Micronutrient trial

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Take Home Messages

- During the extremely dry 2006 season the addition of micronutrients had no significant effect on crop performance and there was no benefit, in terms of grain yield, from the application of nitrogen, regardless of product.
- There is no benefit to apply micronutrients when levels are adequate at GS30 and when there is a good history of applications.

Background

Micronutrient deficiencies have always been a part of life in Australian cropping systems. A great deal of research has been done to find ways to improve the management of these deficiencies. Previously, farmers have successfully applied these micronutrients with the granular MAP and it is becoming common practice in some areas to foliar apply any combination of zinc (Zn), manganese (Mn), copper (Cu), as well as nitrogen (N), on certain soils, at least once a year.

The amount of Zn required by plants is small compared to phosphorus (P) and N, although its role within the plant is essential to plant growth. Without adequate levels of Zn, photosynthesis will be reduced, and cell elongation and reproduction will be impaired. Typical, Zn deficiency symptoms in wheat include: stunting, a characteristic long pale green stripe on each side of the mid-vein of fully emerged leaves (the tissue soon dies and turns pale brown), and a ‘succulent-looking’ or ‘diesel-soaked’ appearance on generally the mid and older leaves. Yield losses in wheat can be between 5-30% of grain yield.

As with Zn, Cu is only required in small amounts by the plant, but is essential for structural strength of the plant, plant enzymes and development of pollen during grain filling. Copper deficiency in wheat is often confused with the damage caused from frosts, drought, root-rots or molybdenum deficiency. Copper mobility within the plant is poor and subsequently the first signs of the deficiency appear on the youngest leaves. Chlorosis or yellowing of tissue will appear on the edges of new leaves and the flag leaf can become twisted giving a ‘rat-tail’ appearance. Tips of glumes can be damaged and often heads are only partially filled. Fertilisers containing Zn can induce Cu deficiency in wheat as the Zn will compete against Cu for uptake however, this only occurs when Cu levels are marginal. High levels of N can also induce Cu deficiency. The critical level for Cu in the youngest emerged leaf blade (YEB) is about 3 mg/kg.

The availability of Mn in soil is strongly related to soil pH; the higher the pH, the lower the availability. The availability of Mn is also strongly affected by seasonal conditions and is lowest during dry spring weather. 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 translocated out. Mn-deficient crops can appear to be water-stressed due to their sagging appearance. Close examination of affected plants can reveal slight interveinal chlorosis but it can be hard to pick up the distinction between green veins and yellow interveinal areas.

Both Zn and Cu have long residual effects, which means that they do not need to be applied to the crops every year. The current recommendations are that to maintain adequate levels of Zn in wheat, 2-3kg Zn/ha should be applied every 3-4 years. The residual value of application of Cu may be greater, with one application of 1-2kg Cu/ha lasting approximately 40 years in most Mallee soils. In those areas prone to Mn deficiency, applications of Mn generally need to be applied every cropping year.

In this trial, each of the micronutrients was applied in the chelated form. Chelated micronutrients are more expensive than the more common Zn and Cu sulphates, however they can be more efficient (less is required) and have greater mobility within the plant.

Urea (46% N) and ammonium sulphate (20.5% N, 23.5% S) were used as two alternatives for applying N. Plant uptake of N is primarily in the nitrate form, and to a lesser degree the ammonium form. For the N in urea to be readily accessible to plants, it must be converted to one of these two forms, primarily through nitrification in the soil to nitrate. Ammonium sulphate has nitrogen in the ammonium form. This means the process for conversion to a plant available form is slightly longer for urea than for ammonium sulphate.

The aim of this trial was to determine if there was an economical benefit in top-dressing nitrogen on a steep sandy rise, with a good zinc history at Hopetoun. The trial also evaluated the addition of the micronutrients zinc, copper and manganese with N, using commercially available foliar products. Ammonium sulphate was compared to urea in combination with chelated micronutrients to observe if there was any interaction between the form of N, and the presence of sulphur, on the uptake of micronutrients.

