CROP SCIENCE SOCIETY OF S.A. INCORPORATED

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INCORPORATING THE WEED SCIENCE SOCIETY

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NEWSLETTER No. 295 SEPTEMBER, 2014

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Next Meeting **'Crop Update and Students'**

Venue **Richardson Theatre, Roseworthy Campus**

Date **WEDNESDAY 17th SEPTEMBER**

Time **7.30 pm**

Speakers

John Both - Nufarm R&D

'Registration of weedmaster DST pre-harvest in canola'

This will be all about the new registration of glyphosate (weedmaster DST) to be used for crop-topping and under windrow spraying of ryegrass, which up until now has been an unregistered practice.

Maddy Mittermaier & Royce Pitchford – Urrbrae HS year 12 agriculture students

Agronomy project prize winners, presenting their research projects.

Mick Lines - SARDI Pulseman (*he's got his finger on it*)

Will be talking about all Pulse issues relevant this current season.

Copper - role, requirements and options.

Rob Norton
International Plant Nutrition Institute, 54 Florence St, Horsham, 3400.

The six macronutrients are complemented by a group of nutrients required in smaller amounts – the micronutrients or trace elements. Even though needed in small quantities, Copper (Cu), Manganese (Mn), Iron (Fe), Zinc (Zn), Boron (B) and Molybdenum (Mo) are all essential for plant growth.

South Australia has a long and proud history of micronutrient research, and in the early 1960's it was found that foliar sprays of Mn onto barley gave a 20 fold responses in the southern Yorke Pennisula. This was the first time foliar trace elements had been applied to agricultural crops in Australia. Similarly, with copper, South Australian scientists have led the way with diagnosis and remediation, as well as developing a deep understanding of cultivar differences in copper (and zinc and manganese) responses.

Even so, between farms and within farms, the response to micronutrients will differ. In the case of copper, there seems to be a trend to routine use of this as a foliar spray as insurance against this and other micronutrient deficiencies. Diagnosis of situations where responses will occur is a critical issue, and that assessment 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.

Diagnosis of the *RIGHT* problem

Just because the macro nutrient demands are met does not always mean that the next limit on yield is on one of the micronutrients. Moisture is still a limit in most situations and if growers are to invest in micronutrients then correct diagnosis and treatment is critical – and the 4R's (Right Source, Right Rate, Right Time, Right Place) concept applies, and these four aspects need to be addressed. Micronutrients work with macronutrients but are not substitutes for them nor will they give responses unless they are a limiting factor.

Soil testing

Soil tests are often the starting point for assessing potential response to micronutrients, and Table 1 shows a summary of DTPA extractable soil test values for various regions within South Australia. The values for Cu and Mn in 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 Mn in particular, as soil test value can change significantly with water logging in particular. So, treat the critical values in Table 1 with caution.

Table 1. DTPA zinc, DTPA copper, DTPA manganese, soil pH and hot water extractable B values (top 10 cm) for regions within South Australia (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	-	-	-
Yorke P	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.

Soil tests for micronutrients generally have a lower reliability than soil tests for the macronutrients. As well as the uncertainties associated with seasonal conditions, rooting depth and nutrient demand, copper availability is affected particularly by soil organic matter, texture and soil pH. The difficulty with assessing the availability of metal cations (like Cu, Zn, Mn and Fe) is affected by redox state as well as the formation of metallo-organic ligand complexes and they can also precipitate (usually as hydroxides) depending on concentration and pH. Copper is also quite reactive and it can bind with organic matter and its availability declines with high pH.

Table 2 shows the results of a survey of wheat grain nutrient contents taken from the NVT sites in 2009 from South Australia. This shows the likely removal of these micronutrients, as well as showing the sorts of variation within and between regions. Like soil test critical values, grain nutrient concentrations are indicators of status, but are not reliable.

Table 2. 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 Penn.	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 (SEAustralia)		2.2±1.3	4.8±1.2	43.5±13.8	23.0±7.3

Soil tests have been correlated to crop responses in properly conducted trials, the trials have been limited and the confidence limits can be quite large. This then reflects on the

critical levels developed, which are often very low in absolute terms and sampling errors and analytical reliability make them difficult to confidently apply (Table 3). As with all soil testing, it is important to use accredited laboratories that use ASPAC accredited methods for assessing nutrients – these tests are ones that have critical values established for Australian conditions. There are no Australian data for soil test calibrations for Mn status. For all tests, often soil pH, organic C levels and clay contents may need to be included to make an assessment of the likelihood of deficiencies from a soil test (Table 4).

