Nutrient disorders in macadamia

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Introduction

Ensuring good soil health and nutrition for macadamia plants will help them to resist attack from insect pests and diseases. Healthy soils require adequate nutrition, which is an important component for any crop protection strategy.

Good soil nutrition begins before planting so site preparation is vital. Before planting, soil testing should be conducted across the whole orchard, separating samples that might vary due to changes in soil characteristics. Sampling depths should be about 0–20 cm and 20–40 cm pre-planting. In well-drained red soils in higher rainfall areas, testing to 40–60 cm will determine subsoil acidity. In planted orchards, ideally try to include samples from different tree varieties and ages. Given the 2 year lead time from ordering plants to delivery, growers have plenty of opportunity to perform complete horticultural soil tests and act on the information received. This will allow the amendments enough time to be effective.

Soil and plant tissue analyses, along with nutrient budgets, can help with planning annual fertiliser programs. Foliar nutrient sprays can be an important component of an orchard fertiliser program but should be seen as supplementing soil nutrition deficiencies rather than being a substitute.

The images in this Primefact are intended to display some of the symptoms that can be seen in the field where specific nutrients are either deficient or at toxic levels. It is hoped they can assist growers and macadamia orchard staff to identify the disorders and what actions they should take regarding crop nutrition and tree health.

Growers should also be aware that this is intended as a guide to nutrient deficiencies and toxicities. It is not a replacement for soil and leaf sampling nor a visual assessment of the orchards, especially for iron deficiency. Soil and leaf samples will inform the grower if an element is deficient or whether it is just not available to the plant due to soil pH or nutrient interaction complexes.

Nitrogen

Nitrogen (N) is essential for plant growth. It is a key component of protein and chlorophyll, the latter being required for the synthesis of plant hormones, which control tree growth.

Deficiency: lack of nitrogen reduces photosynthetic capacity and therefore growth. Nitrogen deficiency can cause reduced flowering and fruit set, therefore decreased production (Figure 1). It is quite mobile in plants so younger leaves recycle it from older leaves which then go yellow (Figure 2) and drop off prematurely.

Too much nitrogen, especially in late summer, can cause excessive growth, reduced flower bud formation and flowering.

Figure 1. Nitrogen deficiency in a macadamia tree. Photo: Andrew Sheard.

Figure 2. Older and younger leaves all show general yellowing, but it is worse on older leaves. Photo: Andrew Sheard.

Phosphorus

Phosphorus (P) is important for cell division and growth. It is involved with sugar and starch formation as well as carbohydrate translocation within the plant.

In certain acidic ferrosols, the low pH (usually < 5) can bind phosphorus, making it unavailable to the plant. However, it is not the actual amount of P that might be low, but rather the availability of the P to the plant. This is further compounded when the tree has exposed roots (Figure 3). These roots indicate minimal proteoid roots and therefore an inability to extract available P, thus leading to deficiency.

Deficiency: macadamia plants deficient in phosphorus will have significant leaf drop, poorly developed new growth and reduced yields. Other symptoms of P deficiency can include dieback of new shoot growth.

Toxicity: soils high in P often induce iron deficiencies.

Figure 3. Exposed roots indicate decreased proteoid roots, creating an environment less able to absorb phosphorus. Photo: Andrew Sheard.

Potassium

Potassium (K) regulates the water balance in plants by controlling the opening and closing of stomata. It is important for photosynthesis and the movement of starch, sugars and oils. Potassium directly affects nut yield and quality, being essential for nut development and oil accumulation.

Cation exchange capacity (CEC) and the amount of potassium available will influence whether plants will suffer from potassium deficiency. Ensure you have the correct CEC ratio and sufficient available potassium in the soil.

Deficiency: potassium is mobile in the plant so deficiency symptoms will appear on older mature leaves as light brown necrotic areas between the veins and along leaf margins (Figure 4).

Figure 4. Necrotic areas between the veins and along leaf margins are signs of potassium deficiency. Photo: Andrew Sheard.

Calcium

Calcium (Ca) is required for cell division and is an important constituent of cell walls and membranes. Low Ca levels cause abnormal development of new leaves, nuts and root tips.

Ideally you should check the calcium levels in the soil as well as the exchangeable calcium in comparison with other nutrients (CEC). The amount of calcium in the soil can affect the availability of other nutrients such as potassium and magnesium.

Deficiency: low levels of calcium can be associated with leached, low pH soils. Amendments for low pH will depend on the availability of other elements such as magnesium. Calcium is not very mobile in the plant so deficiencies appear on the new growing points and include yellowing of the leaf tips (Figure 5 and Figure 6).

Figure 5. Calcium deficient leaves. Photo: Andrew Sheard.

