure washer then treated with a suitable disinfectant or detergent.

A.15.2.4.5 Plant Containers (pots, bags and trays)

Containers ***must*** be managed in accordance with the requirements provided in NIASA Section 1.1.15 Containers.

Further Information

- For used containers, disinfestation using a hypochlorite solution may be used but is not recommended as a means of decontamination to achieve the Macadamia Nursery Stock Specifications.
- The preferred method for used container disinfestation is through the use of a heat treatment procedure. Steam is the best and most common heat source for disinfection. A temperature of 60ºC for 30 minutes is most desirable, because as well as killing pathogens it may leave many beneficial micro-organisms.

Used containers, or new containers not stored in a way to prevent contamination, pose a significant risk of transfer of pathogens and if used, ***must*** be disinfested. When heat treatment is not used, used containers ***must*** be reasonably cleaned of waste material, including plant and media residue, prior to disinfection.

A.15.2.4.6 Working surfaces

Working surface disinfestation and hygiene ***must*** be undertaken in accordance with the requirements provided in NIASA Section 1.1.4 Working surfaces.

Key requirements – Disinfestation and hygiene

- High hygiene levels ***must*** be maintained in risk areas such as propagation, potting or staging operations.
- Production/staging areas ***must*** be protected from contamination by ensuring staff entering an area have clean hands and footwear is clean and decontaminated where required.
- Tools, knives, other instruments, equipment and working surfaces ***must*** be cleaned and disinfected regularly.
- New clean containers need not be disinfected however used containers ***must*** be disinfested using heat, or reasonably cleaned of waste material and then disinfested with a fresh 4000 ppm (or 0.4%) hypochlorite solution for at least 20 minutes.

- Clean and disinfected containers ***must*** be stored above floor level to prevent soil, plant debris and drainage water contamination.
- Please also note APPENDIX 5 NIASA PRODUCTION NURSERY CHECKLIST SECTION 3: Propagation for a complete list of all audited criteria.

A.15.3 Source materials to be used for propagation

Care ***must*** be taken in the sourcing, collection and storage of propagation material prior to use.

Key risks include:

- Lack of material traceability.
- Misidentification of parent tree variety.
- Loss of viability.
- Infection by plant pests, diseases or weeds.

A.15.3.1 Source blocks

A 'block' is defined as a tree, or a group of trees, on a property that is planted and managed as one unit and is separated from other trees that may be present on the property by natural or artificial boundaries, for example by access tracks, roadways or fences.

The production nursery ***must*** maintain a *source block record* for each block on a source property from which material is collected that includes:

- A unique name or code for the source block.
- The source property address, and the entity (e.g. person or business) that exercises care, control or management of the block.
- Geospatial information including the Lot on Plan of the land parcel the block is situated in **OR** a GPS coordinate located at the centre of the block.
- An aerial/satellite image identifying the location of the source block or blocks on the source property.
- The type/s of trees present to variety level and records held that confirm variety, if any, obtained from a recognised or experienced source in varietal identification (see Section A.15.3.3 Parent tree variety identification).
- If the block includes mixed varieties, the number of rows present in the block.
- Information on how individual trees within the source block will be identified for material collection purposes where all parent trees in the source block are not of the same variety.

Where the production nursery receives material from a source block from a *source material supplier* (a third party), the production nursery ***must*** require the information for the source block to be provided by the *source material supplier* in order to complete the record.

An example of a *source block record* is provided in SCHEDULE 2: EXAMPLE RECORD SHEETS.

Further information

- Free Online map search tools, for example https://maps.google.com/, are sufficient for obtaining aerial imagery of source blocks and obtaining appropriate GPS readings for source block location details.

Key requirements – Source blocks

- The production nursery ***must*** make and maintain a record of source blocks (a *source block record*) from which parent material is collected for propagation of nursery trees.
- Information ***must*** be recorded that identifies ownership, and geospatially identifies the location of the source block including an aerial/satellite image/map identifying the location of the source block or blocks on the source property.
- Variety ***must*** be identified, and records held that confirm variety obtained from an experienced or recognised source maintained.
- Method used to identify individual trees within the source block for material collection purposes ***must*** also be documented within the record where all parent trees are not of the same variety.
- Please also note the APPENDIX 15 MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST.

A.15.3.2 Propagation material collection records

A *propagation material collection record* ***must*** be maintained by the production nursery for propagation material used that includes:

- Identification of the source block (name or code) the material was collected from that links back to the *source block record* (see Section A.15.3.1 Source blocks).
- The date of collection and the name of the collector/s.
- The type of material collected (for example, seed nut, budwood or scion material) and the amount of the material collected.
- Identification of the material type to the variety level.
- Identification of the tree, or trees (for example row number), the material was collected from within the source block for each batch of material collected where all parent trees in the source block are not of the same variety.
- A unique batch code.
- Any other comments or observations.

Where the production nursery receives material collected from a source block from a *source material supplier*, the production nursery ***must*** require the information to be provided by the *source material supplier* in order to complete the record.

The *propagation material collection record* ***must*** provide sufficient information to allow traceback to a batch of material collected from a source block should problems be detected in propagated trees.

An example of a *propagation material record* is provided in SCHEDULE 2: EXAMPLE RECORD SHEETS.

Further information

- A source block record and propagation material collection record for a source block may be combined as one record.

Key requirements – Propagation material collection records

- The production nursery ***must*** maintain a record of propagation material collected for propagation of nursery trees (a propagation material collection record).
- The production nursery ***must*** maintain a record for the propagation material that identifies the name or code of the source block, the variety, the date of the collection, the name of the collector, the type of the material collected, the amount, and a unique batch code.
- The production nursery ***must*** also identify the tree, or trees, the batch of material was collected from where all parent trees in the source block are not of the same variety.
- Other comments may also be recorded.
- Please also note the APPENDIX 15 MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST.

A.15.3.3 Parent tree variety identification

Parent trees ***must*** be identified to variety prior to collection of propagation materials to confirm details recorded in the *source block record*.

Parent tree variety may be identified by one or more methods:

1. Records are available to confirm variety from a recognised source.

Further Information

- Examples include variety confirmation in writing from established macadamia variety improvement programs that hold PBR for the trees, or through genetic testing results.

2. Where a variety **may be <u>clearly</u> identified by one or more morphological traits**, parent trees are inspected by a person experienced in variety identification, AND observations are made on one or more relevant features including tree shape, tree size and density, leaf length, leaf width and tip shape, leaf spines, husk shape and distinctive shell features, AND observations made are consistent with morphological norms for the variety.

Further information

- A number of reference materials are available to support correct variety identification. An example is the 'Macadamia Variety Identifier' produced by the Queensland Government in association with the New South Wales Government and the Australian Macadamia Society and available online at - http://era.daf.qld.gov.au/id/eprint/1964/14/mac-varieties.pdf.

Where the production nursery receives material from a source block from a *source material supplier*, the production nursery ***must*** require the information for varietal confirmation to be provided by the *source material supplier.*

Key requirements – Parent tree variety identification

- Variety of parent trees may be confirmed through records provided by a recognised source, including genetic testing results.

- Where a variety may be clearly identified by one or more morphological traits, the variety is identified by a person experienced in variety identification through observation and recording of those morphological traits.
- Please also note the APPENDIX 15 MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST.

A.15.4 Material collection and handling

A.15.4.1 Seed nut

A.15.4.1.1 Collecting seed nut

Seed nut ***must*** only be collected from an identified source block (see Section A.15.3.1 Source blocks). Fruit for seed extraction should be collected from healthy parent trees of a known variety (see Section A.15.3.3 Parent tree variety identification).

Seed nut should be mature and preferably be collected directly off the tree, however freshly fallen seed nut may be collected off the ground where all parent trees in the source block are of the same variety.

Where seed nut is collected from the ground preference should be given to selecting those nuts still in green husks. Seed nut that has been on the ground for any length of time, particularly if it has been wet, can be subject to fungal and bacterial infection. This infection once inside the shell may be difficult to treat and may not be immediately apparent when the nut is collected.

Immature or damaged seed nuts should be rejected. Seed nuts that display disease symptoms, or signs of pest infestation, should be rejected.

After collection, the *propagation material collection record* ***must*** be completed and each batch of seed nut ***must*** be labelled with variety, block name or code, date and assigned a unique batch code (see Section A.15.3.2 Propagation material collection records), that will follow the material through the propagation process.

Further information

- A unique batch code could be developed to meet other labelling requirements, and be as simple as 'variety-block code-collection date'. For example, 'H2-001-131118'.

A.15.4.1.2 Washing seed nut

After de-husking, seed nut may be washed/disinfested in water treated with an appropriate decontaminant to remove soil and other surface contaminants and air dried to remove excess water.

Immature or damaged seed nut should be rejected. Seed nuts that display disease symptoms, or signs of pest infestation, should be rejected. Immaturity may be tested by putting the freshly harvested de-husked nuts into the treated water for a period of time, then removing those nuts which float.

A.15.4.1.3 Storing seed nut

Seed viability reduces over time. Seed nut ***must*** be de-husked prior to storage.

Typically, seed can retain viability for about 12 months at 4°C, but at room temperature viability starts decreasing rapidly after about 3 to 4 months. Seed nut stored at <10% humidity may prolong storage life and viability. Open woven bags (for example onion bags) are recommended for storage.

Key requirements – Seed nut.

- Seed nut ***must*** be collected from an identified source block.
- Mature seed nut ***must*** be collected from healthy parent trees of known variety while still attached to the tree, or may be collected off the ground if freshly fallen and all trees within the source block are of the same variety.
- A propagation material collection record ***must*** be completed after collection, and seed nut are assigned a unique batch code.
- After de-husking, seed nut may be washed/disinfested in water treated with an appropriate decontaminant to remove soil and other surface contaminants.
- Seed nut is stored in appropriate conditions and appropriately labelled.
- Please also note the APPENDIX 15 MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST.

A.15.4.2 Budwood

A.15.4.2.1 Pre-collection preparation

Material ***must*** only be collected from an identified source block (see Section A.15.3.1 Source blocks).

Parent trees selected for material collection ***must*** be inspected and found free of disease symptoms or disorders, and signs of significant pest infestation.

The most common form of grafting uses cinctured wood as this increases the chances of graft success particularly with some varieties and at certain times of the year. Cincturing/girdling, (ring barking) prevents the downward flow of carbohydrates from portion of the branch above the cincture and these are then stored in the wood and provide a source of nutrition for the graft.