Table 3. Soil test critical values and interpretive comments . Data taken from Peverill, Sparrow & Reuter (1999) and Rayment & Lyons (2011). Soil report are values from commercial soil testing labs.

Micron utrient	**Crop**	**Extractant (R&H Method)**	**Critical Value**	**How assessed**	**Region**
Cu	Barley	AmmOxalate	0.3	90% of RY*	WA
	Lupin	AmmOxalate	0.23	90% of RY	WA
	Canola	AmmOxalate	0.35	Non limiting	WA
		DTPA (12C2)	0.2	Non limiting	WA
	Wheat	AmmOxalate	>0.9	-	WA
		DTPA (12C2)	0.2-0.3	Probability	WA
		DTPA (12C2)	<0.2	90% RY	SA
		DTPA (12C2)	<1.4/0.7	-	SA N higher
		DTPA (12C2)	<0.2	-	SA
		DTPA (12C2)	0.3 (poor)	C/N	Qld
	Soil Report	DTPA (12C2)	1-5	-	

Table 4. 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.

Tissue Testing

Testing plant tissue 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 time when nutrient supply is likely to be most limiting. For example, sampling old leaves for N is likely to be of little value as N is mobile and rapidly moved to areas of demand. Figure 1 gives a general view of the types of tissues to sample for nutrient assessment.

Figure 1. Tissues to sample for nutrient testing, symptoms occur in the older leaves first with mobile nutrients and the younger leaves first with less mobile nutrients (Price 2006).

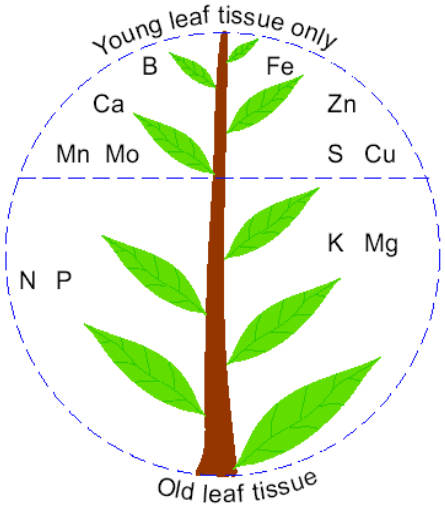
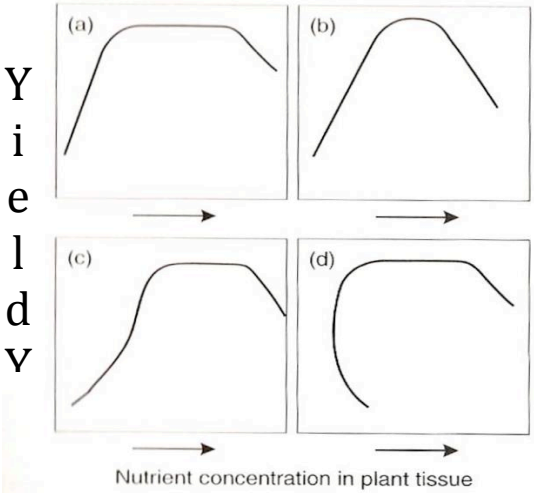


Figure 2. Relationships between yield and nutrient concentrations in plant parts frequently found in plants as nutrient supply increases from deficient to toxic.



A difficulty with interpreting tissue concentrations is that there are at least four relationships seen between yield and nutrient concentration (Figure 2, adapted from Smith and Loneragan, 1997). The most common form is as shown in 2a, which is similar to the soil test and yield relationship. There may be several different yield and nutrient concentrations and examples are shown in figure 2, including 2d (Piper-Steenbjerg effect), which shows that a particular tissue concentration can decline when more nutrient is added such as with Cu. In that situation, added copper initially increases growth so that concentration decreases, but as additional Cu is added, growth and Cu content become more aligned. Another major caution with tissue testing is that when the plant samples are taken, other reserves (*eg* deeper in the soil) may not yet be accessed and so that a false low tissue content can result.

