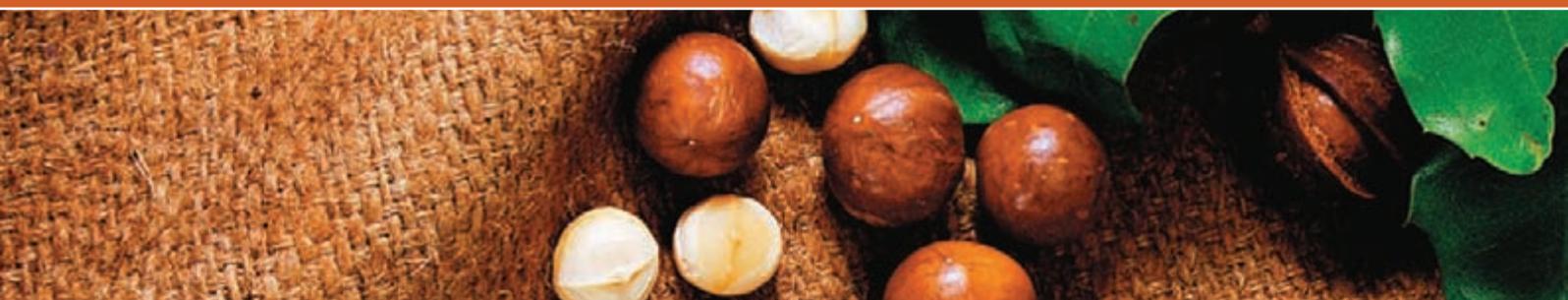


Macadamia problem solver & bug identifier

Reprint – information current in 2003



REPRINT INFORMATION – PLEASE READ!

For updated information please call 13 25 23 or visit the website www.deedi.qld.gov.au

This publication has been reprinted as a digital book without any changes to the content published in 2003. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.deedi.qld.gov.au or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 2003. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

This information has been made available to assist users to identify issues involved in macadamia production. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained in this publication.



Queensland Government

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Typical symptoms— leaf fall, yellow leaves, and twig dieback



Close-up of yellowing and burning of the leaf margins

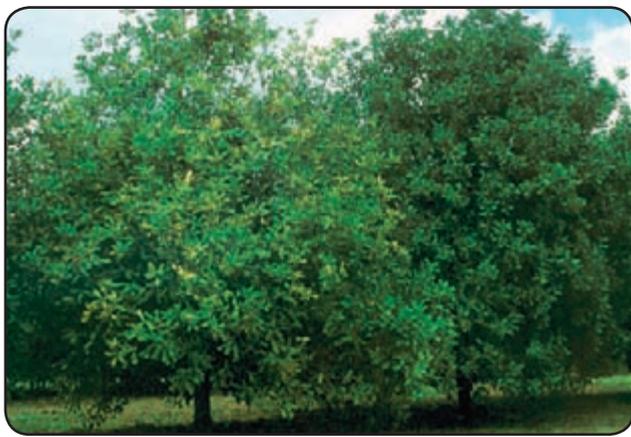
Tree decline

Cause: Undetermined. Believed to be caused by a combination of factors that lead to a run-down in tree health. These include nutrient deficiencies; low soil organic matter levels; soil erosion, exposing surface roots to desiccation; root death in compacted or shallow soils (heavy clay or rock within 1 m of the surface).

Identification: Typical symptoms are leaf fall, yellow or bronzed leaves and twig dieback. Trees may die. Leaves may show a wide range of symptoms but leaf spotting, and yellowing and burning of the leaf margins are common.

Treatment: Prune affected trees to reduce tree size by one-third. Apply a general foliar fertiliser at regular intervals once new leaf growth has occurred. Maintain a layer of mulch 5 cm thick up to and just outside the dripline to help encourage new root growth. Ensure that the mulch is kept away from the trunk. Trees may take some time to recover.

Prevention: Maintain appropriate levels of soil nutrients by using regular soil and leaf analysis. Pay particular attention to phosphorus, calcium and pH. Regularly apply mulch, particularly where soil erosion or mechanical harvesting exposes surface roots. Consider a perennial 'living mulch' such as sweet smother grass in the interrow and tree row areas. Control water flow within the orchard to prevent water flowing down the tree rows, causing soil erosion. Treat insect and disease problems promptly to maintain trees in a healthy vigorous condition. Regular light pruning of healthy trees encourages vigorous new growth. Avoid planting macadamias in shallow marginal soils.



Typical symptoms – lack of vigour, yellow leaves, and leaf fall (healthy tree on right)



Trunk symptoms – mature tree



Trunk symptoms – young tree

Trunk canker disease

Cause: The fungus *Phytophthora cinnamomi*.

Identification: Typical symptoms are lack of vigour, yellow leaves and leaf fall. In advanced cases, twig dieback may also be present, and trees often set a heavy crop of nuts. Trees may die. On the trunks, affected areas (cankers) show as dark discolouration of the bark, often with gum or resin exuding. If the bark is removed, a brown discolouration of the outer wood is visible. As the disease progresses, deep furrowed vertical cankers with split bark may extend up from ground level. Suckers may develop from the rootstock, particularly in young trees.

Treatment: With small cankers, pare back affected bark and wood with a sharp knife; thoroughly soak trunks with an appropriate registered fungicide. Some labels recommend the fungicide be applied in conjunction with a white, water-based paint. This helps seal the wound and keep the fungicide in contact with the tree. Where cankers are extensive, and paring back affected bark/wood is impracticable, either spray or paint affected areas, or spray affected trees with an appropriate registered systemic fungicide. Repeat as directed.

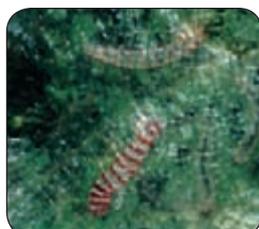
Prevention: Plant disease-free nursery trees. Avoid planting in soils subject to periodic waterlogging. Where drainage is marginal, plant on shallow mounds with an effective orchard surface drainage network. Avoid wounding the trunk, particularly when using slashers. Keep mulch and fertiliser at least 30 cm from the base of the trunk. Before the wet season, spray the trunk with a mixture of a copper fungicide and white, water-based paint to a height of 350mm.



Typical field symptoms – scorched appearance of new growth



Close-up of leaf blisters (left), insect mines (right)



Fully grown larvae under a blister



ready to pupate

Close-up of fully grown larvae (blister removed) – actual size up to 6 mm long

Macadamia leafminer damage

Cause: Larvae of the macadamia leafminer *Acrocercops chionosema*.