However, some material may be grafted successfully without cincturing. The benefit of cincturing can vary with the variety selected and other factors.

When cincturing, at least 6 weeks in advance of material collection (often longer in winter to allow sufficient callous formation), parent trees of a known variety (see Section A.15.3.3 Parent tree variety identification) should be selected and budwood selections identified. This will allow time for carbohydrates to build up in the selected material (after girdling), which assists in graft take.

When suitable budwood is identified, in consultation with the grower, girdle the branch as far back as possible to allow several pieces of scion from the branch to be produced.

Use pliers or another suitable tool to remove 2 to 3cm of bark around the branch at this point.

Remove the bark to a depth that allows you to see the white woody tissue of the branch.

The cincture is left open, and not covered, after completion.

Identify the prepared branch - flagging tape is ideal for this purpose. Additional information may also be included on the marker to assist with future collection processes.

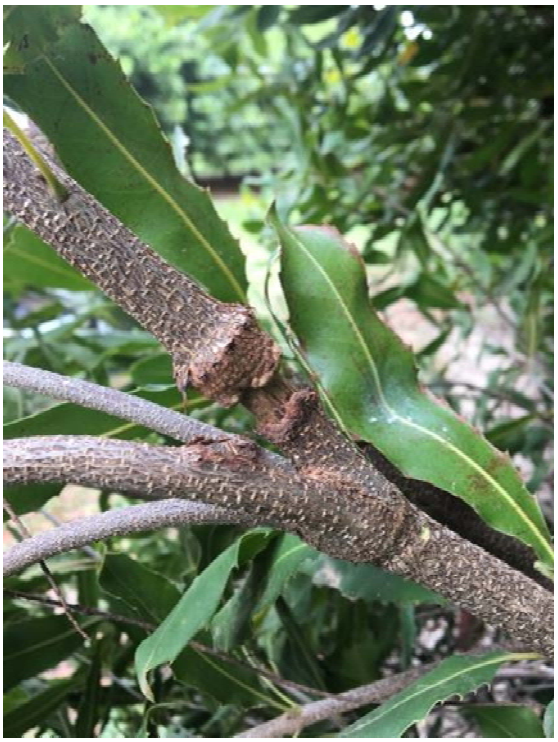

Image 2 – Correctly performed cincture – ready to cut

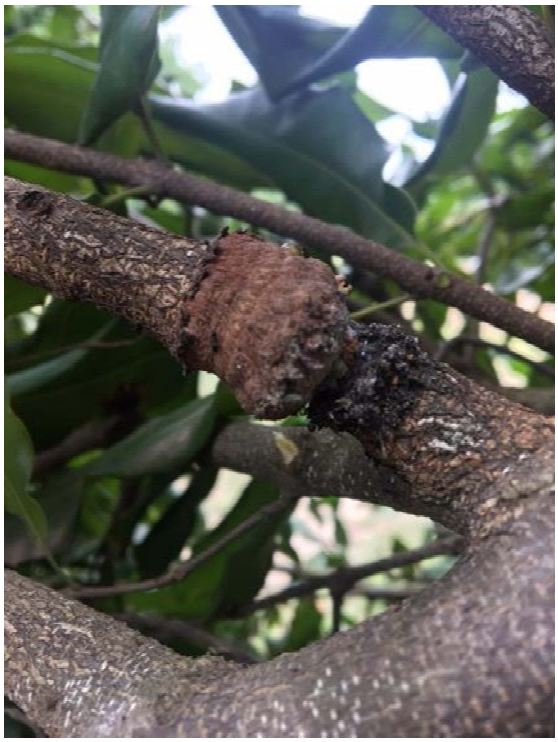

Image 3 – Wood that has been left too long on tree and has calloused over

Tools used to prepare material ***must*** be regularly disinfested (see Section A.15.2.4.3 Tools, knives and other instruments). Disinfect tools between trees, by wiping with a disposable cloth dampened with 30% methylated spirits to 70% water solution to prevent spread of disease.

Further information

- It is recommended that only material that is present at a height greater than 100cm from the ground surface is selected. This will reduce the risk of infection from Phytophthora from contamination by rain splash from the soil surface.
- Budwood selections should be straight hardened wood.
- It is preferable to select upright wood with as few side branches/twigs as possible. This will maximise the amount of potentially viable buds on the grafting material.
- Girdled branches should be kept free of fruit and flowers to an extent that is reasonably practicable.

A.15.4.2.2 Collecting budwood

Material ***must*** only be collected from an identified source block (see Section A.15.3.1 Source blocks).

When collecting material:

- Young material should be collected from healthy trees that have been visually inspected and found free of pest and disease symptoms.

Further information

- Felted coccid (Eriococcus ironsidei) can be particularly hard to detect on budwood sticks as it hides in the cracks in the bark. Great care should therefore be taken in inspecting wood if felted

coccid is thought to be present. Once in a nursery environment, it can rapidly multiply and markedly impact on tree health, growth and saleability. It is also difficult to control in a nursery environment as there are few registered chemicals for its control. Infested nursery trees are one of the main methods by which this pest spreads.

- Material should not be taken from water stressed trees, or wet trees - wet material increases the possibility of wound infection by pathogens.
- Material with internal browning or abscised buds should not be collected.

Secateurs, or other tools used to collect material ***must*** be sharp (to ensure a clean cut) and regularly disinfested (see Section A.15.2.4.3 Tools, knives and other instruments). Disinfect secateurs between trees, by wiping with a disposable cloth dampened with 30% methylated spirits to 70% water solution to prevent spread of disease.

If applicable, cut the material below the girdle and remove all leaves using a cutting tool.

Place the material in a small cooler box containing an icepack, or wrap in a clean damp cloth or damp newspaper and place in a plastic bag to prevent water loss.

The *propagation material collection record* ***must*** be completed and each batch of material ***must*** be labelled with variety, block name or code, date and assigned a unique batch code and be assigned a unique batch code (see Section A.15.3.2 Propagation material collection records), that will follow the material through the propagation process.

Further information

- It is recommended, where practical, that collection of material occurs early in the morning of the same day as grafting, or late afternoon of the day before grafting when the material will not be desiccated by heat and wind as it is being cut.
- A unique batch code could be developed to meet other labelling requirements, and be as simple as 'variety-block code-collection date'. For example, 'G-001-1311218'.

A.15.4.2.3 Storing scion material and budwood

All leaves ***must*** be removed prior to storage taking care not to damage the scion. Material should be used as soon as possible after collection, however, for short term storage of material:

- Budwood can be kept wrapped in a damp cloth in the vegetable section of the fridge for at least a week.
- Risk of pathogen infection and poor plant vigour increases with storage time.

Further information

- Because of respiration producing heat and moisture, it is recommended that no more than 50 scions should be stored in the same bag.

Key requirements – Budwood

- Prior to collection of budwood of a known variety from an identified source block, parent trees selected for material collection ***must*** be inspected and found free of disease symptoms or disorders, and signs of significant pest infestation.
- A propagation material collection record ***must*** be completed after collection and budwood is assigned a unique batch code.

- Budwood is stored in appropriate conditions and appropriately labelled.
- Please also note the APPENDIX 15 MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST.

A.15.4.3 Notes on Cuttings

Cuttings are not widely grown in Australia, due their reputation for having poor root systems making them prone to wind damage. However, in South Africa, a major macadamia producer, cuttings are used extensively. There are two possible reasons for this difference, the South Africans use different varieties to Australia such as Beaumont (695) which grows more readily from cuttings, and the nurseries have developed more expertise in this area and are therefore able to produce cuttings with good root systems.

In Australia, the Hidden valley selections, the A varieties, are generally easier to grow from cuttings than the Hawaiian varieties and there a number of orchards that have been planted with cutting grown A varieties.

Cuttings production is a specialist propagation technique and should not be attempted without considerable trial and research. If this technique is to be used, the same labelling, hygiene and culling standards would need to be applied if a quality tree is to be produced.

A.15.5 Propagation

A.15.5.1 Sowing seed

After de-husking, washing (see Section A.15.4.1.2 Washing seed) and any pre-treatment of seed nuts, the dried seed nuts ***must*** be planted in a quality free draining propagating media (see NIASA Section 1.1.2 Growing media/propagating media) of sufficient depth to allow full expression of the seedling's root system without impediment.

Seeds may be sown in sand beds, heat beds, or directly into containers.

Fresh seed collected directly off the tree, carefully de-husked, and planted within 48 hours generally assists in maximising germination percentage. However, if semi-dried or dried seed nut is going to be planted then soaking the seed nut in water overnight may improve both the germination percentage and the speed of germination. Seed nut that has been stored for any length of time should be thoroughly inspected and any diseased or cracked nut removed prior to planting.

A.15.5.1.1 'Sand' beds

Sand bed construction

The following criteria should be considered in sand bed construction:

- A sand bed should be at least 150mm deep, and often deeper, to ensure the development of a good root system.
- The bottom of the bed should allow for free drainage but should be off the ground or isolated from the ground using polythene sheeting so that the sand bed cannot be contaminated with disease infested water (also see Section A.15.2.3 Beds and benching).
- The sides of the bed should be constructed from non-porous material to prevent diseases contaminating the bed between batches.

- The bed should be filled with disease free coarse sand, or similar material such as crushed granite sourced from an accredited supplier (also see Section A.15.2.2 Growing media / propagating media).
- The beds also need to be designed so that the sand can easily be removed for disposal between batches of seed nut/seedlings, and the emptied bed sterilised (also see Section A.15.2.4.6 Working surfaces).
- The seed bed may be covered with both polythene sheeting to retain heat in winter, and shade cloth in autumn and spring once the seeds have germinated.

Further information

- One method of applying polythene sheeting is to construct half circles of high-density polythene pipe above the bed over which the polythene sheeting and shade cloth can be stretched. The sides of the sheeting/shade cloth need to easily rolled up to facilitate seedbed management and to regulate heat. If the bed is above the ground, then having covers that go down to ground level may be a good idea. Side covers will prevent cold air in winter passing under the bed decreasing the sand temperature and thus prolonging germination time.

