Copper – role, requirements and options

ROB NORTON*

South Australia has a long and proud history of micronutrient research, with some of the earliest reports of micronutrient responses recorded from the Eyre Peninsula and the 90 mile 'desert' – which became the 90-mile plain with the use of micronutrients.

Research on copper (Cu), manganese (Mn) and zinc (Zn) has been led largely by South Australian scientists leading to strategies for diagnosis and remediation of micronutrient deficiency, as well as developing a deep understanding of cultivar differences in copper, zinc and manganese responses.

The response to micronutrients varies between farms, within farms and within paddocks. In the case of copper, there is a trend to routine use as a foliar spray as insurance against this micronutrient deficiency. Even though this intervention is relatively cheap, it may be possible to save that cost with careful diagnosis of the problem. Identifying situations where responses will occur is a critical issue and requires information about the nutrient stores available for redistribution within the plant, the supply of nutrient from the soil and the nutrient requirement for growth and yield.

Copper is essential for chlorophyll formation, pollen production and baking quality.

Wheat and barley are more responsive to copper than lucerne and canola. There have been very few reports of copper responses to canola.

Symptoms of copper deficiency

- Rolling and curling of new leaves, white-tipped leaves and poor seed set. Symptoms tend to be non-specific and can be confused with tipping due to cold or heat damage.
- Severe deficiency results in 'rats-tail' heads with little grain fill.
- Lack of pigmentation in coloured sheep and paling of coats in cattle.

Diagnosis

As a starting point, **soil type** is often a good guide, with copper deficiency most likely on acid sands and calcareous soils like those in large areas of Eyre Peninsula, the lower South-East of SA and western Victoria. It is also becoming an issue (perceived or real) in some of the higher-rainfall cropping regions, where high yields (potentially 8-10 t/ha) may rapidly draw down copper supplies. Data around this hypothesis is inconclusive.

Soil test results have been correlated to crop responses in properly conducted trials but the trials have been limited and the confidence limits can be quite large. This then reflects on the critical levels developed. These are often very low in absolute terms and sampling errors, issues around analytical reliability and in-paddock variability make them difficult to confidently apply. Soil pH, organic carbon levels and clay contents may need to be considered when making an assessment of the likelihood of copper deficiency from a soil test, since these properties all affect micronutrient availability (Table 1).

DR ROB NORTON

TABLE 1.
A SUMMARY OF SOIL AND CLIMATIC FACTORS AFFECTING MICRONUTRIENT AVAILABILITY

	B	Cu	Mn	Mo	Zn
pH → 7.5	+++	---	--	++	---
pH ← 5.5	--	++	+++	--	+
Sand content	--	---	--	-	---
High organic C content	++	---	++	-	++
High P content	-	-	-	+++	---
Water-logged soil		+	++		+
Drought	---	---	---	--	-
Compaction	+	+	+	+	+

+ INDICATES INCREASED AVAILABILITY. – INDICATES REDUCED AVAILABILITY.

Table 2 shows a summary of DTPA-extractable soil test values for various regions within SA. The values for copper and manganese the mid-North and the Lower-EP show huge variation, indicating that in some cases test values are low to very low. Soil test critical values are not that reliable for micronutrients in general and manganese in particular, so treat the critical values in Table 1 with caution.

Soil test results do not always reflect seasonal conditions, rooting depth and nutrient demand. Copper availability is affected particularly by soil organic matter, texture and soil pH. It is quite reactive and can bind with organic matter and its availability declines with high pH, so diagnosis of copper deficiency should not be on soil test alone.

Plant tissue testing for the concentration of nutrient relies on a known relationship between the tissue in question and the degree of limitation that concentration places on crop performance (yield). These relationships are developed between tissues that have consistent responses and at a time when nutrient supply is likely to be most limiting. In most cases the tissue to select for micronutrient assessment should be from the youngest growth, and for cereals this is most often the youngest fully expanded blade (YEB).

Table 3 shows the results of a survey of wheat grain nutrient contents taken from SA NVT sites in 2009. These results show the likely removal of these micronutrients and indicate the levels of variation within and between regions.

TABLE 2. DTPA ZINC, DTPA COPPER, DTPA MANGANESE, SOIL PH AND HOT WATER EXTRACTABLE B VALUES (TOP 10 CM) FOR REGIONS WITHIN SA (NVT SITES)

Region	pH ($CaCl_2$)	HWS B (mg kg^{-1})	DTPA Cu (mg kg^{-1})	DTPA Mn (mg kg^{-1})	DTPA Zn (mg kg^{-1})
Lower EP	7.1±0.1	5.6±0.8	1.9±1.0	14.8±54.2	3.9±3.8
Mid North	6.9±0.1	2.7±0.7	0.5±1.0	1.1±54.3	0.3±3.8
Murray Mallee	7.4±0.2	2.3±1.3	-	-	-
South East	7.1±0.1	3.1±0.6	0.8±0.1	1.7±7.0	0.9±0.5
Upper EP	7.7±0.1	5.1±0.8	-	-	-
YP	7.4±0.1	3.7±0.7	-	-	-
Critical Values*		←0.12	←0.2-0.3	←10	←0.8(?)
All zones	6.3±1.3	3.5±13.3	1.1±1.0	24±43	1.0±2.9

* CRITICAL VALUES ARE FOR WHEAT, FROM REUTER & ROBINSON.