Identification: Field symptoms are a ragged and fire-scorched appearance of the new growth flush. Close-up examination of affected leaves shows meandering mine tracks of the larvae and leaf blistering, the latter occurring with more extensive damage. If leaf blisters are moist, removal of the blister will reveal live larvae underneath. Fully-grown larvae are up to 6 mm long, pale green to yellow in the earlier stages, and with red bands when ready to pupate.

Damage is most severe in orchards located in elevated regions close to rainforest.

Treatment: Treatment is only necessary on young trees when more than 60% of inspected terminals are damaged. Where necessary, spray with an appropriate registered insecticide. Older trees can tolerate the damage with minimal effect, and do not require spraying.

Prevention: Regularly monitor young trees so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.

Leafminer has many natural enemies and if these are properly managed, spraying is generally unnecessary.





Damage first shows at a branch fork or leaf whorl (arrowed)



Close-up of damaged leaf whorls



Leaves webbed together as a shelter for the insect. Note the insect faeces



Close-up of a mature larva protruding from its shelter (actual size 25 mm)

Macadamia twig-girdler damage

Cause: Larvae of the macadamia twig-girdler *Neodrepta luteotactella*.

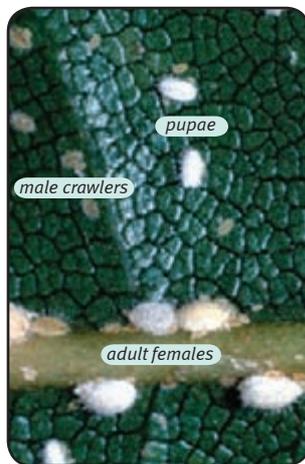
Identification: Damage generally first shows at a branch fork or leaf whorl and is generally confined to young trees in the field or nursery. The leaves may be skeletonised and the larva web them together into a shelter that incorporates larval faeces. Mature larvae are up to 25 mm long and a brown mottled colour with a black head capsule and longitudinal rows of dark-brown dots. They can be difficult to distinguish from larvae of macadamia nutborer. The insect may also affect nuts – see symptoms on page 140.

Treatment: First check that the damage is serious enough to warrant treatment. More than 15% of terminal shoots on young trees and 20% on mature trees need to be damaged to justify treatment. Where necessary, spray affected trees with an appropriate registered insecticide. Specific treatment may be necessary on young trees (up to about five years old), but is generally unnecessary on bearing trees, as sprays applied for nutborer provide adequate control.

Prevention: Regularly monitor trees so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects. The twig girdler has many natural enemies and if these are properly managed, spraying is generally unnecessary.



A heavy coccid infestation



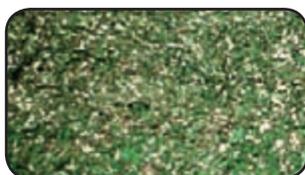
Close-up of infestation – magnified (actual size of adult females up to 1 mm)



Distortion of young shoots from coccid feeding



Feeding damage on older leaves



Close-up of trunk infestation

Macadamia felted coccid damage

Cause: The macadamia felted coccid *Eriococcus ironsidei*.

Identification: There is a range of symptoms. When the coccid feeds on young shoots, extensive distortion and stunting of the youngest leaves occurs. On older leaves, feeding causes yellow spotting, leaf browning and leaf death. Young seedlings and grafted trees may be killed by heavy infestations. Close examination of the undersides of affected leaves reveals a large number of small (up to 1 mm across) raised 'scales'. Depending on the time of year, these may be white to grey adult females (generally present along the leaf mid-vein), brown male crawlers and white pupae. Branches and trunks may also be infested. The insect gains its name from the felty covering of the adults and pupae. The coccid may also affect flowers – see symptoms on page 88.

Treatment: Spray affected trees with an appropriate registered insecticide. Spray only affected trees and trees in their immediate vicinity. Seek specialist advice from a macadamia pest consultant as frequent use of some chemicals destroys the natural enemies and may encourage build-up of the pest.

Prevention: As the pest is generally introduced into an orchard on budwood or nursery plants, carefully inspect all such materials for the pest. If detected, disinfect before use. Regularly monitor trees so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.





Macadamia white scale (actual size up to 2 mm across)



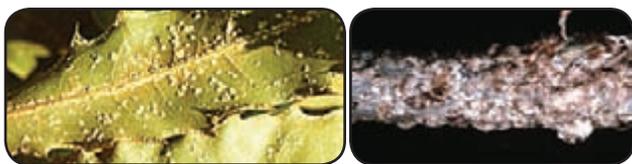
Long soft scale (actual size up to 3 mm long)



Macadamia mussel scale (actual size up to 2 mm long)



Oleander scale (actual size up to 2 mm across)



Latania scale: on leaf (left), on twig (right) (actual size up to 2 mm across)



Strap-leaf symptom showing significant leaf distortion



Curling and cupping symptom with leaf discoloration



Close-up of adult thrips (highly magnified – actual size less than 1.5 mm long)

Scale insects

Cause: Macadamia white scale (*Pseudaulacaspis brimblecombei*), long soft scale (*Coccus longulus*), macadamia mussel scale (*Lepidosaphes macadamiae*), oleander scale (*Aspidiotus nerii*) and latania scale (*Hemiberlesia lataniae*).

Identification: A number of scale insects infest leaves; some also infest twigs and branches. Appearance varies from small white circular patches to raised elongated lumps. Most scales infest the undersides of leaves but oleander scale is also common on the upper surfaces. Long soft scale and oleander scale occur mostly along the main vein. Black sooty mould often grows on honeydew secreted by long soft scale. Ants are often present, feeding on the honeydew. Scale insects may also affect nuts – see symptoms on page 116.

Treatment: Spray affected trees with an appropriate registered insecticide. Spray only affected trees and trees in the immediate vicinity. Spraying should be targeted at periods when young scales are moving to shoots and nuts. Seek specialist advice from a macadamia pest consultant as the frequent use of some chemicals destroys the natural enemies and may encourage build-up of scales.

Prevention: Regularly monitor trees so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects. As scales are commonly introduced into an orchard on nursery plants, carefully inspect these on arrival. If detected, disinfect before use.



Flower thrips damage

Cause: Flower thrips (*Scirtothrips* sp.).