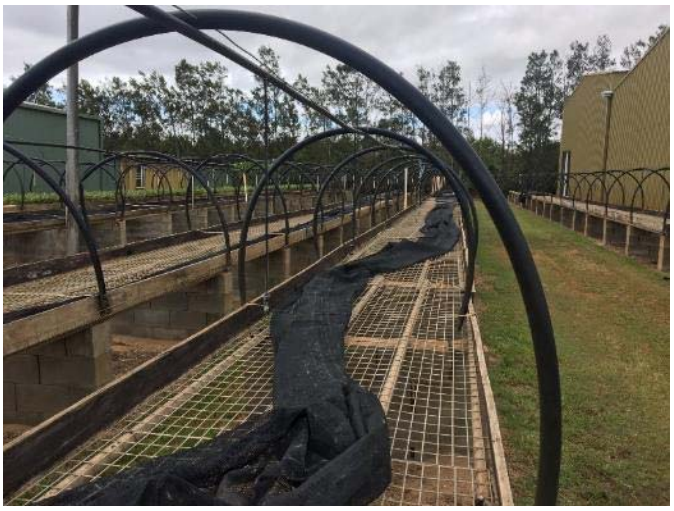

Image 4 – Example hooped seedbed.

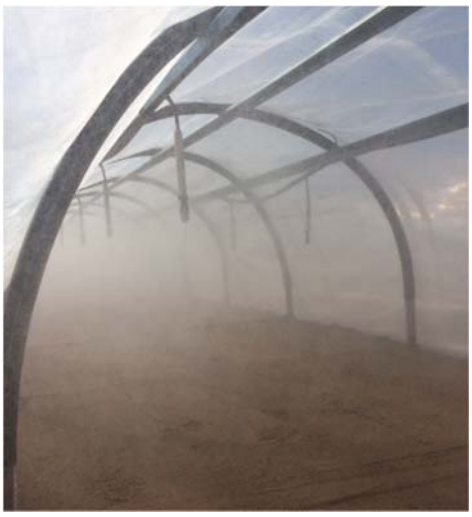

Image 5 – Example polythene sheeting

The irrigation system used in the sand bed should be designed to ensure even water distribution.

Further information

- When irrigating, even coverage is essential as the nuts need to kept damp but not wet. Dry spots can lead to slow germination and death of the apical bud leading to the production of multi-stemmed trees which may need to be discarded. Similarly, areas that are too wet can lead to nuts rotting, disease, and again the loss of the apical bud and the production of multi-stemmed trees.
- The pipes bringing the water should also be buried/protected as much as possible so that the water contacting the emerging seedlings is not too hot as this can cause damage. Similarly, if the irrigation line runs along the apex of hoops over the bed, then the length of the pipe needs to kept as short as possible so as to minimise the amount of hot water that builds up in the pipe. Some systems are designed with a flushing valve at the end of the line which lets the water out when the system switches off and the pressure drops. This is very effective at removing the potential for hot water damage but the flushing valves require a high level of maintenance.

Planting the sand bed

It is important when growing macadamia trees to produce a tree without bends of kinks and this starts with careful orientation and placement of seed nut in the sand bed. The macadamia nut has suture line, a crease or groove, that runs half way around the nut from the micropyle (the white dot at one end of the nut) to the other end. It is along this suture line that the nut will open when it starts to germinate and roots and shoots will both emerge from this point.

Further information

- A common practice when placing the nut in the sand bed is to ensure that the suture line is placed horizontally (not with the seed nut planted with the suture line at the top or bottom of the seed). When the root (radical) emerges, it will then go straight down and the shoot straight up. If the suture line is facing up the root will follow the curve of the shell around leading to a bend in the root and if the suture line faces straight down the shoot will emerge and follow the curve of the nut around leading to a bend in the shoot. (see Image 6).

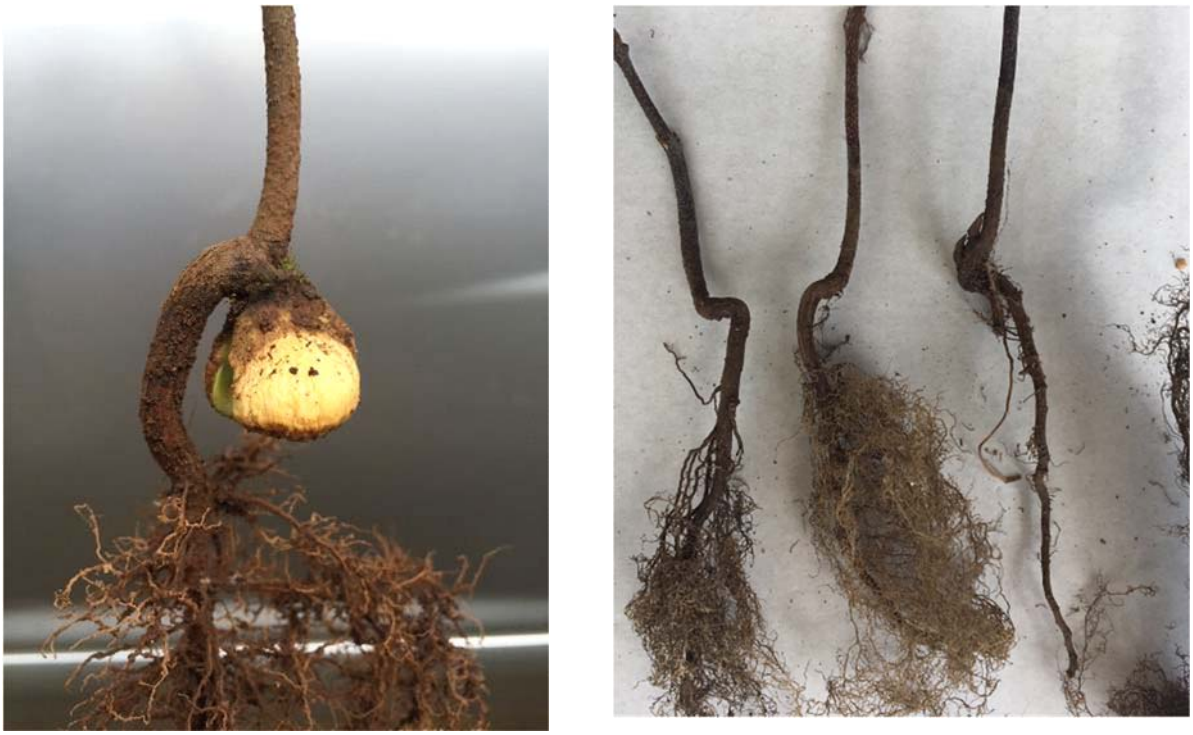

Image 6 – Effect of poor seed orientation. All of these seedlings are unsuitable for use.

When placing the nuts in the sand bed they should be evenly spaced to prevent a nut that rots from contaminating nuts in close proximity and allows the seedlings to be removed from the sand bed with minimal damage.

Further information

- Spacing techniques may vary, however one method of ensuring nuts are evenly spaced is to purchase a piece of 40mm x 40mm weld mesh and press this into the sand before planting. Nuts are then placed evenly in the middle of each square. A 40 x 40mm grid will give a nut density of 400 nuts per square metre of sand bed.

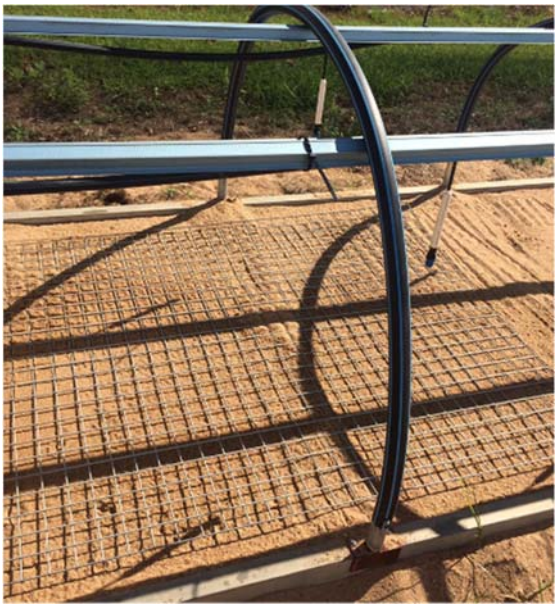

Image 7 – Example of use of mesh sheeting to assist in planting

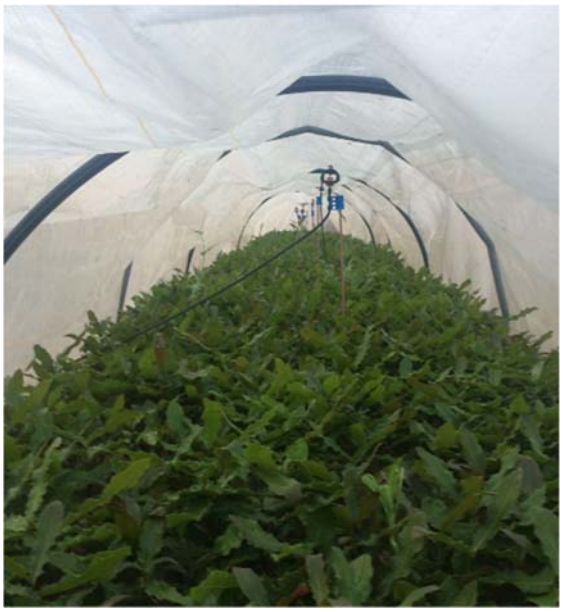

Image 8 – Example of seedlings ready for removal, inspection and transplanting.

Further Information

- There is some debate as to whether nuts should be placed just below the surface of the sand or at a maximum depth of 25mm above the seed surface. Placing the nuts at a depth of 25mm reduces the chance of them drying out as readily as nuts placed just below the surface.
- Planting the nuts at depths greater than 25mm above the seed surface is not recommended as this increases the germination time which may lead to more nuts rotting. It is also more difficult to remove the seedlings from the sand bed.

Managing the sand bed

The seed nuts in the bed should be kept damp but not wet.

Seed beds ***must*** be regularly checked for the presence of pest, disease and for weed growth (see Section A.15.6.1 Inspection and monitoring).

Further information

- The frequency of irrigation required will change with season and with daily weather. Nuts may be checked regularly by digging one or two up to check on the progress of germination and the how wet the nuts are.
- Watering the seed bed late in the afternoon in late autumn or winter may reduce seed bed temperature, through evaporative cooling, and lead to slower germination. A cool wet sand bed is also likely to be more conducive to pathogen development. Similarly, when the seedlings have emerged, they should not 'go to bed' wet at night as this may encourage pathogen development.
- When the seeds have germinated, consider keeping the surface of the sand cool as the emerging shoot tip is very delicate and easily damaged. Sand can easily heat up and retain enough heat to damage the shoot tips.

A.15.5.1.2 Heat beds

Germination may be enhanced with the use of bottom heat supplied by electric heating cables, however specialist heat mats, designed for the purpose, should be used as the combination of water and electricity can be lethal.

