05

FarmLink Research Report 2015

Detecting and managing trace element deficiencies in crops

GRDC Project code – DAS00146

Project Partners

Funding Partners

Report Authors

Nigel Wilhelm and Sjaan Davey, South Australian Research and Development Institute, Waite Research Precinct, Adelaide, as presented at GRDC updates in Adelaide and Wagga.

Introduction

Keywords: trace elements, deficiencies, soil testing, plant testing, micronutrient deficiencies.

Take home messages

- Zinc, manganese and copper are the three most important trace element deficiencies for crops in southern Australia.
- Diagnosis from soil testing or symptoms is often unreliable or too late to manage the problem well. Plant testing is the most reliable, if not fool proof tool to diagnose trace element deficiencies.
- Deficiencies can be overcome with cheap sulphate foliar sprays but boosting soil reserves for copper and zinc is a good investment.

Many soils in the cropping zone of southern Australia are deficient in trace elements in their native condition. Despite many decades of research into trace element management, crops can still be found to be deficient in one or more of these trace elements. Just because trace element deficiencies have not been prevalent in recent years, does not mean they will not return.

There is increasing concern in some districts that trace element deficiencies may be the next nutritional barrier to improving productivity. This is because current cropping systems are exporting more nutrients to the grain terminal than ever before.

Why is there a need for trace elements?

Essential trace elements are nutrients which are required by plants and animals to survive, grow and reproduce but are needed in only minute amounts. Southern Australian cropping soils are more likely to be deficient in zinc (Zn), copper (Cu) and manganese (Mn) than the other trace elements.

Of these three, Zn deficiency is probably the most important because it occurs over the widest area. Zn deficiency can severely limit annual pasture legume production and reduce cereal grain yields by up to 30 per cent. Cu deficiency is also important because it is capable of causing total crop failure.

If these three trace elements are not managed well the productivity of crops and pastures can suffer valuable losses and further production can also be lost through secondary effects such as increased disease damage and susceptibility to frost.

Adequate trace element nutrition is just as important for vigorous and profitable crops and pastures as adequate major element (such nitrogen or phosphorus) nutrition.

Zinc deficiency

Zn deficiency has been identified on many soil types. Acid sandy soils, sandy duplex soils, red-brown earths, 'mallee' soils, and calcareous grey and red heavy soils have all had either Zn responses confirmed or crops have been identified with Zn deficiency symptoms. Zn deficiency appears to be equally severe in both high and low rainfall areas.

Symptoms

It is very difficult to diagnose Zn deficiency in pasture or grain legumes because the characteristic Zn deficient leaf markings are rarely produced in the field. Zn deficiency causes shortening of stems and the leaves fail to expand fully. This results in plants which appear healthy but are stunted and have small leaves.

In cereals, symptoms are usually seen on seedlings early in the growing season. An early symptom of Zn deficiency is a longitudinal pale green stripe on one or both sides of the mid-vein of young leaves (Figure 1). The leaf tissue in this stripe soon dies and the necrotic area turns a pale brown colour. Severely affected plants have a 'diesel-soaked' appearance due to the necrotic areas on the leaves, which generally start mid-way down the leaf, causing the leaf to bend or break in the middle.

Plant symptoms appear to be worst early in the season when conditions are cold, wet and light intensity is low. In spring, symptoms often do not appear on new leaves but grain yields will usually be reduced.

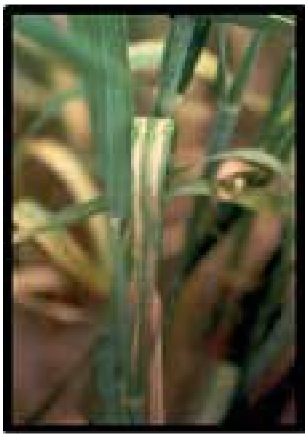

Figure 1: Zinc deficiency symptoms as seen in wheat.