Identification: Flower thrips are tiny insects with rasping and sucking mouthparts, which can damage new growth, particularly in dry seasons. Two types of symptoms can occur – distortion of the youngest leaves causing them to be significantly stunted and strap-like; and distortion of young leaves causing yellow to bronze discolouration with curling and cupping.

Adult thrips are tiny (actual size less than 1.5 mm) and not readily visible to the naked eye. Thrips may also affect flowers and nuts – see symptoms on pages 84 and 128.

Treatment: Spray affected trees with an appropriate registered insecticide. Spray only affected trees and trees in their immediate vicinity ('hot spots'). Heavy infestations are often reduced significantly following heavy rain – in these situations, spraying may not be necessary.

Prevention: Regularly monitor trees so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.





Typical symptoms – healthy tree on left; affected tree on right



Close-up of affected leaves – note that the margins are cupped downwards



Close-up of the mites (highly magnified – actual size less than 0.3 mm long)

Broad mite damage

Cause: The broad mite *Polyphagotarsonemus latus*.

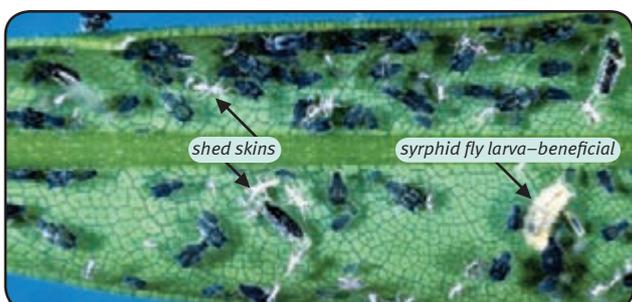
Identification: Damage is most common in nurseries, and occasionally occurs in young trees in the field. Typical symptoms are distorted leaves with the margins cupped downwards. The mites are extremely small – less than 0.3 mm long – and are not visible with the naked eye. The mite also affects flowers and nuts – see symptoms on pages 92 and 130.

Treatment: Treatment is generally only necessary in nurseries. Where required, sprays applied for spotting bugs are generally effective against broad mite. Spray only affected trees and trees in their immediate vicinity ('hot spots').

Prevention: Regularly monitor nursery trees so that the problem can be treated before it gets out of hand.



Typical field infestation – note the ants tending the aphids



Close-up of aphid adults and nymphs (magnified – actual size about 2 mm long)

Aphid infestation

Cause: The black citrus aphid *Toxoptera citricida*.

Identification: Aphids typically infest young shoots where they feed on the succulent new growth. The feeding (sap sucking) damage can cause distortion of the leaves and growing tip. Black sooty mould often grows on the honeydew secretions of the aphids. In many cases, ants tend the aphids for the honeydew secretions. Aphids are black, soft-bodied and up to 2 mm long. Infestations are most common in the cooler months of winter and early spring. Aphids may also infest flowers – see symptoms on page 100.

Treatment: Treatment is rarely necessary as natural enemies generally provide adequate control. Serious outbreaks are generally the result of frequent use of disruptive chemicals for other pests. Where necessary, spray with an appropriate registered insecticide.

Prevention: Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.





Typical 'scorched' appearance of affected leaves



Close-up of adult beetles (actual size about 4 mm long)

Redshouldered leaf beetle damage

Cause: Feeding by swarms of the redshouldered leaf beetle (or Monolepta beetle) *Monolepta australis*.

Identification: Beetles attack young leaves, often leaving only a network of veins. The affected leaves desiccate, giving a 'scorched' appearance to the shoots. Adult beetles are light yellow in colour with a cherry-coloured band across the base of the wing covers and a similarly coloured spot in the middle of each wing cover. Beetles are generally about 4 mm long. The beetles occur sporadically in plague numbers at various times of the year but are most common after rain in spring and summer. Swarms can invade orchards and cause serious damage within 2 to 3 days. Often individual trees or small groups of trees are heavily infested while adjacent trees are largely beetle-free. The problem is more serious in districts where there are large areas of kikuyu or similar pastures. Cadagi gum (*Eucalyptus torelliana*) is particularly attractive to the beetles and can be used as an early indicator of beetle activity. The beetles may also affect flowers – see symptoms on page 86.

Treatment: Spray only trees with beetle swarms and trees in their immediate vicinity with an appropriate registered insecticide. Heavily-damaged trees may take some time to recover.

Prevention: Monitor orchards carefully, particularly after rain in spring and early summer, so the problem can be treated before it gets out of hand. Be particularly vigilant in orchards adjacent to kikuyu pastures.



Typical distortion of leaves on a branch



'Witch's broom' effect. Note how the leaves lower on the branch are unaffected



Stiffened appearance from leaves becoming hard and leathery

Glyphosate herbicide damage

Cause: Drift or accidental application of glyphosate herbicide onto the foliage of the tree.

Identification: The youngest leaves on an affected shoot are small, distorted and often yellow. Often only one branch or part of a branch on a tree shows symptoms. The stunting of growth produces a bunched appearance known as 'witch's broom'. In some cases, the affected leaves become hard and leathery, giving the growth a stiffened appearance.

Young trees are particularly susceptible to damage because of the presence of green stem tissue and leaves close to the ground.

Treatment: If the damage is not severe, trees will gradually grow out of the problem. Pruning off the affected branches may help in recovery.

Prevention: Don't use glyphosate herbicide around young trees, particularly at or near planting-out time. If it is absolutely necessary, use a knapsack sprayer and mix the herbicide at rates at the lower end of the recommended label range. Protect the trees while spraying. To prevent herbicide uptake from lower leaves, strip them off when planting out, or use protective sleeves on the trunk.





Rolling and webbing of young leaves



Damage to the growing point produces multiple side shoots



Close-up of larvae (actual size up to 10 mm long)

Orange fruitborer damage

Cause: Larvae of the orange fruitborer *Isotenes miserana*.

Identification: Young leaves are rolled and webbed together to form silken tunnels or shelters for the larvae. Unlike many other moth and butterfly larval tunnels, the orange fruitborer tunnels are completely free of insect faeces.

Fully-grown larvae are up to 10 mm long and brown to greenish-brown in colour, with two brown stripes running down the length of the body.

In nurseries, damage to the growing point results in the development of multiple side shoots near the tip, instead of the single shoot required for grafting.

Treatment: In bearing trees, specific treatment for this pest is rarely necessary, as sprays applied for macadamia nutborer will generally keep it in check. However, treatment may be necessary in the nursery and occasionally on young trees in the field. Where necessary, sprays registered for nutborer are also generally effective against orange fruitborer.