If using a heat mat then ideally it should be placed on an insulated bed of Styrofoam (polystyrene) to reduce heat loss through the bottom of the mat. This foam pad should be carefully wrapped in plastic so as to prevent it becoming contaminated with pathogens.

The heat mat is generally best placed on a normal height table as this will allow the nuts on the table to be readily inspected for germination. This table needs to be in a room that is not subject to draughts or extremes of temperature or this may negate the effectiveness of the heat mat.

Nut placement

Nut should be evenly placed on the mat so they are not touching so as to prevent pathogen transfer between nuts. It is not as important to orientate the nuts on a heat bed as in a sand bed as they will be transferred to a pot before the radical has developed any length.

Watering the nuts

The nuts need to be kept damp so that they germinate and the heat mat may need to be watered several times a day. If an irrigation system is used then it is better to use sprinklers with fine mist jets as this will dampen the nuts without watering them. Care should be taken to ensure water does not pool in any area on the seed bed.

Heat bed maintenance

The heat bed should be checked daily to ensure they maintain the correct temperature and the room in which it is placed is not becoming excessively hot or cold.

The bed should be checked daily for the presence of nut that have started to rot. Rotting nuts often go a dark black colour and may start to exude a creamy white sometimes orange streaked pus like secretion. Any suspect nut should be removed as soon as it is detected and discarded. Disposable gloves should be worn to prevent cross contamination.

Germination

Seed nut should be removed from the heat bed as soon as the nut has cracked, and the root has started to emerge.

Seeds should be placed on a tray lined with a damp cloth and then while planting the seed nut they should be covered with a clean damp cloth to prevent desiccation. When collecting germinated seed nut, do not collect more germinated seed that can be planted within a short period of time.

Potting up

Containers need to have been prepared in advance of germinated seed nut removal and planting. Containers should be tightly filled and contain well-watered potting media. A dry media may remove moisture from the growing roots and shoot causing damage.

Generally, a small hole is made in the centre of the pot so the top of the seed nut can be placed around 25mm below the surface of media surface. The nut should be placed so the suture line is parallel with the surface of the pot. This will promote a root that grows straight down and a shoot that grows straight up. The nut should then be carefully covered with potting media.

A.15.5.1.3 Direct seeding in containers – Interim potting

Direct seedling into small pots (e.g. 'forestry pots') is another method of germinating seed.

While it has the potential reduce both labour and transplant losses, great care ***must*** be taken when using this technique to ensure the trees do not become pot bound.

Further information

- Despite the use of root training and air pruning pots, there is some evidence to show that trees that have become pot-bound in smaller interim pots do not develop a strong spreading root system. This may, after planting, result in trees that are prone to instability and lodging.

Planting seed

Seeds nuts should be treated as for sand bed planting and heat bed planting with any diseased or damaged seeds discarded.

- Use only 'root training pots' so that the roots are guided down.
- The pots should contain a growing media similar to that into which they will be eventually be transferred.
- The seeds should be planted just below the potting mix surface with the suture line parallel with the surface on the mix.

The pots should then be kept moist but not wet until the seedlings emerge.

Image 9 – Satisfactory root system on left - on right unsatisfactory root system (left in interim pot too long).

Image 10 –Tree that was planted but fell over as root system still restricted by having been left in interim pot too long

Seedling maintenance

Once germinated, it is important to ensure that trees which are at the optimum stage for transplanting are identified. Once identified, these trees need to be transplanted as soon as practically possible to avoid them becoming root bound.

As for the other techniques, poorly performing seedlings need to be discarded.

If two or three batches of seeds are planted the care needs to be taken to keep the batches separate. For example, the poorly performing seedlings from the first batch should not be confused with the

better performing seedlings from subsequent batches simply because they are the same size. Poorly performing seedlings should be disposed of.

A.15.5.1.4 Direct seeding – Final container

Seeds nuts should be treated as for sand bed planting and heat bed planting with any diseased or damaged seeds discarded.

As with other techniques there are no hard and fast rules around the depth of planting the seed, with some nurseries placing the seed just at the surface and others with the top of the seed 25mm below the potting media surface. Whatever depth is chosen, the seed should still be placed so that the suture line is parallel with the surface of the mix so as to ensure as straight a tree as possible.

Rogueing of poor performing seedling ***must*** be undertaken in the same manner recommended for the other methods of growing macadamia trees. All poorly performing seedlings need to be removed as soon as they are detected.

Unlike other methods, there are not the stages where the root system can be examined during early development and this should be considered.

A.15.5.1.5 Poor performing seedlings

Poor performing seedlings that are stunted, deformed or showing any form of abnormality ***must*** be removed for disposal.

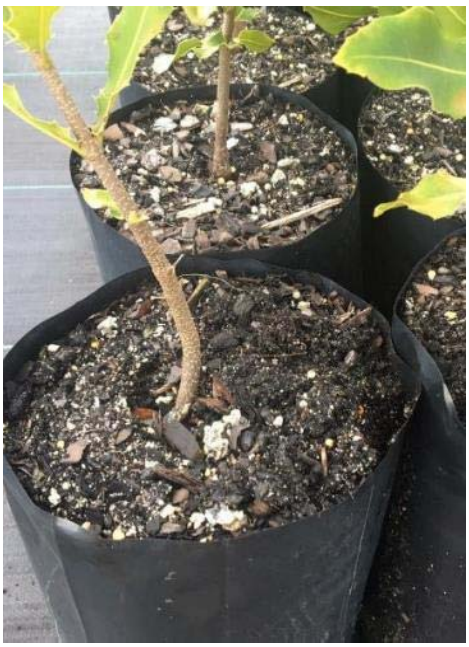

Image 11 – Bent stem and loose in pot.

Image 12 – Poor performing seedings. Irrigation water with a (high) EC of 1200.

Image 13 – Bent stem.

A.15.5.1.6 Labelling

Sown seed/seedling batches ***must*** be clearly labelled to identify variety and origin and allow tracing back to the *propagation material collection record* (see Section A.15.3.2 Propagation material collection records

Key requirements – Sowing seed nut

- Seed nuts ***must*** be sown in a quality free draining propagating media of sufficient depth to allow unimpeded development of the seedling's root system.
- Sown seed/seedling batches ***must*** be clearly labelled to identify variety and allow tracing back to the propagation material collection record.
- Poor performing seedlings ***must*** be removed and disposed of.

A.15.5.2 Transplanting seedlings into a final container

A.15.5.2.1 Removal

When seedlings are of sufficient size for transplanting into larger containers, each seedling should be gently removed from the propagating media taking care not to break off the seed attached to the root system.

A.15.5.2.2 Inspection

After removal, the root system of each seedling ***must*** be inspected to ensure only seedlings with a healthy well-developed root system are chosen for replanting. Seedlings with root abnormalities ***must*** be disposed of (see Section A.15.6.3.1 Root quality).

Once inspected, the seedlings should be placed in a container with as much of the germination media attached to the roots as possible and then covered with a damp cloth to reduce desiccation. Don't remove more plants that can be comfortably planted in a short period of time

Prior to replanting, seedling roots may be trimmed to encourage further development of a compact fibrous root system and to avoid creating J roots when seedling is placed in containers.

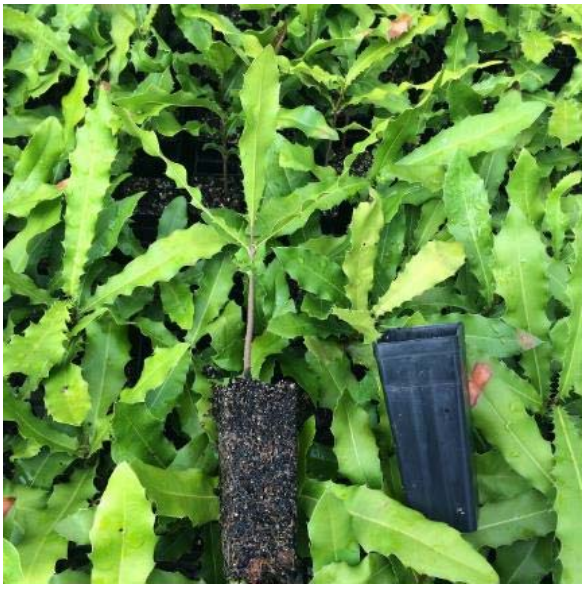

Image 14 – Healthy well-developed root system. smaller interim pot.

Image 15 –. Root bound. Left in smaller interim pot too long.

Image 16 – 'J' rooting. Unsatisfactory root system.

Image 17 – Healthy root system on left, poor quality roots on seedlings on right.

A.15.5.2.3 Replanting

Without delay, seedlings should be replanted in a container of appropriate size using a good quality growing media.

Containers ***must*** provide for adequate drainage and the size of the container used ***must*** consider the vigour of the plant and the time that the plant will be occupying the container in order to minimise the risk of development of root disease and allow appropriate root development and prevent excessive root binding (see NIASA Section 2.7 Root binding).

Containers should be prepared in advance of replanting. Potting media should be firmly packed with sufficient space made in the centre to accept the root ball.

Care ***must*** be taken to ensure that each seedling is planted within the centre of the container and the root system is not bent (J rooting). The seedling is planted to the same depth as it was planted prior to removal.

Further information

- When filling bags, the bag needs to be packed as tightly as possible. As the media degrades over time the bag may ‘slump’ causing a crease to form in the lower portion of the bag. This crease often forms along the line of the drainage holes. As the mix ‘slumps’, and the crease forms, these holes may go from round to oval and may eventually completely close reducing their drainage ability. This can then create an anaerobic or waterlogged bottom of the pot causing roots to die. Purchasing a suitable macadamia growing media and tightly packing the bags at the beginning may reduce this problem.

A.15.5.2.4 Avoiding wind damage and sunburn

Seedlings ***must*** be provided with sufficient wind protection, and sufficient shade to avoid sunburn on lower leaves and death of apical bud.

Further information

- Although not mandatory, it is recommended that the nursery be surrounded by a shade cloth fence at least 1.8m high. This will help protect the seedlings from side winds which may desiccate the trees and damage delicate new growth. When the trees are older the fence may also reduce the number of trees that are blown over during periods of high wind. An incidental benefit may include a reduction the amount of weed seed that is blown into the nursery area from the nursery surrounds which may reduce the amount of weeding required.

Image 18 – Sunburn on lower leaves

A.15.5.2.5 Labelling

Transplanted seedlings ***must*** be clearly labelled to identify variety and origin and allow tracing back to the *propagation material collection record* (see Section A.15.3.2 Propagation material collection records).