TABLE 3. WHEAT GRAIN NUTRIENT CONCENTRATIONS (NORTON, 2011) AND CRITICAL NUTRIENT CONCENTRATIONS FOR NVT SITES IN SOUTH AUSTRALIA (REUTER AND ROBINSON, 1997)

Region	Site Years	B mg kg^{-1}	Cu mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}
SA Lower EP	6	2.3±0.3	4.4±0.3	25.3±3.0	18.7±2.0
SA Mid North	7	1.3±0.3	5.6±0.3	51.1±2.7	25.4±1.8
SA Murray Mallee	9	1.9±0.2	5.2±0.2	38.9±2.4	19.2±1.6
SA South East	5	1.5±0.3	3.5±0.3	26.8±3.2	24.5±2.2
SA Upper EP	12	2.4±0.2	4.9±0.2	49.3±2.1	26.0±1.4
SA Yorke Penninsula	6	1.8±0.3	5.6±0.3	41.8±3.0	22.2±2.0
Critical Value		1.0	1.5	10	15
Mean (S-E Australia)		2.2±1.3	4.8±1.2	43.5±13.8	23.0±7.3

Like soil test critical values, grain nutrient concentrations are indicators of status, but are not reliable. The copper values in the table are all above what would be considered 'deficient'.

A difficulty with interpreting tissue concentrations is that there are at least four relationships between yield and nutrient concentration (Figure 2, adapted from Smith and Loneragan, 1997).The most common of these is similar to the soil test and yield relationship, but there are other yield and nutrient concentrations relationships including Piper-Steenbjerg effect, which shows that a particular tissue concentration can decline when more of a nutrient such as copper is added. Where this occurs, added copper initially increases growth so the concentration of copper in the tissue decreases, but as additional copper is added, growth and Copper content become more aligned. Another major caution with tissue testing is that when the plant samples are taken, other reserves of the nutrient being tested for, perhaps deeper in the soil, may not yet be accessed.

Diagnosis

- Critical soil test DTPA extractable Cu is around 0.12 and has moderate to poor reliability.
- Critical tissue levels reported as <1.5 mg/kg YEB in wheat (Brennan et al. 1986).
- Grain Cu concentrations are most often >0.2 mg/kg and seem to have poor diagnostic reliability.

Source, rate, time and place

Micronutrients can be applied either as supplements to macronutrient fertilisers or as in-crop treatments. Because of the potential for soil reactions reducing nutrient availability, it may be necessary to protect the micronutrients by the use of chelating agents such as EDTA. Some new chelating agents (Stacey et al. 2008) can enhance zinc and copper uptake, particularly on alkaline soils. There have been several comparisons of copper products (including one by Brennan, 1990) and these should be considered when selecting an appropriate product. It is also advisable to refer to some general texts such as Price (2006). Soil applications can have long (more than five years) residual activity.

Copper is quite immobile in the soil, so even application is important to facilitate root interception. Copper co-granulated with base fertilisers generally results in more even distribution of the micronutrient than blending micronutrient into a base fertiliser. Some of the benefits seen with fluid micronutrients may be a consequence of improved distribution. There may also be particular carrier effects with some products, such as are seen with better zinc supply from MAP than DAP, due to the different pH reactions of these products.

The use of foliar micronutrient is useful when root uptake is reduced and a rapid response is required. The disadvantages of foliar application are that there is little residual activity and to avoid foliar damage only low concentrations can be used. Uptake is limited because only small quantities can be taken up through the stomata, leaf cuticles or parts of the epidermis, but if the nutrient (such as copper) is rapidly fixed in soils, foliar application may an effective strategy.

There is considerable interest in the use of adjuvants and other materials to enhance micronutrient uptake and effectiveness of foliar application but there is little evidence to support this in the literature.

The chemistry in the spray tank also needs to be considered, particularly if the micronutrient is being applied with other nutrients or crop protection chemicals.

Rates for copper supplements vary with source efficiency. Experiments in WA show that foliar applications to achieve maximum yields occurred with roughly half the copper when supplied as chelate versus sulphate, and twice the copper when supplied as oxychloride versus sulphate (Brennan, 1990). In other words, chelated copper provided the highest yield response per unit of copper, followed by copper sulphate and copper oxychloride, with the chelate twice as effective as the sulphate, which was in turn twice as effective as the oxychloride.

However, cost is also a significant practical consideration.

Early application of copper, maybe a little later than zinc, is most effective and is also less likely to cause canopy damage, especially when applying copper sulphate on warm sunny days.

** Rob Norton is Regional Director of the International Plant Nutrition Institute*