Prevention: Regularly monitor trees in nurseries and young trees in the field so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Cup moth larva (*Anaxidea lozogramma*) on damaged leaf – actual size of larva up to 25 mm long



Macadamia cup moth larva (*Comana fasciata*) – actual size up to 20 mm long and 10 mm wide. Note the yellow stripe down the back, which helps the larva resemble a leaf



Large bagworm: female case on left (actual size about 100 mm long) and male case on right (actual size about 50 mm long)



Variegated hairy caterpillar (actual size about 60 mm long)

Caterpillar damage – 1

Cause: Caterpillars (larvae) of a range of moths and butterflies including cup moths (*Comana fasciata* and *Anaxidea lozogramma*), large bagworm (*Oiketicus elongatus*), and variegated hairy caterpillar (*Anthela varia*). See pages 30 and 32 for symptoms of damage by other caterpillars.

Identification: Leaf symptoms vary widely depending on the pest, but may range from complete defoliation of the young leaves through to ragged holes and patches in leaves.

Treatment: In bearing trees, specific treatment for caterpillars is rarely necessary, as sprays applied for macadamia nut borer and fruitspotting bug will generally keep them in check. However, treatment may be necessary in the nursery and occasionally on young trees in the field. Where necessary, sprays registered for nutborer and fruitspotting bug are also generally effective against caterpillars.

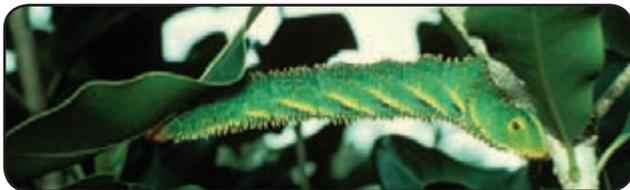
Prevention: Regularly monitor trees in nurseries and young trees in the field so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Bizarre looper viewed from above (actual size up to 30 mm long)



Bizarre looper; side view showing the typical looping body motion



Doubleheaded hawk moth larva (actual size up to 120 mm long)



Pencilled blue butterfly larva on a damaged leaf (actual size up to 16 mm long). Note that colour may vary according to diet

Caterpillar damage – 2

Cause: Caterpillars (larvae) of a range of moths and butterflies including bizarre looper (*Eucyclodes pieroides*), doubleheaded hawk moth (*Coenonympha triangularis*), and pencilled blue butterfly (*Candalides absimilis*). See pages 28 and 32 for symptoms of damage by other caterpillars.

Identification: Leaf symptoms vary widely depending on the pest, but may range from complete defoliation of the young leaves through to ragged holes and patches in leaves.

Treatment: In bearing trees, specific treatment for caterpillars is rarely necessary, as sprays applied for macadamia nut borer and fruitspotting bug will generally keep them in check. However, treatment may be necessary in the nursery and occasionally on young trees in the field. Where necessary, sprays registered for nutborer and fruitspotting bug are also generally effective against caterpillars.

Prevention: Regularly monitor trees in nurseries and young trees in the field so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Brown tufted caterpillar on damaged leaf (actual size of caterpillar up to 25 mm long)



Brown looper. Left immature larvae on a damaged leaf. Note that larvae are satiny-black in colour with transverse white bands, and are up to 25 mm long.



Right: mature larva. Note that larva is now brown in colour and up to 50 mm long

Caterpillar damage – 3

Cause: Caterpillars (larvae) of a range of moths and butterflies including brown tufted caterpillar (*Olene mendosa*), and brown looper (*Lophodes sinistraria*). See pages 28 and 30 for symptoms of damage by other caterpillars.

Identification: Leaf symptoms vary widely depending on the pest, but may range from complete defoliation of the young leaves through to ragged holes and patches in leaves.

Treatment: In bearing trees, specific treatment for caterpillars is rarely necessary, as sprays applied for macadamia nut borer and fruitspotting bug will generally keep them in check. However, treatment may be necessary in the nursery and occasionally on young trees in the field. Where necessary, sprays registered for nutborer and fruitspotting bug are also generally effective against caterpillars.

Prevention: Regularly monitor trees in nurseries and young trees in the field so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Affected tree showing branches affected by cicada egg-laying



Egg-laying slits made by female cicadas on twigs



Close-up of the twig damage at a later stage



Shed nymphal cases (actual size about 20 mm long), are often attached to the branches and trunks of affected trees

Cicada damage

Cause: Adult cicadas (*Psaltoda* sp.).

Identification: Large numbers of adult cicadas often emerge in orchards during summer. After mating, the female deposits eggs in slits cut in the branches by its spear-like egg-laying apparatus (ovipositor). These branches may splinter and die, and are also more susceptible to wind damage.

When the eggs hatch, the nymphs enter the soil and feed on the roots. When nymphs mature, they exit the soil and climb the tree. The emerging adults leave the shed skins attached to the branches and trunks.

Treatment: Damage is not generally serious enough to warrant treatment.

Prevention: As the damage is generally sporadic, no preventative measures are considered practical.



Distortion of the growing point from mealybug feeding



Close-up of mealybugs – magnified (actual size about 4 mm long) and a larva of the predatory ladybird (*Cryptolaemus montrouzieri*)

Mealybug damage

Cause: The hibiscus mealybug *Maconellicoccus hirsutus*.

Identification: Mealybugs congregate near the growing points. Feeding results in distortion of the youngest leaves and eventually, permanent damage to the tip. This results in stunting of the shoot and the formation of a rosette of leaves. Adult mealybugs are oval-shaped, about 4 mm long, with thin filaments extending from the body, and covered by a thin coating of greyish-white mealy wax.

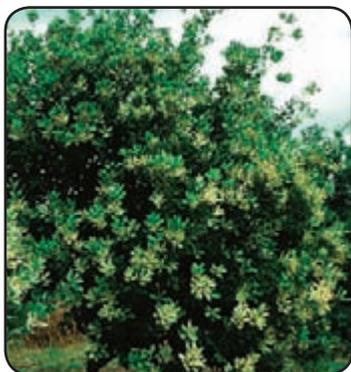
Ants often tend the mealybugs for their honeydew secretions. Sooty mould often grows on the honeydew secretions. The insect may also affect nuts – see symptoms on page 146.

Treatment: Treatment is rarely necessary as outbreaks are sporadic and natural enemies generally provide adequate control. Serious outbreaks are generally the result of frequent use of disruptive chemicals for other pests.