Use the right source, rate, time and place.

Micronutrients can be applied either as supplements to macronutrient fertilizers and/or as in-crop treatments. Because of the potential for soil reactions reducing nutrient availability, it may be necessary to protect the micronutrients such as by the use of chelating agents such as EDTA. There have been some new chelating agents developed (Stacey et al. 2008) that can enhance Zn and Cu uptake, particularly on alkaline soils. There have been several product comparisons, such as for copper (Brennan 1990), and these should be considered when selecting an appropriate product as well as referring to some general texts such as Price (2006).

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, it may an effective strategy. While there is also considerable interest in the use of adjuvants and other materials to enhance micronutrient uptake and effectiveness, there is little evidence in the literature.

Copper:

Occurrence

- Coastal and inland calcareous soils of marine origin.
- Acid weathered soils derived from granites and sandstones.
- Calcareous and siliceous sands of southeastern SA and western Victoria.
- Organic soils and sandy low organic matter soils deficiency common, as well as where there is high Fe, Mn or Al in the soil.
- Often occur with Zn deficiencies and areas with potential Mn deficiency.

Symptoms

- Essential for chlorophyll formation and pollen production as well as 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 are rolling and curling of new leaves, white tipped leaf 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 colored sheep and paling of coats in cattle.

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 youngest expanded blade in wheat (Brennan et al. 1986).
- Grain Cu concentrations are most often >0.2 mg/kg and seem to have poor diagnostic reliability.

Treatment

- Cu can be applied as an additive to fertilizers and smaller particles tend to be more effective because of higher chance of root interception. Most effective is through mixing.
- Fluid copper applied in furrow has promise although most of the work done uses multi-nutrient sources.
- Rates for copper supplements vary with source efficiency. Experiments in WA showed that foliar applications to achieve maximum yields occurred with roughly half the Cu when supplied as chelate versus sulfate, and twice the Cu when supplied as oxychloride versus sulfate (Brennan, 1990). So, chelate Cu provided the highest yield per unit of Cu applied (but it does come down to cost)
- Efficiency was similar irrespective of timing.
- Yield response is higher when Cu is applied earlier (6 leaf) rather than later. Earlier application is also less likely to cause canopy damage especially with copper sulfate when applied on warm sunny days.
- Copper can be applied a little later than zinc, late applications (>ear emergence) may be ineffective.
- Long to very long residual availability (>5 years) when soil applied.
- Copper seed treatments are insufficient to meet plant requirements for the current season.

Summary

Trace elements are important and can be limiting factors under certain conditions. Diagnosis of the disorder can be done through a combination of situation, selected crop, soil tests and tissue tests, allied with careful observations. Treatment options are either to use supplemented fertilizers, which can give long term increases or the use of foliar sprays to treat growing crops. There are many products on the market, and demand the evidence of their efficacy from properly run experiments.

The effect of zinc and "protecting agent" on the survival of Rhizobia in liquid

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Introduction

The application of rhizobia to legumes prior to sowing is often done via seed coating with a peat slurry of the N-fixing bacteria. Growers are increasingly using new formulations and methods such as granules in furrow or liquid in furrow at sowing.

Rhizobium biologists recommend that the bacteria not be mixed with fertilizers, trace elements or pesticides, however growers often wish to apply two or more treatments in the one operation. One example is the mixing of rhizobium formulation with zinc sulphate (for plant nutrition) in water in a large (8000L) tank and applying the mixture in furrow at sowing of a grain legume crop such as Faba Bean, over a period of several hours.

A laboratory experiment was conducted to test whether mixing rhizobia with the $ZnSO_4$ preparation would lead to a detrimental result such as reduced survival of the bacteria. The farmer's operations were scaled down to 50 ml liquid cultures in the laboratory and the survival of rhizobia was assessed over a 6 hour period.

Materials and methods:

Zinc: the product used was "Balance Zn" from Agrichem, which is 16.7% $ZnSO_4$. This was diluted 1:20 as per farmer practice.

Protecting agent: this is provided by the manufacturer of the Rhizobium preparation, and is normally used to improve bacterial survival when coated on to seed. However it is also used in the liquid application method. The protecting agent was made up in water as per manufacturer's instructions.