Key requirements – Transplanting seedlings

- When seedlings are removed for transplanting into larger (final) containers, only seedlings with a well-developed root system ***must*** be selected.

- Seedlings ***must*** be planted at the centre of the container and care ***must*** be taken to not bend the root system.
- Seedlings should be provided with adequate wind/sun protection.
- Seedlings ***must*** be clearly labelled to identify variety and allow tracing back to the propagation material collection record.

A.15.5.3 Grafting

Success in establishing a successful graft in macadamia is not absolute. Graft success in a conventional production nursery situation has been reported on average to be in the order of 75%, however this varies with variety and the time of year. The cause or causes of graft failure are often not clear, however poor graft technique is likely to be associated with early death of the scion. Good nursery stock hygiene coupled with monitoring graft success rates and changes in technique will allow a production nursery to improve graft success over time.

The grafting method used by the business may vary, however whip and side-wedge graft are most frequently used. With all methods, the rootstock or scion ***must*** not be allowed dry out prior to attachment. While grafting in the production nursery, budwood/scion should be kept in a box lined with wet cloth or newspaper and covered with a damp cloth to prevent desiccation.

A.15.5.3.1 Conventional grafting

For conventional grafting, when material is ready for grafting (the diameter of the rootstock matches the diameter of the scion to be used) remove the top portion of the tree leaving approximately at least 250mm of the rootstock measured from the media surface. Remove leaves present at the top of the rootstock.

When performing a whip graft, a sloping surface should be made that extends at least 20mm in length at the top of the rootstock using a sharp cutting instrument or a plane. As soon as the rootstock is prepared select a scion of the same approximate diameter and cut/plane a matching sloped surface to provide the best contact with the cambium.

When performing a side-wedge graft, the scion is prepared by making a 'V' shaped wedge cut at the base of the scion then the wedge is inserted into a straight downward cut on the edge of the rootstock. Again, the wedge and the cut ***must*** match and align to provide the best contact with the cambium. Where the process causes the rootstock to split, the graft process ***must*** be started again.

The graft surfaces ***must*** then be mated and tightly wrapped and tied with grafting tape or parafilm or equivalent, then the remaining scion is also wrapped, or provided with an alternative coating, to prevent desiccation. Grafting paint is often used to cover the graft to reduce desiccation and also reduce the heat load on the new graft.

The propagated tree should then be well watered. The appearance of vegetative shoots on the scion some weeks later will indicate a successful graft.

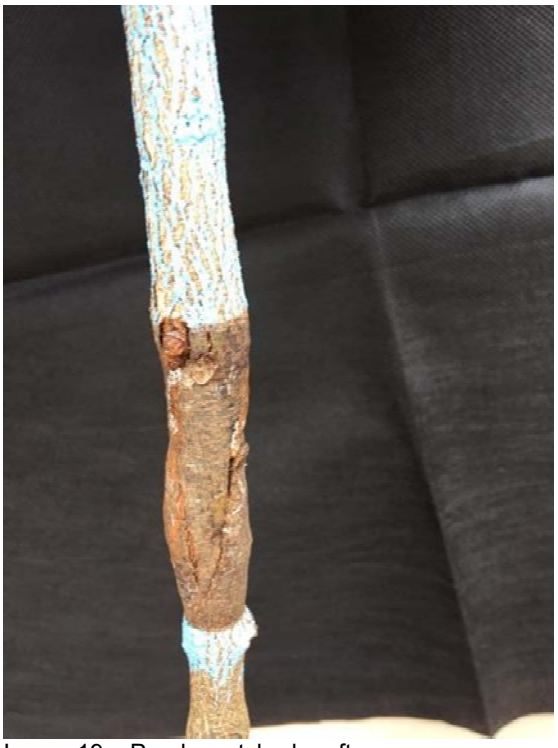

Image 19 – Poorly matched graft

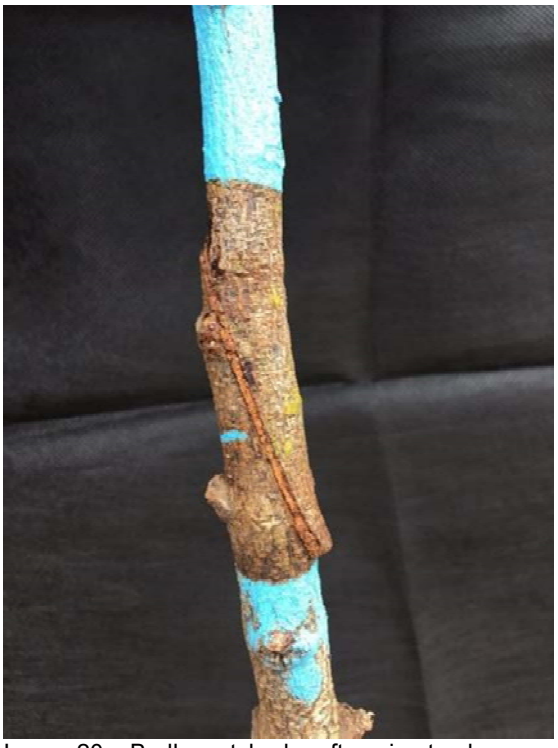

Image 20 – Badly matched graft - scion too large.

Image 21 – Gaps at side of graft

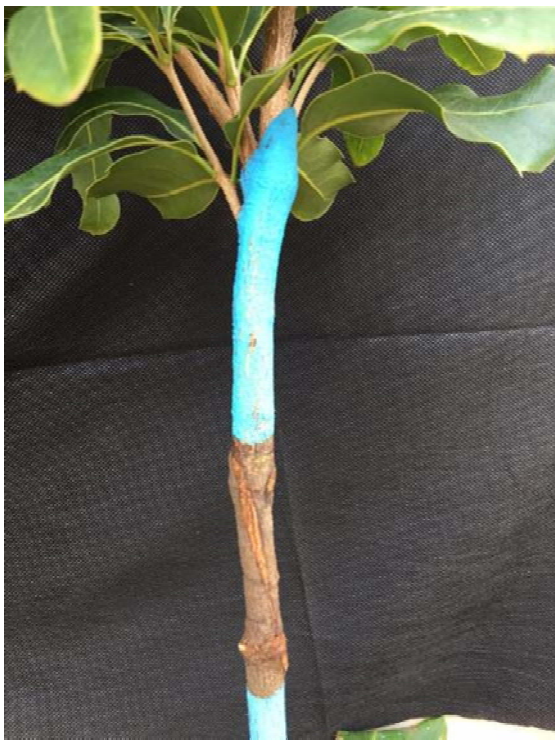

Image 22 – Better graft – even sides.

A.15.5.3.2 Micro-grafting

Micro-grafting (grafting when the trees are less than 15cm high), and mini-grafting (grafting when the trees are as thick as a large pencil and <30cm high), are specialist propagation techniques and should only be attempted by highly experienced nurseries with appropriate facilities.

Businesses contemplating micro or mini-grafting should seek specialist advice. In both these systems there is the need for a misting system to maintain humidity post-grafting. This can lead disease problems unless strict hygiene procedures are followed.

Key requirements – Grafting.

- Rootstock and scion diameter ***must*** be matched to allow maximum cambium contact.
- Graft surfaces ***must*** not be allowed to dry out.
- Once surfaces are mated, they ***must*** be tightly wrapped and tied with grafting tape or parafilm or equivalent.
- The remainder of the scion ***must*** be sealed to prevent desiccation.

A.15.5.4 Labelling of grafted trees

Propagated trees ***must*** carry a durable label that identifies:

The variety of rootstock and/or scion material used.

The material used for its propagation that links back to the *propagation material record*.

Key requirements - Labelling

- Trees ***must*** carry a durable label that identifies the rootstock/scion variety and links the material used back to the propagation material collection record.

A.15.6 Plant health monitoring

A.15.6.1 Inspection and monitoring

All trees ***must*** be regularly monitored for root, stem, graft and foliar pests and diseases, weeds, and nutritional and physiological disorders.

An early indicator of infection can be identified through monitoring of both above ground and below ground plant parts.

Inspection for symptom expression on above ground plant parts should be conducted on propagated plants as part of good nursery practice, however a representative number of plants will require monitoring for root quality and disease expression. Where suspicious symptoms are detected, samples ***must*** be sent for diagnostic testing.

A.15.6.1.1 Inspection frequency

Monitoring of propagated trees for pests, diseases, weeds and disorders ***must*** be conducted at least quarterly.

Quarterly monitoring and inspection of above ground plant parts continues throughout the production cycle, **however inspection of the below ground plant parts**:

- **commences 6 months after the initial establishment of an individual tree**, that being from the time of establishment / planting of a rootstock plant in its final container; **and**
- **concludes** 3 months prior to the anticipated despatch date.

Below ground plant part monitoring is conducted on 'sentinel' plants established within the crop and on any other tree displaying symptoms consistent with root disease and nutritional/physiological disorders.

A.15.6.1.2 Establishing sentinel trees for root health monitoring

The proportion of propagated trees to be monitored for below ground plant part quality and health is based on the estimated number of trees (rootstock or rooted cuttings) established in containers by the production nursery per year.

Sentinel trees are established in a systematic manner based on the estimated annual production of the business in accordance with Table 3 – Sentinel tree establishment rate.

For example, for a business that establishes an estimated 100,000 rootstock trees in containers per year, each new batch of trees should have at least 1 sentinel tree for every 600 trees containerised. For a business that has an estimated annual production rate of 40,000 trees per year, each new batch of trees should have at least 1 sentinel tree for every 200 trees propagated.

Table 3 – Sentinel tree establishment rate

Number of macadamia trees produced by the production nursery per year	Proportion of trees to be monitored as sentinel trees	
	Approximate % of total	Actual rate per batch of new trees
<30,000	1.5%	1 in 50 trees
>=30,000	0.50%	1 in 200 trees
>=60,000	0.25%	1 in 400 trees
>=90,000	0.17%	1 in 600 trees
>=120,000	0.125%	1 in 800 trees
>=150,000	0.10%	1 in 1000 trees

Sentinel trees should be evenly distributed through each batch and also be kept at a practical distance from walkways to allow for inspection without damaging surrounding trees.

Each sentinel tree ***must*** be given, and marked with, a unique sentinel tree number that is to be linked to the *crop monitoring record* (see Section A.15.6.4 Maintaining records of inspection).