Prevention: Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Stunting of the growing point from mealybug damage



Bleaching of young leaves from heat stress



Close-up of affected leaves



Leaves sometimes show an uneven yellow bleaching



Typical heat damage symptoms



Leaf burning from hot dry winds

Heat stress and damage

Cause: High temperatures (over 35°C) during leaf growth (heat stress) and hot, dry conditions (heat damage).

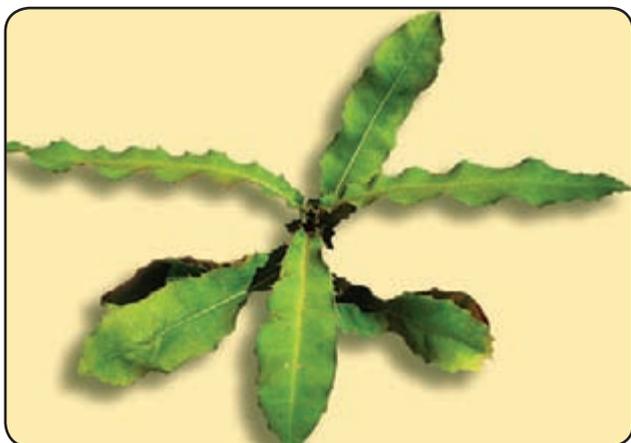
Identification: In susceptible varieties, high temperatures may cause a bleaching of the young leaves. Depending on tree condition, leaf symptoms vary from a complete bleaching to an uneven yellow bleaching and mottling. Damage is generally confined to highly susceptible varieties such as 781. Symptoms may be similar to those of winter yellows caused by cold weather (see pages 72 – 73).

Hot dry conditions may cause leaf death. This may vary from the death of leaf margins through to the death of a whole leaf. Damage is generally confined to the leaves of the most recent growth flush.

In young trees exposed to hot dry winds, all the leaves may be burnt and eventually drop off. The new flush emerges from the remaining skeleton of the tree.

Treatment: None is practicable. Short-term heat stress does not appear to significantly affect nut yield or quality.

Prevention: Avoid highly susceptible varieties in hotter areas. The appropriate use of windbreaks and irrigation, where available, helps to minimise damage.



Typical symptoms on a shoot, showing the overall pale-green colour



Close-up of affected leaves. Note that the veins may be distinctly lighter in colour than the interveinal areas. The lower leaf is beginning to show the bronzing associated with advanced nitrogen deficiency

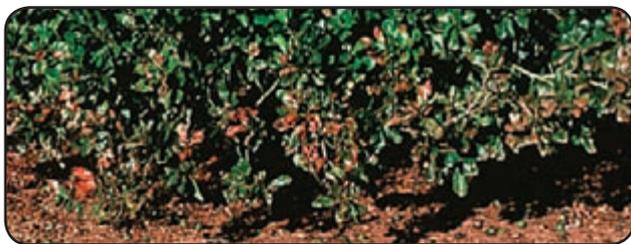
Nitrogen deficiency

Cause: Insufficient nitrogen available to the tree.

Identification: Affected leaves are an overall pale-green colour. Symptoms first appear on the older leaves. This generally distinguishes the problem from heat stress, where only the youngest leaves are generally affected. In advanced nitrogen deficiency, leaves may become bronzed in colour.

Treatment: Do a leaf analysis to check nitrogen levels. Apply fertiliser as recommended by the results.

Prevention: Do regular leaf and soil analysis and apply fertilisers to maintain appropriate nitrogen levels.



Typical damage to the lower leaves



Close-up of two examples of damage



Typical field symptoms. Note the severe marginal burn



Severe salt damage in nursery plants

Desiccant herbicide spray damage

Cause: Damage from desiccant herbicide accidentally applied to foliage. Desiccant herbicides include paraquat, diquat and paraquat/diquat mixtures.

Identification: Affected leaves show a variety of brown spots and burnt areas. Damage generally occurs on the lower leaves closest to the herbicide spray path.

Treatment: No treatment is possible.

Prevention: Apply herbicides very carefully, avoiding any contact with foliage. Avoid applying herbicides during windy conditions. Skirting of trees (removing low hanging branches) will minimise the risk. Use shielded low-pressure fan or flood nozzles, calibrate machinery, use a pressure gauge to monitor pressure, and instruct operators in application technique.



Salt damage

Cause: High salt levels in the root zone. Caused by either the use of salty irrigation water or the over-use of fertilisers.

Identification: The typical symptom is a distinct browning of the leaf margins of older leaves. The younger leaves may also be pale in colour. The problem is commonly seen in nursery plants.

Treatment: Do not apply fertilisers until the problem has been investigated. Get an analysis done on soil, plant tissue and irrigation water. Check fertiliser rates and re-adjust if necessary. Water heavily to leach the salt out of the root zone. If water analysis confirms salt damage, use another water source. If the problem occurs in the nursery, re-pot affected plants.

Prevention: Thoroughly test irrigation water before use. Water with a salt level of less than 1.2 dS/m is preferred. Before planting macadamias, do a soil analysis to check underlying salt levels. Calculate fertiliser rates very carefully to avoid over-fertilising, especially in young plants.





Typical symptoms showing the collapse of the shoot at the point of feeding



Nymph – actual size about 10 mm long (excluding antennae)



Adult bug – actual size about 12 to 15 mm long (excluding antennae)

Bananaspotting bug damage

Cause: The bananaspotting bug *Amblypelta lutescens lutescens*.

Identification: The bug attacks young lush shoots, particularly in late summer and early autumn after the nuts mature. The shoot collapses at the feeding point and dies. Nymphs are orange-red with a distinctive light-red stippling surrounding a pair of large black spots on the abdomen. Adults are light green to brown, winged, somewhat rectangular in shape and slender in build. Adults are about 12 to 15 mm long (excluding antennae). Damage is worse in orchards adjacent to rainforest. The bug occurs in Queensland only.

Treatment: In bearing trees, damage is insignificant and is rarely sufficient to justify specific treatment. The essential sprays applied for nut protection are generally sufficient to prevent tip damage. Specific treatment may be necessary in the nursery (where the maintenance of a single shoot for grafting is necessary) and occasionally on young trees in the field. Where necessary, spray with an appropriate registered insecticide. The bug also attacks nuts – see symptoms on page 102.