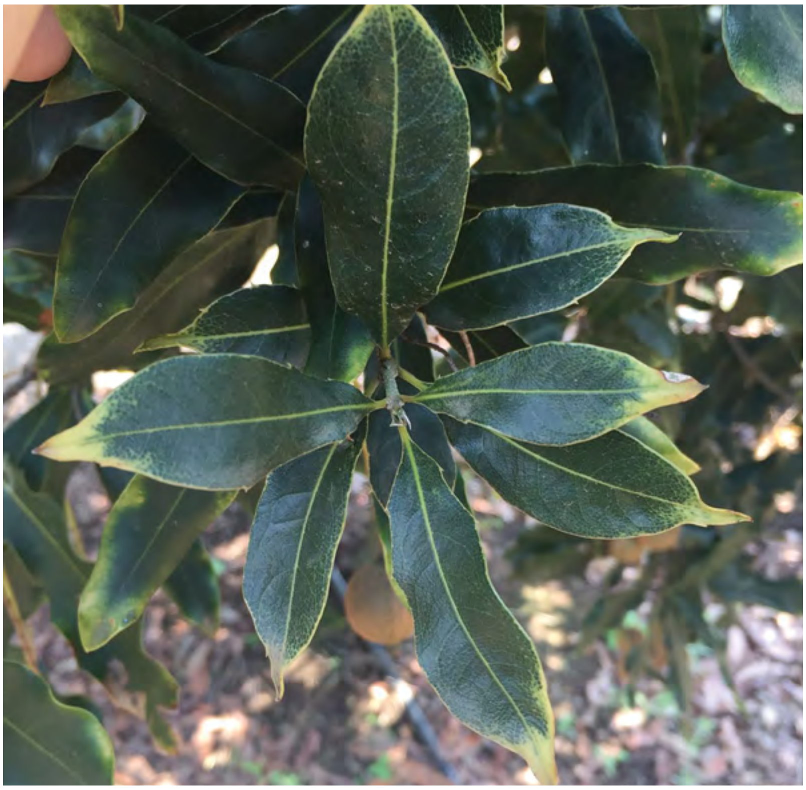

Figure 6. Yellowing leaf tips is a symptom of calcium deficiency.
Photo: Theunis Smit.

Magnesium

Magnesium (Mg) is an important component of chlorophyll and is essential for photosynthesis. It regulates plant nutrient uptake and essential cellular functions.

Deficiency: magnesium is readily mobile in the plant, moving from older to newer plant tissues (Figure 7). Magnesium deficiency will appear as interveinal yellowing from the leaf tips and edges towards the central midrib areas (Figure 8). Exchangeability and the ratio of magnesium in relation to other nutrients such as calcium and potassium will influence its uptake. Deficiencies mainly occur in high rainfall areas with low pH sandstone soils and ferrosols. Heavy applications of potassium can also induce magnesium deficiency.

Figure 7. Magnesium deficiency in macadamia, note that older leaves are most affected as magnesium is quite mobile within the plant. Photo: Andrew Sheard.

Figure 8. Interveinal yellowing from leaf tips to the midrib is a symptom of magnesium deficiency. Note the leaf base area remains green. Photo: Andrew Sheard.

Iron

Iron (Fe) is required for chlorophyll production.

Deficiency: macadamia plants deficient in iron will display interveinal yellowing with the leaf veins remaining green (Figure 9). In severe cases, young leaves can turn almost white with dieback of the leaf tip and shoot growing point, and young nut husks will lose their green lustre to become pale yellow (Figure 10). As iron is not very mobile within the plant, these symptoms will be displayed on the younger leaves and nutlets.

Iron deficiency is induced by high soil pH and phosphorus. Low organic matter can also contribute to iron deficiency. Organic matter compounds can form iron complexes that improve availability. Excessive amounts of phosphorus fertiliser can reduce iron uptake.

Toxicity: poorly aerated soils that are acidic can create iron toxicity.

Figure 9. Yellowing of iron-deficient plants due to the lack of chlorophyll. Remember iron deficiencies can be induced through high levels of competing elements such as phosphorus. Photo: Andrew Sheard.

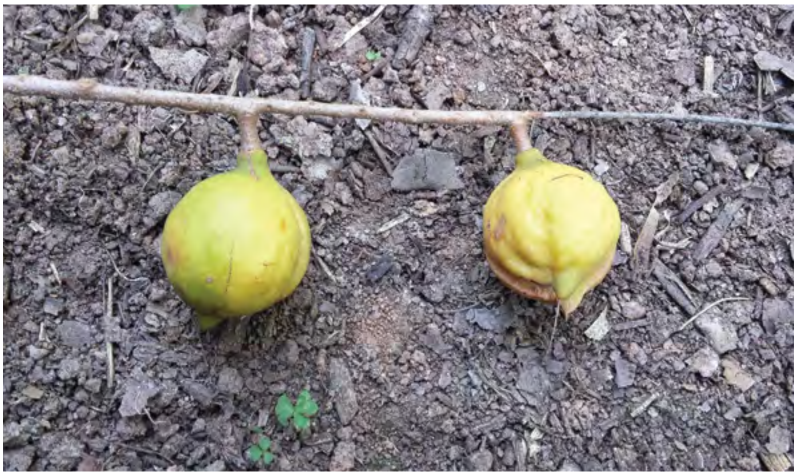

Figure 10. Iron deficiency in macadamia nutlets showing chlorosis due to lack of chlorophyll. Photo: Andrew Sheard.