Diagnosis

Plant tests for diagnosing Zn deficiency are reliable and have been calibrated in the field under Australian conditions for wheat, barley, medic, beans and peas. In tillering plants of wheat and barley, YEB (youngest fully emerged blades) levels above 20-24mg/kg are considered adequate. The minimum value in YOLs (youngest fully open leaves) of medic is 15mg/kg and in beans and peas the figure is approximately 23mg/kg (although our information on peas is very limited). For lucerne, levels above about 20mg/kg in young shoots appear to be adequate.

Correction

Correction of Zn deficiency in a way which provides benefits after the year of treatment is possible through the use of Zn-enriched fertilisers or a pre-sowing spray of Zn onto the soil (incorporated with subsequent cultivations). There is also the option of a Zn-coated urea product which can be used to supply Zn to the crop, and is most useful when pre-drilling urea before the crop.

Another option that will also provide long term benefits but has become available only recently is the application of fluid zinc at seeding. The advantage of this approach is that it will provide residual benefits for subsequent crops and pastures and has a low up-front application cost (providing you ignore the capital investment in a fluid delivery system!). At current prices, a typical application may cost about $6.00/ha (this is 1kg of Zn/ha).

Only Zn-enriched fertilisers of the homogenous type (fertiliser manufactured so that all granules contain some Zn) are effective at correcting Zn deficiency in the first year of application. A rate of two kilograms of elemental Zn per hectare applied to the soil is necessary to overcome a severe Zn deficiency and should persist for three to 10 years (depending on soil type). Short intervals between repeat applications of Zn will be necessary on heavy and calcareous soils in the high rainfall areas, while seven to 10 year intervals will be acceptable in the low rainfall areas. Following an initial soil application of 2kg Zn /ha repeat applications of 1 kg/ha will probably be sufficient to avoid the reappearance of Zn deficiency in crops and pastures. Most zinc-enriched fertilisers are now not sold as pure homogeneous types but providing a homogeneous fertiliser is used as part of the mix then the final product is still satisfactory for correcting Zn deficiency. For example, the company may produce a diammonium phosphate (DAP) Zn five per cent 'parent' product which has Zn on every granule which they will then blend with straight DAP to give 1 and 2.5 per cent products for the retail market. This option will currently cost approximately $17.00/ha.

Zn deficiency can be corrected in the year that it is recognised with a foliar spray of 250-350g Zn/ha but it has no residual benefits and is therefore not the best approach for a long-term solution. This option will currently cost approximately $1.00/ha (plus the cost of the operation). Zinc can be mixed with many herbicides and pesticides but not all, so check with your supplier for compatible tank mixes before you make the brew. Recent trials in eastern Australia suggest that chelated sources of trace elements are no more effective at correcting a deficiency than their sulphate cousin (see Figure 2 for an example of treating copper deficiency in wheat), although older results from WA showed that there are situations where they can be superior.

Seed dressings of zinc are another option for managing Zn deficiency. These products are effective and will supply Zn to the young crop but they will not completely overcome a severe deficiency, nor will they increase soil reserves of Zn. Seed with high internal levels of Zn can also be used in a similar way. However, both approaches should be used in conjunction with soil applications to correct and manage Zn deficiency in the long term. This option will currently cost approximately $3.00/ha.

Copper deficiency

Symptoms

Apart from shrunken heads in cereals, heads with gaps in them or 'frosted' heads, Cu deficiency rarely produces symptoms in plants in the field. The symptoms produced by Cu deficiency in the maturing cereal plant are due to poor seed set from sterile pollen and delayed maturity. However, under conditions of severe Cu deficiency cereal plants may have leaves which die back from the tip and twist into curls. Cereal stubble from Cu-deficient plants has a dull grey hue and is prone to lodging due to weak stems.

Cu-deficient pasture legumes are pale, have an erect growth habit and the leaves tend to remain cupped (as if the plant were suffering from moisture stress).

Diagnosis

Leaf analysis to detect Cu deficiency in plants is a very important management tool because Cu deficiency can produce devastating losses in grain yield of crops and pastures with little evidence of characteristic symptoms.