Prevention: Regularly monitor trees in nurseries and young trees in the field so that the problem can be treated before it gets out of hand. Monitor first in areas adjacent to rainforest or known 'hot spots'. In some cases, spraying may be necessary only in these parts of the orchard. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Affected tree with healthy tree on the right



Large root showing the cream-coloured fungus (arrowed) growing under the bark



'Shoestrings' of the fungus at the base of a tree (soil removed)



Mushrooms of the fungus at the base of a tree

Armillaria root rot disease

Cause: The fungus *Armillaria luteobubalina*.

Identification: Affected trees slowly decline, with yellow or dead leaves, stunted growth and twig dieback. The disease can be diagnosed by the presence of one or more of the following symptoms – cream-coloured fungal growth just beneath the bark of the crown and larger roots; black, cord-like strands of the fungus (called 'shoestrings') in the soil around the base of the tree; honey-coloured mushrooms at the base of the tree (generally present during cold wet weather).

Treatment: There is no effective treatment for affected trees. If decline of the tree is well advanced, it is probably best to remove the tree together with as many of the major roots as possible. This limits further spread, and allows treatment of the planting site before re-planting.

Prevention: On newly cleared ground, ensure all tree stumps and major roots are removed before planting macadamias.



Affected tree showing the diseased branches amongst otherwise healthy foliage



Close-up of *Dothiorella* branch canker with bark removed. Note narrow dark lines in wood



Close-up of Pinks disease fungal growth encircling a branch

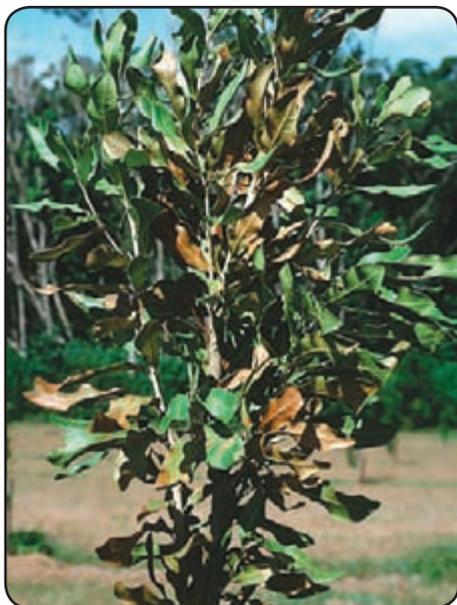
Branch dieback disease

Cause: The fungi *Dothiorella ribis* (Dothiorella canker), and *Corticium salmonicolor* (Pinks disease).

Identification: The disease generally affects individual branches. Leaves of affected limbs first look pale and lack a healthy sheen. They eventually dry out, making the diseased branches very conspicuous amongst the otherwise healthy foliage. The leaves stay attached to the affected branch. With Dothiorella canker, the bark of affected limbs is darker than normal with a slight water soaked appearance at the leading edge of the infection. When the bark is peeled away, a brown-purple discolouration of the wood in narrow lines may be seen. With Pinks disease, a thin, pink fungal growth develops on the bark of affected limbs. As the growth ages, it turns white and the affected bark often cracks and peels off. Pinks disease is more common in wetter, humid areas and in large trees subject to shading from adjacent forest.

Treatment: Prune out affected limbs at a point below the infection (look for discoloured wood or mould). Seal all wounds with water-based plastic paint or grafting mastic. Spray the affected area with an appropriate registered copper-based fungicide.

Prevention: Maintain tree vigour so that branches are not exposed to heat, frost, nutrient or moisture stress. Avoid unnecessary wounding of branches. Disinfect pruning machinery when moving between orchards. Reduce canopy density to increase air movement and assist the lower canopy to dry out after rain.



Affected tree showing the rapid browning and death of leaves

Cross-section of the basal trunk of an affected tree showing the discolouration of water conducting tissues



Bacterial wilt disease

Cause: The bacterium *Ralstonia* (syn *Pseudomonas*) *solanacearum*.

Identification: Leaves on affected trees brown and die quickly, but remain on the tree. When the lower trunk is cut across, a grey to brown, watersoaked discolouration of the water conducting wood can be seen. A slimy bacterial ooze may exude from the affected tissues on the cut surface. The disease is more common in shallow marginal soils subject to waterlogging.

Treatment: There is no practical treatment, as the trees die very quickly.

Prevention: Where possible, avoid planting macadamias into sites that have recently grown bacterial wilt susceptible crops such as tomato, potato, capsicum and eggplant. Avoid planting macadamias in shallow marginal soils. Avoid waterlogging by ensuring adequate surface drainage and, where appropriate, mounding. Keep broadleaf weeds under control, as many are hosts for the disease.



Yellow mottling symptom. Note the green 'iron spots'



'X-ray' effect where the veins remain dark green



Symptom in a nursery plant showing the yellowing of young leaves. Note that the older leaves remain green



Affected shoot showing yellowing in the older leaves while the youngest leaves remain green



Close-up of affected leaves – severe deficiency in leaf at right

Iron deficiency

Cause: Insufficient iron available to the tree. Generally caused by over-liming or overuse of phosphorus fertiliser. May also be a problem in alkaline (high pH) soils.

Identification: Field symptoms vary from an overall yellow mottling to an 'x-ray' effect where the tissue between the veins yellows and the midrib and major veins remain green. In severe cases, nuts are also yellow.

In nursery plants in pots, the growth tip is brown and stunted and the next oldest leaves are yellow with green midribs. In all cases, the oldest leaves remain dark green throughout.

Treatment: Foliar sprays of either iron chelate or soluble ferrous sulphate can be used to reduce the severity of the symptoms. However, where the problem is due to over-liming or overuse of phosphorus fertilisers, symptoms may disappear in time without further treatment. Do a soil analysis to determine if the soil is deficient in iron. If so, apply ferrous sulphate to the soil. If the soil pH is above 7.0 (1:5 water test), acidify the soil by applying either elemental sulphur or sulphate of ammonia.

Prevention: Do regular leaf and soil analysis and apply fertilisers in accordance with the results. This will help avoid over-liming and overuse of phosphorus fertilisers.



Magnesium deficiency

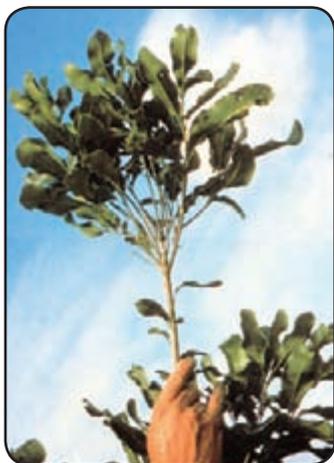
Cause: Insufficient magnesium available to the tree.