Further information

- By applying the sentinel tree establishment rate provided in Table 1, approximately 150 trees will be established as sentinel trees for below ground plant part monitoring within the production nursery.
- It is recommended that sentinel trees are established in pots of equivalent size to other containers that will be used (for example, bags) to allow easy inspection of roots and sampling where necessary. Sentinel trees may then be transferred into other containers when root quality and health monitoring concludes, based on the production nursery's desired container type.

Key requirements – Inspection and monitoring.

- Propagated trees ***must*** be regularly inspected for the presence of stem, graft, foliar pests and diseases, weeds, nutritional and other disorders, and root health and quality.
- Above ground plant parts ***must*** be inspected at least quarterly. At least 35 trees within each batch within each production area ***must*** be closely examined for pests, diseases and disorders.

- Below ground plant parts ***must*** be examined for root quality and disease symptoms at least quarterly commencing 6 months after individual tree establishment and up to three months before anticipated despatch date.
- Below ground plant parts ***must*** be examined on sentinel trees established throughout the crop at a rate determined based on estimated annual nursery production and on any other tree displaying symptoms consistent with root disease.
- Sentinel trees ***must*** be marked with a unique sentinel tree number that is to be linked to the crop monitoring record

A.15.6.2 Inspection procedure - Above ground plant parts

Enter each separate area within the nursery and visually inspect for abnormal plant growth, pest presence, disease symptoms or weed growth.

Abnormal plant growth inspection includes inspection for distorted, brown, yellowed or damaged leaves, leaf fall, stem/trunk/graft abnormalities, stunting, dieback, abnormal tree form, temperature or water stress or damage, chemical damage, or signs of mineral deficiency.

Pest inspection includes inspection for leafminer, felted coccid, scale, thrips, mites, aphids, beetles (including beetle larvae), weevils, caterpillars, cicadas, tip borer, ants (many ant species, including fire ants, are regulated pest species), mealybugs, fungus gnats and other bugs.

Further information

- The NGIA provides pest fact sheets and a Pest ID Tool that is free to download at http://nurseryproductionfms.com.au/pests-diseases-weeds/ to assist in pest inspection and identification.

Weed inspection includes inspection of plant parts for saprophytic or parasitic weeds as well as inspection of the growing media for weeds growing independent of the tree.

Within each batch of trees within each growing area, **closely examine at least 35 trees**. Make an effort to select those trees that appear less healthy for close up inspection.

Inspect the tops and undersides of leaves, branches, stems and buds.

Use at least a 10x hand lens when examining abnormal growth. Damage from pathogens, insects, thrips, mites or scale insects suspected non-pathogenic sources should be recorded.

Symptoms caused by insect pests should be managed as required such that outbreaks are minor and limited. No trees should be knowingly sold that are infested with a pest population that is likely to become damaging and would require a customer to take corrective action (see Section A.15.8 Product quality and meeting customer expectations).

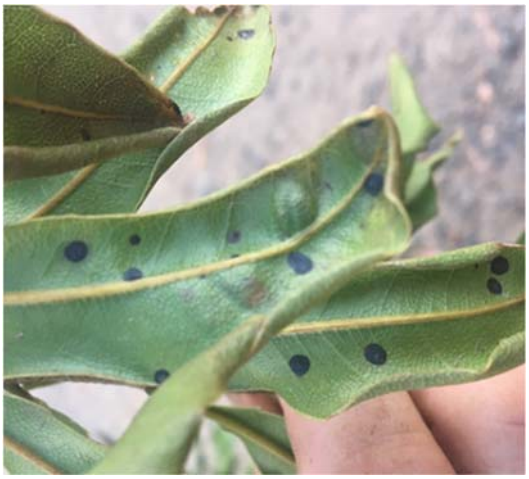

Image 23 – Scale on foliage

Monitor health of graft union by looking for excessive build-up of necrotic tissue around the graft union. Check under graft tape for the presence of felted coccid. Felted coccoid can rapidly multiply under the graft tape where it is protected from predators and chemicals. The developing graft union also acts as a source of food. Trees with such symptoms should be removed from the production area. Where a tree shows stem rot or graft necrosis (cell death causing tissue darkening or wilting) that is not suspected to be the result of poor formation of the graft, mechanical damage, graft incompatibility or the physiological condition of the rootstock, submit the tree for diagnostic testing (see Section A.15.7 Pathogen testing). Likewise, examine the stems of the same tree to assess if there are any necrotic lesions present.

Do not sell trees that have symptoms of stem or graft necrosis (see Section A.15.8 Product quality and meeting customer expectations.

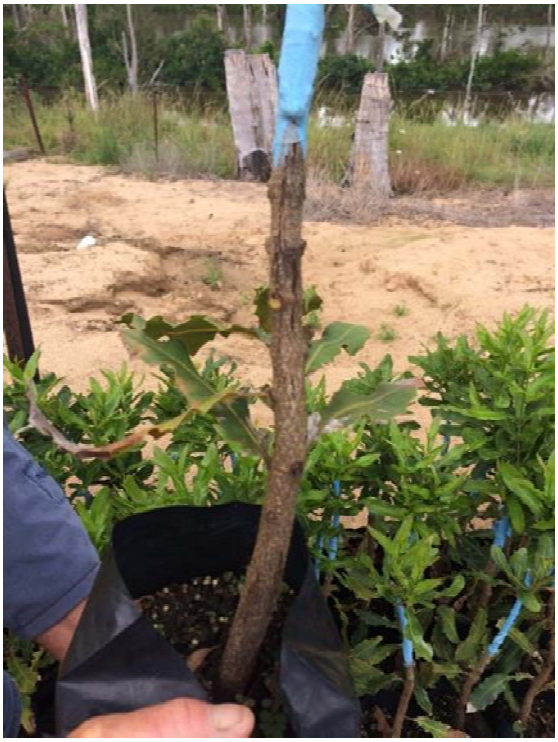

Image 24 – Canker on stem

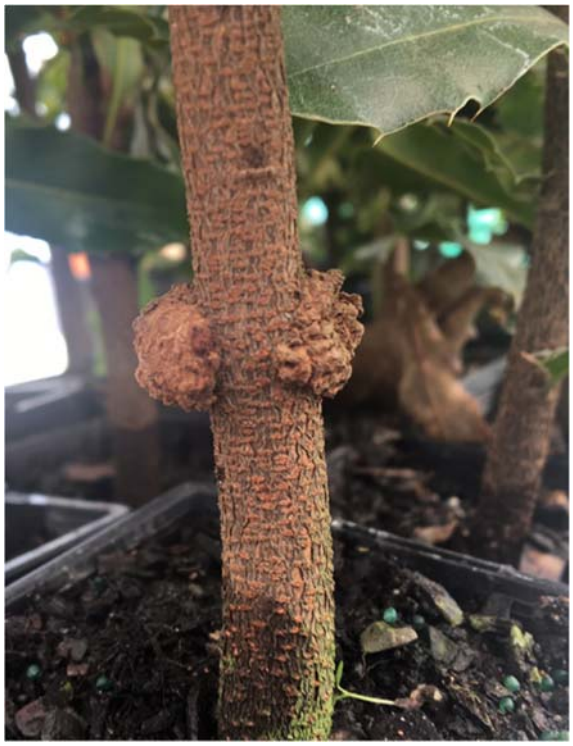

Image 25 – Stem canker

Symptoms of necrosis and chlorosis (causing yellowing) on foliage should be assessed as to the suspected cause. Those symptoms that are consistent with non-pathogenic causes (sunburn, nutrient regime, environmental conditions etc.) may need to be sent for testing.

Due diligence ***must*** be taken to limit the extent and severity of such symptoms developing in the future. Any remedial action that can be taken, e.g. alteration of light, irrigation or nutrient regime, should also be taken such that trees grow optimally.

No trees should be knowingly sold with symptoms of disease, necrosis and chlorosis on foliage that would require a customer to take corrective action (see Section A.15.8 Product quality and meeting customer expectations.

Examine trees around symptomatic tree/s to ensure that they are free of disease. Where a large number of trees (greater than 5) show symptoms speak to a diagnostic laboratory about the specific symptoms and submit trees that will best equip them to test and diagnose the problem based on their advice (see Section A.15.7 Pathogen testing). For example, a problem in propagation will require more trees to be submitted than larger, more mature nursery trees.

Should weeds be detected they ***must*** be removed and managed as required. No tree should be knowingly sold that is infested with weeds.

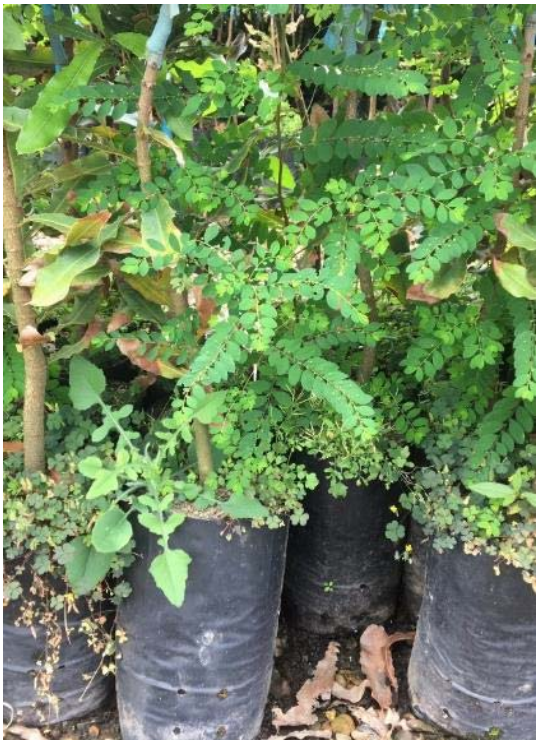

Image 26 – Serious weed infestation

A.15.6.3 Inspection procedure - Below ground plant parts (Sentinel trees)

Remove each sentinel tree from its container and examine the root system.

A.15.6.3.1 Root quality

Trees should have a uniform distribution system of roots. Advanced trees should retain at least 90 percent of the growing media volume around the rootball.

Examine trees around problem tree/s to ensure that they are free of root quality problems. Where further quality problems are identified, the batch ***must*** be rejected until such time that the extent of the problem has been determined and corrective taken to eliminate the problem has been taken.

Do not sell trees that display signs of root spiralling, root binding, J-roots, girdled or kinked roots.