Cu concentrations in YEBs of cereals above 3mg/kg are considered adequate and below 1.5mg/kg deficient. Pasture legumes including lucerne, have higher requirements for Cu and plants are considered deficient if YOL values are below 4.5mg/kg. Lupins are tolerant of Cu deficiency and levels above 1.2mg/kg are adequate.

Cu deficiency in livestock (steely wool in sheep; sway-back in lambs; rough, pale coats and ill-thrift in young cattle) is a continuing problem in some areas because livestock have a higher requirement for Cu than pasture plants. The low availability of Cu in the diet can be induced by high Mo intake which can be further exacerbated by high sulphur (S) levels. The introduction of Cu bullets which provide protection for 12 months has made treatment of the problem simple and cost-effective.

Correction

Traditionally, Cu deficiency has been corrected by applying Cu-enriched fertilisers and incorporating them into the soil. Most soils require 2kg/ha of Cu to fully correct a deficiency, and this application may be effective for many years.

Due to the excellent residual benefits of soil-applied Cu, Cu deficiency in crops and pastures has been largely overcome in most areas from the use of the 'blue stone' mixes in the 1950s and 1960s.

However, Cu deficiency may be re-surfacing as a problem due to a number of reasons:

- The applications of Cu made 20-40 years ago may be running out.
- The use of nitrogen fertilisers is increasing and they will increase the severity of Cu deficiency.
- Cu deficiency is affected by seasonal conditions and farming practices, e.g. lupins in a lupin/wheat rotation make Cu deficiency worse in succeeding wheat crops.

Application of Cu by Cu-enriched fertilisers will currently cost approximately $19.00/ha. Cu deficiency in crops can also be corrected by fluid application at seeding with an application cost as low as $4.60/ha. Performance of soil applied Cu will improve with increased soil disturbance.

Although Cu deficiency is best corrected with soil applications, foliar sprays will also overcome the problem in the short term. A foliar spray of Cu (75-100 g/ha of Cu) is very cheap (approximately 90c/ha for the ingredient) but a second spray immediately prior to pollen formation may be necessary in severe situations. This was the case in a trial conducted on lower Eyre Peninsula in 2015 where a late foliar spray was necessary to completely eliminate Cu deficiency in an area that was extremely deficient for Cu and the problem was exacerbated by a dry spring when wheat was forming pollen ad setting grains (Figure 2).

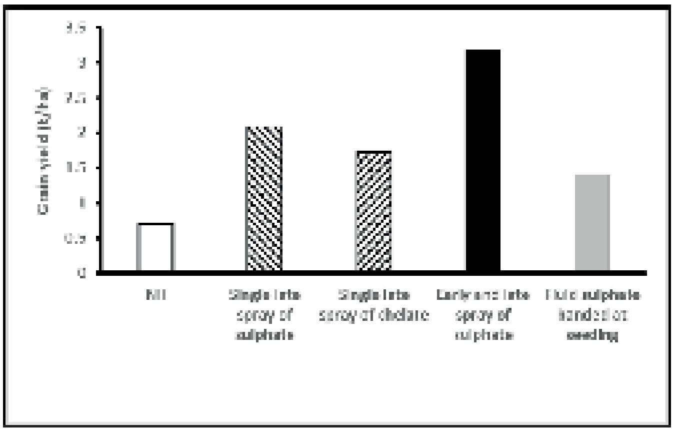

Figure 2: Effectiveness of four application strategies for treating Cu deficiency in wheat. Foliar sprays were applied at 90g Cu/ha, the fluid at seeding at 1kg Cu/ha. Trial at Cummins, lower Eyre Peninsula, 2015.

Manganese deficiency

The availability of Mn in soil is strongly related to soil pH. Soils with higher pH have lower Mn availability than soils with lower pH. Mn deficiency is therefore more likely to be a problem on alkaline soils however, responses to Mn have also been recorded on impoverished, acid to neutral sandy soils.

The availability of Mn is also strongly affected by seasonal conditions and the availability is lowest during a dry spring. Transient Mn deficiency may also appear during cold, wet conditions but affected plants are often seen to recover following rains in spring when soil temperatures are high.