Identification: Symptoms first develop in older leaves with yellowing occurring between the veins, extending out towards the margins. In all but severe cases, the veins and adjacent tissue remain green, producing a 'Christmas tree' shaped band of green tissue.

Treatment: Do leaf and soil analysis to check soil pH and calcium and magnesium levels. Apply dolomite if both calcium and magnesium levels are low and the soil pH is less than 5.0 (1:5 water test). Otherwise apply magnesium oxide.

Prevention: Do regular leaf and soil analysis and apply fertilisers to maintain appropriate soil pH and magnesium levels.





Zinc deficiency – clusters of stunted leaves at the end of shoots



Zinc deficiency – close-up of stunted leaves

Zinc deficiency

Cause: Insufficient zinc available to the tree.

Identification: The deficiency causes restricted shoot growth resulting in the formation of clusters of stunted leaves at the ends of the shoots (known as ‘rosetting’). The stunted leaves show an interveinal yellow mottling, which initially develops away from the leaf margins.

Treatment: Get a leaf analysis done to confirm the diagnosis. Apply zinc to the ground under the tree. In severe cases, also spray zinc sulphate heptahydrate to the spring leaf flush.

Prevention: Do regular leaf and soil analysis to monitor nutrient levels. Apply zinc to the ground under the trees during orchard preparation and then annually according to leaf and soil analysis results.

Extreme boron deficiency

Cause: Extremely low levels of boron available to the tree.

Identification: Affected leaves are hard and leathery, malformed with splits in the veins. The growing tip may die.

Treatment: Get a leaf analysis done to confirm the diagnosis. Apply a foliar spray of Solubor. For a permanent solution, also apply a soil application of boron. Seek specialist advice on rates and application processes.

Prevention: Do regular leaf and soil analysis to monitor nutrient levels. Apply boron to the ground under the trees during orchard preparation and then at regular intervals according to leaf and soil analysis results.



Extreme boron deficiency – note the split veins and dead growing point



Typical symptoms of severe damage in a nursery tree



Close-up of symptoms in a nursery tree showing the uneven marginal burn and interveinal yellowing

Boron toxicity

Cause: Excessive use or uneven application of boron fertiliser.

Identification: A range of symptoms may occur, depending on the situation. In nursery plants, the most common is an uneven marginal burn of leaves with associated interveinal yellowing. The veins remain dark green. Leaves may curl upward as the marginal burning progresses. Field trees generally show severe yellowing, without the marginal burn. Again, the veins remain green.

Treatment: In nursery plants, water heavily to leach the boron out of the root zone. Where possible, replant in a new potting medium. Provided the damage is not too severe, field trees will eventually grow out of the problem.

Prevention: Calculate boron rates very carefully, based on leaf and soil analysis recommendations. When applying boron to the soil, apply it very evenly. Because of the small quantities involved, this is very difficult when applying boron in solid form. The best way is to mix the boron in water and spray it onto the soil surface.



Field symptoms





Algal leaf spot

Algal leaf spot

Cause: Saprophytic (non-pathogenic) algae growing on the leaf surface.

Identification: The algae produce distinct grey spots on the upper leaf surface. Although the spots are superficial and do no permanent damage to the leaf, they remain until the leaves age and drop off.

Treatment: Treatment is not necessary as algal leaf spot causes no permanent damage.

Prevention: Preventative measures are not necessary as algal leaf spot causes no permanent damage.



Lichens on a trunk

Lichen infestation

Cause: Growth of lichens (organisms that are a symbiotic association between algae and fungi).

Identification: Lichens appear as greyish-green irregular growths on the branches and tree trunks. They are more common in old orchards in elevated regions where mists and fog regularly occur.

Treatment: Treatment is not necessary as lichens cause no permanent damage.

Prevention: Preventative measures are not necessary as lichens cause no permanent damage.



Tip borer damage to the growing point

Tip borer damage

Cause: The nut stemborer *Paranepsia amydra*.

Identification: The insect causes death of the growing tips on new leaf flushes, especially in late summer and autumn. The insect may also affect nuts – see symptoms on page 138.

Treatment: Treatment may be necessary in the nursery and occasionally young trees in the field. Where necessary, sprays registered for nutborer are generally effective against tipborer.

Prevention: Regularly monitor trees in nurseries and young trees in the field so that the problem can be treated before it gets out of hand. Use an integrated pest management (IPM) approach, which includes the use of less disruptive insecticides with minimal impact on beneficial insects.



Close-up of mistletoe infestation

Mistletoe infestation

Cause: Infestation by plant-parasitic mistletoes.

Identification: Mistletoe seeds germinate on macadamia branches and connect to the tree's sap stream. From there, they produce their own leaves, branches and flowers. Mistletoes should not be confused with natural epiphytic ferns, which are commonly found growing on main limbs in the lower canopy.

Treatment: Cut off and destroy accessible mistletoe clumps.

Prevention: There are no available preventative measures.



Manganese toxicity – typical symptoms

Manganese toxicity (dark spots around margin) combined with magnesium deficiency ('Christmas tree' effect)



Hail damage to trunk

Manganese toxicity

Cause: High uptake of manganese from the soil. Occurs in soils with high manganese levels when pH falls below 6.5 (1:5 water test).

Identification: Affected leaves have an irregular pale yellow margin towards their tip, with many small dark spots. The toxicity often occurs in combination with magnesium deficiency.

Treatment: Get a leaf analysis done to confirm the diagnosis. Apply lime or dolomite to raise soil pH to 6.5 (1:5 water test).

Prevention: Do regular leaf and soil analysis to monitor nutrient levels. In high manganese soils, maintain soil pH at 6.5 or above (1:5 water test).

Hail damage

Cause: Impact damage from hailstones.

Identification: Symptoms are typically confined to one side of the tree and consist of brown 'pock marks' of varying size and shape. Young trees are more prone to trunk damage because the foliage provides limited protection against hailstone impact. See page 140 for nut damage symptoms.

Treatment: There is no practical treatment, although copper fungicide sprays may protect the trunk against subsequent trunk canker infection.

Prevention: There are no practical preventative measures.

Copper deficiency

Cause: Insufficient copper available to the tree – generally caused by low levels of copper in the soil.

Identification: The newly formed flush of affected branches is twisted and 'vine-like', particularly in young trees. The problem is caused by the weakness of the shoot, which bends downwards under the weight of foliage. The twisting follows through the shoot tip attempting to grow upward. Terminal leaves may be small and distorted. The problem is more likely in sandy soils. Copper deficiency can sometimes be confused with the vining disorder – see page 70.

