

CROP NUTRITION FACT SHEET

NORTHERN, SOUTHERN AND WESTERN REGIONS

MICRONUTRIENTS

Micronutrient deficiencies can be tricky to diagnose and treat. By knowing your soil type, considering crop requirements and the season, and supporting this knowledge with diagnostic tools and strategies, effective management is possible.

KEY POINTS

- Micronutrient deficiencies are best determined by looking at the overall situation: region, soil type, season, crop and past fertiliser management.
- Soil type is useful in deducing the risk of micronutrient deficiencies.
- Tissue testing is the best way to accurately diagnose a suspected micronutrient deficiency.
- When tissue testing, sample the appropriate tissues at the right time. Plant nutrient status varies according to the plant's age, variety and weather conditions.
- The difference between deficient and adequate (or toxic) levels of some micronutrients can be very small.
- When applying fertiliser to treat a suspected deficiency, leave a strip untreated. Either a visual response or tissue testing can allow you to confirm whether the micronutrient was limiting.

Introduction

Micronutrients are essential for healthy plant growth. The key challenge is accurate identification of deficiencies and knowing your risk level.

Unlike the macronutrients such as nitrogen (N), phosphorus (P), sulphur (S) and potassium (K) micronutrients are only needed in small quantities. Even so, they can limit production.

The most likely limiting micronutrients to Australian cropping systems are boron



PHOTO: MATTHEW WITNEY

This zinc trial shows the plot on the left with zinc compared to no zinc on the right. Zinc deficiency appears as a lesion and a chlorosis between the veins of new leaves, producing a banding appearance. Leaf and plant growth become stunted with increasing severity of the deficiency, and leaves eventually die and fall off the plant.

(B), copper (Cu), manganese (Mn), molybdenum (Mo) and zinc (Zn).

Iron (Fe) can be important, especially on strongly alkaline soils. Other micronutrients are also important for particular plants in particular situations.

A recent study undertaken by the International Plant Nutrition Institute (IPNI) on behalf of the GRDC found that zinc deficiency is a major risk on soil types across all three cropping regions (northern, southern and western).

Copper deficiency is also a concern, although not as widespread as possible zinc deficiency. Copper and zinc are immobile in the soil, so must be in the pathway of as many crop roots as possible to be accessed by the plant.

Traditionally, cultivation distributed these micronutrients through the topsoil but the introduction of no-till and one-pass seeding equipment has led to more limited physical distribution.

Crop demand and uptake

Different crop species have different micronutrient requirements and this can be seen in the amount present in grain (Table 1, page 2).

Even though the overall amount of micronutrients in the soil may be high, uptake and their removal depends on the amount available, which in turn depends on the soil properties.

For example, even though there may be 130 kilograms per hectare of zinc in the soil, much of it may be unavailable and so is unable to meet the modest plant requirement of 0.1kg/ha in a wheat crop.

The differing requirements of various crops are often due to differences in root systems,

making some crops more susceptible to deficiencies than others (Table 2). Copper is a good example: canola is far more efficient at accessing this nutrient than wheat.

Micronutrient concentration can also vary between cultivars. For example, when grown on the same sites, Yitpi[®] wheat had

higher grain zinc content (25 milligrams/kg) than Gladius[®] (21mg/kg).

Diagnosis of deficiencies

The overall situation – soil type + season + crop – is the most reliable indicator of the possibility of the deficiency. While soil tests

Micronutrients

For tissue testing in cereals take the youngest emerged leaf blade at mid-tillering. (Copper can be sampled at the flag leaf stage).

For canola, sample the youngest fully emerged leaf.

Boron (B)

- Tissue test results below 2 to 4mg/kg are marginal, values greater than 5 to 10mg/kg indicate B adequacy.
- Critical level for hot water soluble (HWS) B soil test: <0.5mg/kg.
- Very small window between deficiency and toxicity (0.5mg/kg to 5mg/kg)
- Deficiency most likely on acidic, sandy soil with low organic matter (OM), low pH and low water-holding capacity (WHC).
- Deficiency can also appear after liming.
- Very mobile and subject to leaching, has limited residual availability.
- Adequate supply is likely on alkaline, low OM soils.

Copper (Cu)

- Copper can be tested at the flag leaf stage in cereals. A tissue test result of 1.3 to 1.6mg/kg indicates a mild deficiency. <1.3mg/kg is moderately to severely deficient.
- Critical level for DTPA Cu soil test: <0.2 to 0.4mg/kg
- Deficiency most likely on alkaline and sandy soils in the south and west, and soils with a high OM concentration (high pH, low WHC, high OM).
- Early season Cu deficiency is evidenced by 'pig tailing' (curling) but may be temporary, due to dry conditions or large N applications. If deficiency is prolonged, heads may go dark at the end of the season with grains missing from the head.