Symptoms

Mn is poorly translocated within the plant so symptoms first appear in young leaves. Old leaves on plants severely affected by Mn deficiency can still be dark green and healthy because they acquired Mn from the seed and once Mn enters a leaf it cannot be shifted out.

Mn deficiency results in plants which are weak and floppy and pale green/yellow in appearance. Mn-deficient crops can appear to be water-stressed due to their sagging appearance. Close examination of affected plants can reveal slight interveinal chlorosis; the distinction between green veins and 'yellow' interveinal areas is poor.

In oats, Mn deficiency produces a condition known as 'grey speck'. Mn-deficient oats are pale green and young leaves have spots or lesions of grey/brown necrotic tissue with orange margins (this contrasts with Septoria lesions which have purple/

red margins). These lesions will coalesce under severely Mn-deficient conditions.

Mn deficiency delays plant maturity, which is a condition most marked in lupins. Mn-deficient patches in lupins will continue to remain green months after the rest of the paddock is ready for harvest. Delayed maturity in patches of the crop is frequently the only visual symptom of Mn deficiency in lupins. Mn deficiency will also cause seed deformities in grain legumes. Lupins suffer from 'split-seed' which is caused by the embryo breaking through a very weak seed coat. 'Split-seed' will reduce yields and also viability of the harvested grain. A similar condition in peas is known as 'marsh spot' due to a diffuse dark grey area within the seed.

Diagnosis

Plant analysis will accurately diagnose Mn deficiency in crops and pastures at the time of sampling but Mn availability in the soil can change dramatically with a change in the weather condition. This means that the Mn status of the sampled crop or pasture can also change dramatically after sampling which must be allowed for when making recommendations on Mn deficiency.

Concentrations of Mn in YEBs greater than 15mg/kg are considered adequate for cereals at tillering. For legumes, the corresponding figure in YOLs is 20mg/kg. The Western Australia Department of Agriculture also advocates a main stem analysis of lupins for diagnosing Mn deficiency at flowering.

Correction

Due to the detrimental effect of high soil pH on Mn availability, correction of severe Mn deficiency on highly calcareous soils can require the use of Mn-enriched fertilisers banded with the seed (three to five kg Mn/ha) as well as one to two follow up foliar sprays (1.1kg Mn/ha). In the current economic climate, growers on Mn-deficient country have tended not to use Mn-enriched fertilisers (due to their cost) but have relied solely on a foliar spray. This is probably not the best or most reliable strategy for long term management of the problem.

Neither soil nor foliar Mn applications have any residual benefits and must be re-applied every year. Another approach is the coating of seed with Mn. This technique is cheap and will probably be the most effective in conjunction with foliar sprays and/or Mn enriched fertilisers. Mn deficiency in lupins must be treated with a foliar spray at mid-flowering on the primary laterals. The use of acid fertilisers (e.g. nitrogen in the ammonium form) may also partially correct Mn deficiency on highly alkaline soils but will not overcome a severe deficiency.

Mn deficiency in crops can also be corrected by fluid application at seeding.

Final Note

There are other trace element deficiencies which can occur in crops and pastures (e.g. boron, molybdenum, iron, etc). Deficiencies in these trace elements however are likely to be localised or not at all in many districts, and therefore, discussion wasn't included in this paper. If you do however, require any information on these please contact the author (nigel.wilhelm@sa.gov.au).

Conclusion

Trace elements are as essential to productive and profitable crops as nitrogen and phosphorus. The difference is that crops only require them in minute amounts. Zinc, manganese or copper deficiencies are the most common and severe problems.

Trace element deficiencies are difficult to diagnose with soil tests or from plant symptoms. Plant testing is the most reliable, if not fool proof tool to diagnose trace element deficiencies.

Foliar sprays will usually correct a problem in crop. However, for long term correction of the deficiency boosting soil reserves is a sound investment.

Useful Links

https://www.agric.wa.gov.au/mycrop

http://anz.ipni.net/topic/micronutrients

Contact Details

Nigel Wilhelm

GPO Box 397, Adelaide, SA, 5001

0407 185 501

nigel.wilhelm@sa.gov.au