Treatment: Apply a foliar application of a copper-based spray. Get a soil analysis done to check soil copper levels. If deficient, apply copper sulphate to the soil at rates determined by the soil analysis results.

Prevention: Do regular leaf and soil analysis to monitor nutrient levels. The use of copper based fungicide sprays for husk spot control generally reduces the likelihood of copper deficiency.

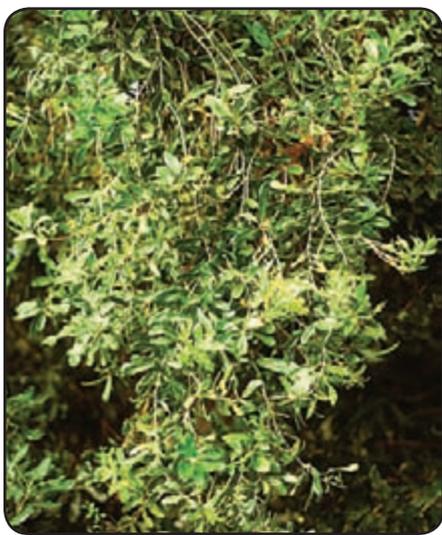


Typical symptoms showing the long willowy growth and upward curling at the end of the shoot



Close-up of an affected shoot





Vining disorder

Vining disorder

Cause: Unknown.

Identification: The disorder causes abnormal long, slender branches, sometimes up to a metre in length. Sometimes the leaves on affected branches are small and because of short internodes, also bushy. Affected branches are non-productive. The problem seems more common at higher altitudes in cool and foggy (low light) situations, for example Malanda on the Atherton Tableland.

Treatment: There is no available treatment, although pruning affected branches will improve the aesthetics of the tree.

Prevention: Avoid planting macadamias, particularly the variety 508, in cool, foggy areas. In these situations, avoid close planting.

Abnormal vertical growth disorder (tall tree syndrome)

Cause: Unknown.

Identification: Affected trees appear to have excessive upright branching, and are taller than unaffected trees of the same age. Flowering and nut production cease. When severe, trees take on the appearance of poplar trees.

Treatment: There is no available treatment.

Prevention: There are no available preventative measures.



Abnormal vertical growth disorder

Cold weather/frost damage

Cause: Damage from cold winds or freezing temperatures. Temperatures below -1°C will damage young trees. Older trees can withstand short periods of frost to -6°C .

Identification: There are two types of symptoms. Damage from cold winds may occur in young trees on winter growth flushes induced by fertilising in late autumn (winter yellows). It is most common in colder production areas. Young leaves become yellow then bleached and develop a hard rubbery appearance. Damage from freezing temperatures causes browning and death of the young leaves, and where severe, splitting of the bark on the trunk. This ringbarks the tree, and in most cases it dies. Damage usually occurs in the lowest lying part of the orchard, where the cold air pools.

Treatment: Trees affected by cold wind damage and mild freezing damage (foliage symptoms only) will generally recover. Where trunks are damaged, remove the loose bark. If less than half the circumference of the trunk is damaged, spray the affected area with a copper fungicide then seal it with water-based plastic paint. If more than half the circumference is affected, replanting is usually necessary.

Prevention: With young trees in colder areas, do not apply nitrogen fertiliser in late autumn. Avoid planting trees in frosty areas. Protect young trees by loosely wrapping the trunk before winter with insulating material (newspaper, corrugated cardboard, aluminium foil or grass/straw). Remove after the risk of frost has passed. Plant tree rows so cold air can flow to lower areas. Anti-transpirant sprays applied before the frost season may help reduce damage.



Cold wind damage (winter yellows)



Foliage symptoms of freezing damage



Trunk symptoms of freezing damage: early symptoms (left) – note the bark splitting and falling off; later symptoms (right) – note how the trunk becomes effectively ringbarked





Typical fire burn damage in a row of young trees



Close-up of damage from radiant heat. Note how the damage is more severe on the right side facing the fire front



Trunk symptoms. Note the sucker regrowth



Brown nodules (callus tissue) forming on the burnt trunk



Graft incompatibility - rootstock overgrowing scion



Graft incompatibility - scion overgrowing rootstock



Chimera (genetic mutation)

Fire burn damage

Cause: Heat from bush and grass fires. Macadamias are highly susceptible to heat damage, both from radiant heat from fires in the near vicinity and from actual fire burn around the tree.

Identification: Leaf and branch damage generally occurs through radiant heat from fires. This causes varying degrees of scorching and death of leaves and branches. Damage is generally more severe on the side of the tree facing the fire front. Trunks are mostly damaged by grass or ground fires, causing bark splitting and ringbarking. Later, brown nodules (callus tissue) form on the burnt areas. Sucker growth occurs from the rootstock.

Treatment: If the damage is confined to just the leaves and branches, the tree will generally recover. However if the trunk is severely damaged, the tree will not recover. These trees are best removed and the sites replanted. Where trunks are partially damaged, seal all wounds with water-based plastic paint or grafting mastic.

Prevention: Maintain an effective firebreak around the orchard. In forested situations where only minimal firebreaks may be possible, a border of mango trees, which are more heat and fire resistant, may help shield the macadamia trees from major damage. During periods of high fire risk, keep interrow areas mown and watered (where irrigation is available), and keep dry mulch such as husks or straw away from young trees. Avoid build-up of dry organic material around trees, particularly before the high fire-risk period.



Graft incompatibility

Cause: Incompatibility between the scion wood and the rootstock.

Identification: Two types of symptoms may occur. The first involves the rootstock swelling and overgrowing the scion. The second involves the scion swelling and overgrowing the rootstock. Cracking of the bark sometimes occurs at the swelling point.

Treatment: There is no available treatment. Some trees show little apparent ill-effect from the problem, while others may show obvious symptoms of decline.

Prevention: There is little that can be done apart from avoiding the use of rootstocks known to cause problems.

Chimera

Cause: Genetic mutation in a branch on the tree.

Identification: Affected leaves may show a range of symptoms including distortion and colour variation. Other branches on the tree will be normal by comparison. Irregular patterns of variegation are a common symptom. In this case, the variegation of leaves is completely unrelated to the veins, unlike most nutrient disorders.

Treatment: There is no treatment.

Prevention: The problem is sporadic and not significant enough to warrant any preventative measures.