TABLE 1 Micronutrient concentration and crop removal in a 4t/ha wheat crop, a 2.5 t/ha canola crop and a 2.0t/ha lupin crop.

Nutrient	Wheat grain mg/kg	Removal 4t/ha (g/ha)	Canola grain mg/kg	Removal 2.5t/ha (g/ha)	Lupin content (mg/kg)	Removal 2.0t/ha (g/ha)
Boron	2	8	13	33	20	40
Copper	5	20	4	10	5	10
Manganese	44	176	49	125	40	800
Molybdenum	0.2	0.8	0.3	0.8	2	4
Zinc	25	100	34	85	30	60

SOURCE: ROB NORTON, IPNI

- Adequate supply under acidic and wet, compacted heavy soils.
- Not readily leached.
- Long to very long residual availability of applied Cu (>15 years).

Manganese (Mn)

- A tissue test resulting in an Mn value of <20mg/kg indicates a possible deficiency, less than 10mg/kg is almost certainly deficient.
- Critical levels for DTPA Mn soil test: <5mg/kg (but this is an unreliable test).
- Deficiency most likely on well-drained, alkaline and dry soils (high pH, low WHC).
- Adequate supply most likely on acidic, waterlogged soils with high OM.
- Can leach as Mn²⁺ or MnO²⁺.
- Shorter residual availability than Cu.

Molybdenum (Mo)

- A tissue test result of <0.03mg/kg indicates Mo deficiency.
- Critical level for CaCl₂ Mo soil test: <0.1mg/kg although like Mn, soil tests for Mo are unreliable.
- Deficiency most likely on acid sandy soils with poor P history (low pH, low WHC). High sulfur supplies can also induce deficiencies.
- Adequate supply on alkaline heavy soils.
- Frequently adequate where acid soils have been limed to pH_{Ca}>4.8.
- Declines to around 50 per cent after two years, depending on soil pH.

- On very acidic soils, soil-applied Mo may not supply a wheat crop for the entire season.

Zinc (Zn)

- A tissue test result of <10mg/kg indicates Zn deficiency.
- Critical level for DTPA Zn soil test: <0.2 to at least 0.4mg/kg, or even higher on alkaline clay soils. Critical values vary with pH, clay content and OM content.
- Deficiency most likely on alkaline sands with a high P concentration (high pH, low WHC).
- Deficiency can first appear as stunted, irregular growth and two-toning of leaves, followed by a lesion developing in the middle of the leaf. Leaf may 'kink' over.
- Adequate supply most likely on heavy, acidic, high OM soils.
- Residual availability of applied zinc is moderate (three to five years) on alkaline soils.
- Residual availability of applied zinc is >15 years on acid, low OM, sandy soils.
- Zn stimulates root systems so healthy levels can assist in fighting diseases such as rhizoctonia.
- If group B herbicides have been used Zn strategy may need to be revisited. Some group Bs can lower levels of Zn uptake in the plant.
- On soils with high levels of free lime, more than one application may be needed.

work best for macronutrients, tissue tests are the most robust method of identifying a micronutrient deficiency.

A major challenge is that we simply do not have adequate critical interpretation criteria for tissue testing for many micronutrients.

Tissue testing

Plant tissue testing is a more reliable method than soil testing for diagnosing and monitoring micronutrient status.

It is essential to collect a proper sample for tissue testing. The distribution of micronutrients can be different in leaves, stems or whole plants.

Plant nutrient status may also vary according to the age of the plant, the variety and the weather conditions.

Tissue test samples can become contaminated if they come into contact with any other surface, such as skin, soil, cars, etc. Always wear disposable gloves

TABLE 2 Susceptibility of different crops to micronutrient deficiencies.

Micronutrient	Susceptible crops
Boron	Legumes, brassicas
Copper	Wheat, barley, sunflower, lucerne (canola tolerant)
Iron	Some legumes (cereals tolerant)
Manganese	Oats, legumes
Molybdenum	Brassicas, legumes
Zinc	Oats, wheat, barley (canola tolerant)

SOURCE: ROB NORTON, IPNI



Copper is a key element of chlorophyll and plays a central role in photosynthesis, and deficiencies are often associated with high organic matter soils. Early season deficiency is evidenced by 'pig tailing'. If deficiency is prolonged heads may go dark with grains missing.

PHOTO: MATTHEW WITNEY

PHOTO: INTERNATIONAL PLANT NUTRITION INSTITUTE



Boron is essential for growth and development of new cells. It is immobile in the plant, so deficiency symptoms will appear as abnormal growth on the youngest leaves. Boron-deficient canola can appear as deformed, curled and rough-skinned leaves with torn margins and yellow to brown spots in the interveinal area of the leaves.

and handle the samples very carefully to ensure their integrity.

For cereals, take the youngest emerged leaf blade at mid-tillering. Copper can be sampled for at the flag leaf stage, and if it is marginal in the youngest tissue it can be applied as a foliar spray before flowering.