Image 27 – Satisfactory roots (media removed)

Image 28 – Unsatisfactory roots (media removed)

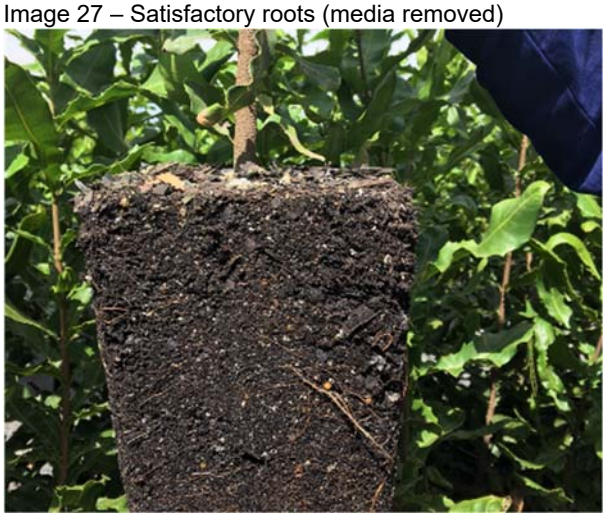

Image 29 – Quality root systems. Note growing media retention when removed from the container.

A.15.6.3.2 Root health

In general, greater than 90% of visible roots should be white, healthy feeder roots. Where roots appear to be unhealthy or rotten (darkened or otherwise damaged), cut the epidermis along the root with a sharp knife to expose the centre of the root (the stele). If the root is white it is not rotten. However, if there are few actively growing, white feeder roots visible compared to the number of dark roots, it may indicate that growing conditions are not optimal.

Inspect the roots for signs of nematode infestation (root galls).

Inspect the potting mix for the presence of cane grub larvae. These larvae feed on the roots in the pot and can lead root loss. If the pots have sufficient water but still show then wilting, this may indicate root problems that are impacting on the plant's ability to uptake water**.**

Examine the roots of plants around the sentinel tree to determine if symptoms are present in more trees. If roots of trees are consistently showing signs of disfunction, submit a tree for diagnostic testing (see Section A.15.7 Pathogen testing). If it is only one tree, assess growing conditions, take remedial action and only submit a tree for testing if root health does not improve as is expected.

Examine trees around problem tree/s to ensure that they are free of root health problems. Where further health problems are identified the batch ***must*** be rejected until such time that the extent of the problem has been determined.

Where the internal root tissue appears rotten submit the tree for diagnostic testing (see Section A.15.7 Pathogen testing). Check root health of trees around the sentinel, ensuring that the blade is sterilised between trees (or use a different blade). Submit at least one tree for diagnostic testing. If more than one tree shows symptoms talk to your diagnostic laboratory for advice on how many trees to submit.

Do not sell trees with unhealthy root systems.

Where problem seeds are suspected as the cause of a disease or disorder, submit as many symptomatic seeds (and plants that may be growing from symptomatic seeds) as is practical to a diagnostic laboratory for testing (in general, 10 seeds per symptom type can be used to test for and identify a range of pathogens). See Section A.15.7 Pathogen testing.

Use disposable gloves or wash with hand sanitiser if moving on to another tree.

A.15.6.4 Maintaining records of inspection

The business ***must*** maintain a *crop monitoring record* that documents:

- the date that the activity was conducted;
- the person who conducted the activity;
- the activity type (sentinel tree inspection or above ground tree part monitoring);
- the crops monitored (for example "Propagation area 2 – Bed 3");
- the scope of the monitoring (for example "all trees" or "35 trees" or "sentinel trees 1-10"; and
- the outcomes of the inspection (for example "no suspicious symptoms detected", or a description of the symptoms detected and the tree or trees that the symptoms were identified on, and the unique sample number or sample numbers if samples are collected).

An example of a *crop monitoring record* is provided in SCHEDULE 2: EXAMPLE RECORD SHEETS.

Key requirements – Maintaining records of inspection

- Records ***must*** be made and maintained of tree inspection and monitoring and outcomes including any samples collected and testing results.

A.15.7 Pathogen testing

A.15.7.1 NIASA approved testing laboratories

Samples that are collected may be despatched to an approved NIASA testing laboratory for analysis. Contact the NIASA accreditation provider for a list of approved testing laboratories.

Samples ***must*** be accompanied by the laboratory's request for testing form. Contact the testing laboratory for a copy of the laboratory's request for testing form and instruction on how to send samples.

A.15.7.2 Maintaining records of testing

Sample details ***must*** be recorded on the approved laboratory request for testing form and sent to the approved laboratory in accordance with the advice provided by the testing laboratory.

A copy of the laboratory request for testing form and sample testing results ***must*** be maintained by the business.

The production nursery ***must*** send a copy of test results that show a positive detection of a Group 1 pathogen (see SCHEDULE 1: GROUP 1 and GROUP 2 PATHOGENS) to the NGIA accreditation provider within 24 hours of receiving the result.

Key requirements - Pathogen testing.

- Where symptoms of infection are identified, steps ***must*** be taken based on the plant part inspected including requirements for sample collection and submission.
- Should a positive test for a Group 1 pathogen be received, follow up inspection and resampling is to be conducted to confirm infection, and determine the extent of contamination and determine the likelihood of elimination. Until such time as the extent of contamination is identified, propagated trees produced at the production site ***must*** not be certified as meeting the requirements of the Macadamia Nursery Stock Specification. Trees ***must*** be identified as "NOT TO SPECIFICATION".

A.15.8 Product quality and meeting customer expectations

Requirements for meeting customer expectations are managed in accordance with requirements provided in NIASA Section 3.5 Product quality and meeting customer expectations. Trees ***must*** meet the following quality requirements, prior to consignment, to meet Macadamia Nursery Stock Specifications:

- Trees are labelled in accordance with this Appendix (see Section A.15.5.4 Labelling of grafted trees).
- Trees are true-to-type without any obvious sign of pest, disease, mechanical, nutritional or chemical disorder.
- Leaves are glossy green and uniform in colour, and without any sign of deformity.
- The above graft head of the tree should comply with the customer requirements. If a central leader is specified than a central leader should be supplied. If a multi-shoot head is specified then a multi-shoot head should be supplied.
- Stems are straight (<15 degrees vertical deviation) without significant bends or kinks.
- Graft unions are smooth and healthy without any indication of incompatibility.

- Trees are free of shoots and suckers below the graft.
- Trees are uniform and of the size specified by the customer for field planting, and carry a minimum of two hardened flushes.
- Trees are planted into containers that are of adequate volume and depth to provide sufficient space to accommodate a healthy and vigorous root system.
- Trees are self-supporting.
- Containers are free of weeds.
- Containerised trees are no more than 24 months in age.

Trees should be continually monitored throughout the production process; however, trees ***must*** be inspected towards the end of the propagation process and no later than 72 hours prior to despatch and comply with the quality specifications. In accordance with requirements provided in NIASA Section A.12.2 Dispatch, a visual assessment of trees ***must*** be conducted prior to loading and consignment.

Trees that do not meet these requirements ***must*** be rejected for consignment, and action ***must*** be taken to determine the source of the problem and correct the problem.

Image 30 – Trees ready for despatch

A.15.9 Auditing for compliance and continual improvement

Audits to assess compliance to Macadamia Nursery Stock Specifications shall be conducted annually in conjunction with annual NIASA auditing.

The auditor shall assess compliance to requirements based on examination of records, examination of general health of the crop and through crop pathology sampling where necessary. The cost of pathology analysis will be borne by the production nursery business. Examination of general health of the crop may include pathology sampling of individual trees that demonstrate symptoms of infection.

Sentinel trees will be examined for root health in the manner described within this Appendix. Where non-compliance to the Specifications is suspected, pathology samples may be taken for analysis. The cost of pathology analysis will be borne by the production nursery business.

Inspection will be undertaken on trees ready for despatch to assess whether stock meet the required standard of product quality (see Section A.15.8 Product quality and meeting customer expectations).

The inspected crop ***must*** not exceed detection of non-conformity in greater than 5% of the crop inspected and the crop ***must*** not display symptoms of infestation by Group 1 and 2 Pathogens. The auditor may remove graft tape on selected trees in order to undertake an inspection of these trees for graft union quality. After inspection the business may replace the tape should it see fit.

The business ***must*** achieve a **Satisfactory** result at audit for each of the requirements specified within this Appendix to be accredited as meeting Macadamia Nursery Stock Specifications. Results are captured within the Nursery Production Checklist (see MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST).

Further information

Audit assessment results for NIASA are categorised as follows:

1. Doesn't Apply (means not applicable to the business)

Is recorded where a requirement/procedure, in the opinion of the auditor, does not apply to the activities undertaken by the business, and implementation of the procedure is not required to satisfy the conditions of accreditation.

2. Complies Fully

Is recorded where the business, in the opinion of the auditor, can demonstrate that it complies fully with the procedural requirement.

3. Satisfactory

Is recorded where, in the opinion of the auditor, compliance to a procedure is generally satisfactory however a non-conformance to a requirement(s) of a procedure is identified which threatens neither the effectiveness nor the assurance provided by the accreditation. These non-conformances are generally minor, administrative or technical in nature.

4. Being Upgraded

Is recorded where, in the opinion of the auditor, a non-conformance is identified with compliance to a procedure which could threaten the assurance provided by the arrangement, but where there is no evidence of a failure to address the specific risk provided for by the procedural requirement and the business has corrective action already underway.

5. Needs Attention

Is recorded where, in the opinion of the auditor, a non-conformance is identified that could seriously threaten the effectiveness of the accreditation arrangement.

This may include a circumstance where a business fails to carry out a procedure or activity that is critical in addressing a serious risk.

Acknowledgements

The development of this Appendix has been funded by Hort Innovation under project MC17001, using the Macadamia Industry research and development levy and contributions from the Australian Government. Appendix banner image modified from an original image courtesy of Forest & Kim Starr [CC BY 3.0 (https://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons. Other images included within this Appendix provided courtesy of Dr Chris Searle, MacAvo Consulting.

Hort Innovation Strategic levy investment | MACADAMIA FUND

This project has been funded by Hort Innovation using the macadamia research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

SCHEDULE 1: GROUP 1 and GROUP 2 PATHOGENS

Macadamia nursery stock pathogens are divided into two groups based on their seriousness:

- **Group 1 pathogens**- This group contains pathogens which are destructive in both the nursery and post-nursery phase. Detection of these pathogens ***must*** be reported to the accreditation provider and trees that are infected ***must*** not be sold.
- **Group 2 pathogens**- This group contains pathogens that only cause issues in the nursery and not in the field.