Boron

Boron (B) is important for cell division and growth, especially for root tip development, shoot and nut growth as well as flowering.

High soil pH reduces boron availability. Boron is easily leached from coarse-textured acid soils and organic matter in the soil can hold boron to make it available to the plant.

Deficiency: as boron is not very mobile within the plant, younger leaves will display symptoms first, becoming leathery and having split veins. In severe cases, poor internodal growth and leaf dieback (Figure 11) become apparent. To rectify the deficiency, boron is best applied by spreading on the ground and the application should be timed with irrigation or rain. Boron deficiency might affect pollination success and therefore a quick-fix foliar application could be timed to precede peak flowering.

Recent work showed that a foliar boron spray on boron-deficient plants gave clear benefits for first grade kernel yield and kernel recovery (Russ Stephenson, pers. comm.).

There is a fine line between boron deficiency (Figure 11) and boron toxicity (Figure 12).

Figure 11. Boron deficiency showing poor internode growth and leaf dieback. Photo: Andrew Sheard.

Figure 12. Marginal leaf burn from boron toxicity. Photo: Andrew Sheard.

Zinc

Zinc (Zn) is required to produce enzymes and plant hormones, especially auxin which determines leaf size. Therefore it is required for new growth.

Deficiency: zinc is relatively immobile in the plant so symptoms will appear on younger shoots first, as rosetting of leaves at the end of shoots and stunted leaves with intercellular chlorosis (Figure 13 and Figure 14).

Soil zinc availability decreases as pH increases. High phosphorus, calcium or potassium levels will also contribute to zinc deficiency. Ideally you should aim to build up zinc levels in the soil. However, if regular leaf analysis shows deficient zinc levels (especially in ferrosols), then foliar applications may be warranted. Zinc should be applied on the summer flush.

Figure 13. Distinct intercellular chlorosis which is typical with zinc deficiency. Little leaf or rosetting is also present. Photo: Andrew Sheard.

Figure 14. Intercellular chlorosis caused by zinc deficiency. Photo: Andrew Sheard.

Manganese

Manganese (Mn) is necessary to form chlorophyll and assimilate carbon dioxide in photosynthesis. It is an essential part of the plant enzyme system and is directly involved in iron and ascorbic acid uptake. Manganese assists in fruiting and nut growth and development.

Deficiency: manganese is relatively immobile so deficiency symptoms will appear on young leaves as interveinal chlorosis close to the midrib (Figure 15). Leaves usually maintain a distinct band of darker green along the midrib and veins. High pH soils will reduce Mn availability and high organic matter can also tie up manganese.

Toxicity: in soils on the north coast of NSW, particularly where pH is low (< 5), we have seen many plants displaying manganese toxicity. Toxicity symptoms include interveinal brown spots along the outside edge of older leaves (Figure 16). Leaves may eventually brown off and die back. Ameliorating low soil pH and increasing organic matter in the soil will alleviate Mn toxicity.

Figure 15. Chlorosis due to manganese deficiency with dark green along the midrib. Photo: Andrew Sheard.

Figure 16. Manganese toxicity showing brown spots along the outer edges of the leaves. Photo: Alan Mason.

Copper

Copper (Cu) is necessary for energy transfer for photosynthesis and nitrogen metabolism. It is also necessary for lignin production, which provides strength to the growth of lateral branches. It is a constituent of several enzyme systems involved in building and converting amino acids to proteins.

Copper is usually evenly distributed throughout the plant but is not very mobile in the soil or the plant. Anything that inhibits new root growth will also inhibit copper uptake.

Deficiency: as copper is key to lignin production, deficiencies will be displayed as twisted or distorted lateral branches. The most obvious indicator of copper deficiency is the appearance of a 90-degree branch angle of new flush (Figure 17); almost in the shape of a 'C'. Alkaline soils will inhibit copper uptake.

Figure 17. A 90-degree branch angle of new flush is a typical sign of copper deficiency. Photo: Andrew Sheard.

Further reading

O'Hare P, Quinlan K, Stephenson R and Vock N. 2004. *Macadamia grower's handbook*. Queensland Department of Primary Industries, http://era.daf.qld.gov.au/id/eprint/1964/6/mac-growing_guide_Part6.pdf

Weir RG, Cresswell GC and Loebel MR. 1995. *Plant nutrient disorders 2*: *tropical fruit and nut crops*. NSW Agriculture (Inkata Press).

Reference number: PUB22/609.

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