Rhizobia: Freeze-dried inoculant for Faba Bean, freshly supplied by New Edge Microbials was used. The bacteria were suspended in sterile distilled water and added to the final mixture in the same ratio as used by the grower. Rhizobia were added last. The total volume of liquid was 50 ml in 250 ml conical flasks, which were shaken gently on an orbital shaker at approx. 25C.

Treatments were as follows:
R = Rhizobia alone
RP = Rhizobia + Protecting agent
RZ = Rhizobia + Zinc
RPZ = Rhizobia + Protecting agent + Zinc
There were three replicate flasks per treatment.

Samples were taken at 0, 1, 2, 4, 6 hours and bacterial populations were estimated after dilution plating on to yeast mannitol agar, using the Miles and Misra (droplet) plating method, with three replicate 10 ul droplets per dilution.

Results and discussion:

The results are shown in Figure 1.

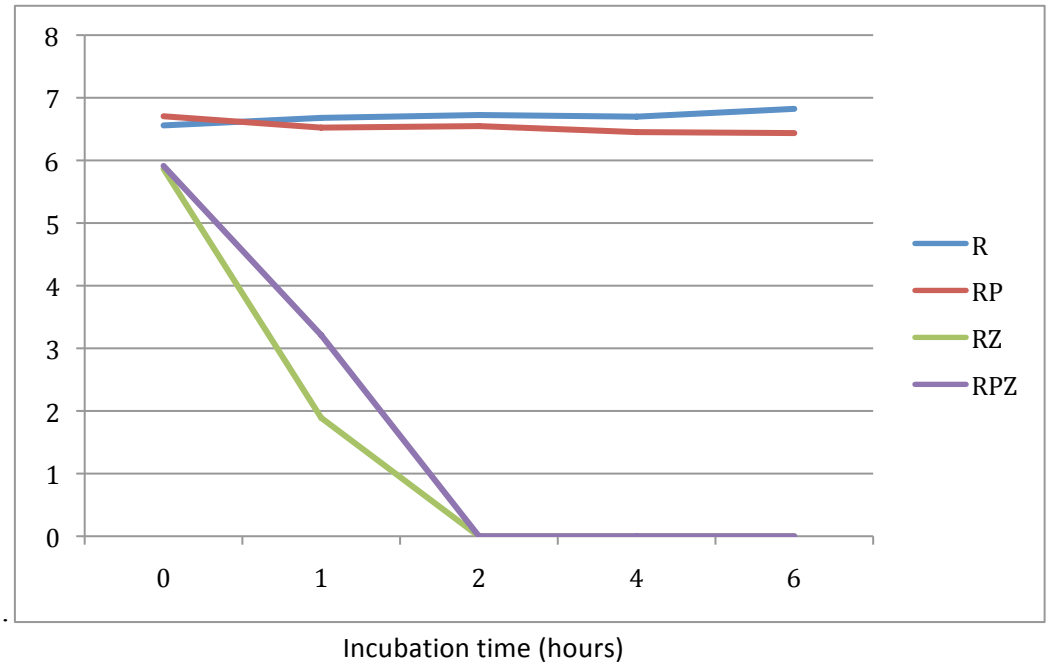

Figure 1. Changes in populations of Rhizobia incubated in liquid with or without zinc sulphate and "protecting agent"

The figure shows that:

1. Rhizobia survived well over the 6 hour incubation where no zinc was added.
2. Where zinc was added, approximately 80% of rhizobia were lost in the first 5 to 10 minutes, this being the time it took to obtain the "zero time" samples through the process of dilution and plating the samples on to Petri dishes.
3. Where zinc was added, no rhizobia were detected at 2 hours or more after the start of the experiment.

The experiment clearly shows that at the concentrations used, the $ZnSO_4$ was quite toxic to the bacteria. In addition, the pH of the undiluted $ZnSO_4$ product was approx 2.4, and the $ZnSO_4$ diluted 1 in 20 was approx pH 3. Acidic conditions are also known to be detrimental to the survival of rhizobia.

The farmer is reassessing the method of applying rhizobia and is looking for alternative ways that do not cause rapid loss of the bacteria.

The authors thank New Edge Microbials and Agrichem for supplying materials used in this research.