For canola, sample the youngest fully emerged leaf for diagnostic tissue testing.

Detailed sampling procedures for each crop, related to the optimum growth stage, can be obtained from fertiliser companies, agribusiness personnel or agricultural consultants.

Soil testing

In general, soil tests have a low reliability in predicting micronutrient deficiencies because the elements are present in such low quantities.

Analytical laboratories use a range of chemicals to extract the micronutrients in soil to assess what is available to the plant. For example, DTPA is a common extractant and the critical value for DTPA extractable zinc can be as low as 0.2mg/kg or less, depending on soil type. Obtaining reliable analytical results with such low soil concentrations requires careful soil sampling and handling.

In addition, a low soil test value may be close to either a normal or toxic value for that nutrient. For example, hot water soluble (HWS) boron at less than 0.5mg/kg is considered a deficiency, while more than 5.0mg/kg is toxic.

Similarly, a DTPA manganese soil test value of 3 to 4mg/kg may be deficient for lupin

production in Western Australia in some seasons and adequate in others. The soil test values also change with soil types.

Note: there are no reliable soil tests for iron, manganese or molybdenum.

If you plan to use soil testing, choose a laboratory accredited by the Australasian Soil and Plant Analysis Council (ASPAC). ASPAC accreditation provides assurance that the lab is proficient in the particular test you require. You will find a list of certified labs on the ASPAC website (see Useful Resources).

Visual symptoms

Visual symptoms can also be a guide, but be aware some symptoms may mimic other unrelated problems. They may also be temporary or transient due to cold weather, drought or slow root growth.

For example, a copper deficiency in cereals can resemble frost, take-all or drought, and even a molybdenum deficiency can produce white heads.

SoilMapp

CSIRO has developed an excellent app for iPads called *SoilMapp*, an Australian soil database that allows users to learn about the likely soil types on their property or anywhere else in the country (see Useful Resources).

The app's location service can be used to place you on the soil map so your particular soil type can be identified. Once known, the risk of micronutrient deficiency can be assessed.

Effects of soil type

In the northern region, the main issue appears to be zinc on Kandosols, Vertosols

and Sodosols. There is uncertainty about copper generally.

In the south, Calcarosols, Sodosols and Vertosols have high risk of zinc deficiency, while manganese deficiency is likely to be a significant risk on these soils if they contain more than 60 per cent free calcium carbonate.

In the western region Sodosols are the major soil order and low zinc is seen on these soils. However Kandosols and Tenosols are also more prevalent in the west than in eastern states.

Acidic soil types, such as the more strongly acidic Tenosols, are likely to be at risk of molybdenum deficiency. Manganese deficiency is also moderately likely in Kandosols and Tenosols.

Treatment

With immobile nutrients such as copper and zinc, physical distribution through the soil is important to ensure roots interact with placed fertiliser.

Smaller granules of fertiliser, more of them and better placement, will be more effective than a fertiliser with larger granules, even if it is more concentrated. Some growers

have seen good results with fluid or liquid in-furrow micronutrients.

It is best to apply immobile nutrients to the most responsive crop; cereals respond better than oilseeds to zinc and copper application. Depending on the soil type, annual applications may not be needed.

For nutrients with a lower residual activity or where soils are likely to strongly bind micronutrients, annual or tactical applications may be best. These can be in-furrow or in-crop foliar applications.

If a spray application of foliar fertiliser is to be undertaken, leave a strip untreated. This will allow you to determine whether it was the micronutrient that was limiting.

For foliar applications to be effective, a large plant leaf area is required to absorb the product. If applying to seedlings, multiple applications may be necessary.

Post-harvest, grain nutrient testing can be considered. This will not provide a conclusive guide to the risk of micronutrient deficiency, but in conjunction with information from the overall situation (crop, season, soil type) it can be used to inform potential management decisions.

PHOTO: INTERNATIONAL PLANT NUTRITION INSTITUTE



Manganese is part of the plant's enzyme systems. Deficiencies often occur on high organic matter soils with neutral to alkaline pH and on those soils that are naturally low in manganese. Manganese is immobile in the plant, so its deficiency appears as reduced or stunted growth with visual interveinal chlorosis on younger leaves. Cereals can develop gray spots on their lower leaves, and legumes can develop necrotic areas on their cotyledons.

USEFUL RESOURCES

ASPAC

www.aspac-australasia.com

Find a laboratory with comprehensive ASPAC certification:

www.aspac-australasia.com/index.php/component/labproficiency

Better fertiliser decisions for cropping systems in Australia

www.bfdc.com.au

Fertcare® accreditation

www.fertilizer.org.au

IPNI micronutrients presentation

anz.ipni.net/article/ANZ-3181

SoilMapp

www.csiro.au/soilmapp

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