Trees infected with a Group 1 soil borne pathogen may not display any above ground plant part symptoms in the nursery even though there has been drastic damage to the root system over several months.

Pathogens causing stem or graft rot symptoms are very serious and often cause death of the tree, either in the production nursery or after planting. Trees should not be sold with any signs of stem or graft necrosis. Such trees should be removed from the nursery hygienically to reduce risk of infecting surrounding trees.

Similarly, a number of fungi can cause seed rot symptoms that may lead to increased risk of stem rot diseases.

For some pathogens, when present, the level of infestation can be generally low and their presence in the production nursery is frequently associated with poor cultural conditions or retaining trees in the nursery for too long. Their presence may also be indicative of a failure in nursery hygiene.

Group 1 pathogens

Common name	Scientific name (Causative agent)
Phytophthora root rot	*Phytophthora cinnamomi*
Pythium root rot	*Pythium* species
Phytophthora trunk canker	*Phytophthora cinnamomi*
Gall canker	*Tubercularia lateritia*
Stem dieback or graft rot	Fungi from the family Botryosphaeriaceae

Group 2 pathogens

Common name	Scientific name (Causative agent)
Rhizoctonia root rot	*Rhizoctonia* species

SCHEDULE 2: EXAMPLE RECORD SHEETS

The following recording sheets are examples of how the mandatory record keeping for NIASA can be achieved.

There is no requirement to use these sheets but they indicate the information that ***must*** be kept in accordance with the NIASA Macadamia Nursery Stock Specifications.

Records ***must*** be made available to the Nursery Production FMS Auditor when requested.

- Source Block Record - (Example)
- Propagation Material Collection Record – (Example)
- Crop Monitoring Record - (Example)

Macadamia Nursery Stock Specifications
Source Block Record

Example Record

Accredited Business (Name):

Source Block Address:

Source Block Reference (Name or Code):

SECTION A – Property Ownership Details	
Owner name/business name:	
Other details if applicable:	
SECTION B – Block Details	
Date block record started:	
Lot on Plan Number OR GPS coordinate at centre of block:	
Variety or varieties present:	
Number of rows present in the block if more than one variety present:	Map attached with block identified? ☐ Yes
SECTION C – Variety identification	
How is parent tree variety determined at or prior to material collection?	☐ Records are attached (genetic test results, varietal improvement program records, PBR etc.) AND/OR ☐ Examination of all or a combination of the following morphological trait/s below. ☐ Tree shape ☐ Tree size ☐ Tree density ☐ Leaf length ☐ Leaf width ☐ Tip shape ☐ Leaf spines ☐ Husk shape ☐ Shell features ☐ Other (specify) -
SECTION D – Identification of trees where there is more than one variety present in the source block	
Description of how parent trees to be harvested in a mixed block will be identified within the block (for example a tag placed on each tree, a row number and tree number in row, GPS or other method):	
SECTION E – Any other comments	

Macadamia Nursery Stock Specifications
Propagation Material Collection Record

Example Record

Accredited Business (Name):

Source Block Address: Source Block Reference (Name or Code):

Collection Details						
Date:	Collector name:	Material type:	Variety	Amount:	Batch code:	Comments:
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				
		☐ Seed nut ☐ Budwood/scion				

Macadamia Nursery Stock Specifications
Crop Monitoring Record

Example Record

Accredited Business (Name):

Business address: Inspection Person (name):

Date:

Crop area monitored (Site Plan reference – e.g. Shadehouse 1)	Monitoring activity	Crops monitored (e.g. Bench 3)	Plants inspected (e.g. Sentinels 1-10, 35 plants etc.)	Pest/diseases/disorders detected? (record NO or describe)		Comments / actions (Include sample numbers if applicable)
				Insects/pests	Diseases/disorders/abnormalities	
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					
	☐Sentinel/roots ☐Above ground					

MACADAMIA NURSERY STOCK SPECIFICATIONS CHECKLIST

Confidential

Nursery Industry Accreditation Scheme, Australia

Business Name: _____

Address:_____

_____Postcode:_____

Proprietor's Full Name(s):_____

Telephone:_____Facsimile:_____

Email_____

Application Number:_____

Nursery Production FMS Auditor:_____
Audit Date:_____
Review Date:_____

Note: Grey checklist items ***must*** be graded as satisfactory or greater to achieve NIASA accreditation

This project has been funded by Hort Innovation using the macadamia and nursery levy and funds from the Australian Government.

CHECKLIST: Macadamia Nursey Stock Specifications

*Applicable to businesses seeking Macadamia Nursery Stock Specifications accreditation **in addition** to meeting other NIASA production nursery accreditation requirements.*

SOURCE MATERIALS TO BE USED FOR PROPAGATION

Source block records

Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply

A *source block record* is maintained that identifies the source/s of material used for propagation

- Unique identification name or code
- Property address and owner
- Lot on Plan or GPS coordinate
- Block map
- Variety or varieties
- Variety confirmation records
- Method of identifying variety in mixed block
- Number of rows in the block (if mixed variety block)

Records must be sighted by the Nursery Production FMS Auditor

Comments:

Propagation material collection records

Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply

A *propagation material record* is maintained that identifies material collection details from the source block.

- Source block name or code
- Collection date
- Type of material collected
- Variety
- Source of material identified for collection from variety in mixed block
- Unique batch code

Records must be sighted by the Nursery Production FMS Auditor

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

MATERIAL COLLECTION AND HANDLING

Seed nut

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Seed nut is stored under appropriate storage conditions					
Stored seed nut batches are labelled to identify variety, block code, collection date and a unique batch code					
Batches of seed nut can be traced back to the *propagation material collection record*					

Comments:

Budwood / scion material

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Budwood has been girdled					
Material is stored under appropriate storage conditions					
Stored material is labelled to identify variety, block code, collection date and a unique batch code					
Batches of material can be traced to the *propagation material collection record*					

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

PROPAGATION

Sowing seed nut

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Seed nut is sown in a quality free draining propagating media					
The seed bed / container is of sufficient depth to allow unimpeded development of the seedling's root system					
Seedlings are adequately spaced					
The business has a system in place for removal and disposal of poor performing seedlings					
Seedling batches are clearly labelled to identify variety and allow tracing back to the *propagation material collection record*					

Comments:

Transplanting

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Seedlings are inspected and only seedlings with a well-developed root system are selected for transplanting					
The container is of sufficient depth to allow unimpeded development of the tree's root system and provides sufficient drainage					
Transplanted seedlings are planted at the centre of the container					
Care is taken to not bend the root system					
Transplanted seedlings are planted at an appropriate depth					
Trees are provided with sufficient shade - sunburn on lower leaves or death of apical bud is not evident					
Transplanted seedlings are provided with adequate wind protection – wind damage is not evident.					
Transplanted seedlings are clearly labelled to identify variety and allow tracing back to the *propagation material collection record*					

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

Grafting

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Rootstock and scion diameter are matched to provide maximum cambium contact					
A system is in place to ensure that graft surfaces do not dry out					
Graft unions are tightly wrapped and tied					
The remainder of the scion is sealed to prevent desiccation					

Comments:

Labelling of propagated trees

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Trees are clearly labelled to identify variety of scion and rootstock and allow tracing back to the *propagation material collection record*					

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

PLANT HEALTH – ABOVE GROUND PLANT PART MONITORING

Above ground plant part monitoring	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Monitoring of plants for abnormal growth, pests, diseases and weeds is conducted quarterly					
At least 35 plants are inspected within each batch of plants present within each growing area					
Inspection staff can demonstrate the inspection process required for each plant inspection					
Inspection staff understand actions that *must* be taken on detection of suspicious symptoms					
Records of any testing conducted and test results are maintained					
A *crop monitoring record* is maintained that documents: • the date/s on which monitoring was conducted • the person conducting the inspections • the activity type (above ground plant part inspection) • the crops monitored (location, crop batch) • scope of the monitoring (e.g. the number of plants inspected per batch) • the outcomes of the monitoring including sample numbers if applicable					

Records must be sighted by the Nursery Production FMS Auditor

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

PLANT HEALTH – BELOW GROUND PLANT PART MONITORING

Estimated number of trees produced per year for sentinel plant root monitoring
(Tick which box applies)

Tick	Action
	< 30,000 trees produced per year
	>=30,000 tress produced per year
	>= 60,000 trees produced per year
	>= 90,000 trees produced per year
	>= 120,000 trees produced per year
	>= 150,000 trees produced per year

Comments:

Below ground plant part monitoring (Sentinel Plants)

Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
Sentinel plants are established at the specified rate				
Each sentinel plant is marked with a unique sentinel plant number				
Sentinel plant monitoring for root quality and health is conducted quarterly, commencing six months after the initial establishment of an individual plant until three months prior to the anticipated despatch date				
Inspection staff can demonstrate the inspection process required for each inspection				
Inspection staff understand actions that *must* be taken on detection of suspicious root symptoms				
Records of any testing conducted and test results are maintained				
A *crop monitoring record* is maintained that documents: • the date/s on which monitoring was conducted • the person conducting the inspections • the activity type (sentinel plant) • the crops monitored (location, crop batch) • the scope of the monitoring (e.g. the unique number/s of the sentinel plants inspected in the batch) • the outcomes of the inspection including sample numbers if applicable				

Records must be sighted by the Nursery Production FMS Auditor

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

PRODUCT QUALITY AND MEETING CUSTOMER EXPECTATIONS

Product quality at consignment	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
The business has a system in place to inspect trees for quality requirements within 72 hours of despatch					
Trees are labelled in accordance with requirements					
Trees are planted in appropriate size containers					
Trees appear true to type and uniform in appearance					
Trees are without any obvious sign of pest, disease, mechanical, nutritional or chemical disorder					
Leaves are glossy green and uniform in colour without any sign of deformity or malnutrition					
Stems are straight without significant bends or kinks					
Graft unions are smooth and healthy without any indication of incompatibility					
Trees are free of any shoots and suckers below the graft					
Trees are at the height specified by a customer for field planting					
Trees carry a minimum of two hardened flushes					
Trees are self-supporting					
Containers are free of weeds					
Staff can explain quality requirements and the process for rejection of non-conforming trees					

Comments:

CHECKLIST: Macadamia Nursey Stock Specifications *Continued*

CROP INSPECTION BY AUDITOR

	Needs Attention	Being Upgraded	Satisfactory	Complies Fully	Doesn't Apply
General crop health and quality - above ground plant parts					
General crop health and quality – below ground plant parts					

Comments:

Note- Auditor samples are recorded in Section 12 of the Production Nursery Checklist