Methods

Trial Site:	Hopetoun
Replications:	3
Plot size:	3 × 12m
Variety:	Yitpi, Wheat
Sowing Date:	16th May 2006
Seeding Density:	175 plants/m^2
Seeder:	Gason Scaritill, NoTill, narrow points, 10-inch row spacings, presswheels.
Fertiliser:	MAP + 2.5% Zn (30kg/ha)
	Urea (70kg/ha)
Herbicide:	25/7/06 Brodal (300ml/ha) + MCPA (300ml/ha)
Soil Type:	Sandy Clay Loam
Nutrient application:	Foliar, using BCG Herbicide Resistance Boom

Table 1: The list of products, rates used and cost per hectare.

Product	Application Rate (per ha)	Cost ($/ha)
Urea (46%N)	65kg *(30kgN)*	$32
Sulphate of Ammonia (20.5%N: 23.5%S)	146kg *(30kgN)*	$64
Chelated Manganese (10.0%Mn: 4.0%S)	3.5L	$13
Chelated Zinc (11.0%Zn:5.0%S)	3.0L	$11
Chelated Copper (5.0%Cu:4.0%S)	1.25L	$4.50
Chelated Mn, Zn (6%Zn:4%Mn:5%S)	3.0L	$11
Chelated Mn, Zn, Cu (4%Zn:3%Mn:1%Cu:4%S)	2.0L	$7.70

The chelated products were applied at the recommended rates and therefore the level of micronutrients varied between treatments with a constant supply, in each treatment. The rate of N was kept constant. The treatments were applied at Growth Stage 39 (Flag Leaf emergence) on a steep rise near the Hopetoun site. Emergence was not even across the rise and subsequently crop growth varied between the replicates.

Whole Shoots (WS) and the Youngest Emerged Blade (YEB) were taken for analysis from ten randomly selected plants from areas with both good and poor plant establishment at the end of tillering (Growth Stage 30), which is often the time that micronutrient deficiencies begin to appear and foliar spraying is considered.

The following table shows the tissue concentrations of zinc, manganese, copper and nitrogen in the crop taken from both areas of good and poor germinations. The concentrations of each micronutrient in the base crop, before any treatments were applied, were measured in whole shoots and in the youngest (fully) emerged blade (YEB).

Table 2: Concentrations of Zn, Cu and Mn in Yitpi wheat at GS30.

	Zinc	***Adequate range***	**Manganese**	***Adequate Range***	**Copper**	***Adequate range***	**Nitrogen**	***Adequate range***
	mg/kg	***mg/kg***	**mg/kg**	***mg/kg***	**mg/kg**	***mg/kg***	**%**	***%***
YEB (good)	**25**	*24-90*	**32**	*>12*	**3.3**	*3*	**4.6**	*4.1-5*
YEB (poor)	**41**	*24-90*	**32**	*>12*	**4.2**	*3*	**5.2**	*4.1-5*
WS (poor)	**32**	*9.4-12.5*	**36**	*23*	**3.3**	*5-25*	**4.9**	*>2*
WS (good)	**22**	*9.4-12.5*	**43**	*23*	**3.6**	*5-25*	**4.1**	*>2*

Good – plants from good germination areas
Poor – plants from poor germination areas
YEB – Youngest Emerged Blade Analysis (ideal for testing deficiencies)
WS – Whole Shoot Analysis, whole plant was ground, mixed and sampled (accurate for determining nutrient uptake)

Grain is being analysed to determine if there was any increase in the chemical composition of Zn, Cu and Mn. These figures would only improve the grain quality if seed is to be kept for next year, not the grade delivered to the silo.

Results

The initial tissue tests indicate that the crop had at least adequate amounts of all the nutrients of interest and no deficiencies were evident at this stage. Early emergence meant crop growth was more prolific in the good areas and thus concentration of each nutrient was lower in these areas. Copper concentrations in the whole shoot samples were below the adequate range in both areas, despite YEB analysis indicating adequate levels.

Table 3: The effect of nutrient application on grain yield and quality.

Treatments	Yield (t/ha)	Protein (%)	Screenings (%)
Control	1.14	12.6	12.8
Control + Mn	1.23	12.4	15.0
Control + Zn	1.22	12.2	10.8
Control + Cu	1.06	12.9	11.6
Control + Mn + Zn	1.08	12.4	10.0
Control + Mn + Zn + Cu	1.01	13.3	11.9
Urea	1.12	11.5	10.5
Urea + Mn	1.02	12.0	9.9
Urea + Zn	1.30	11.9	11.7
Urea + Cu	1.11	12.6	9.7
Urea + Mn + Zn	1.10	12.1	14.1
Urea + Mn + Zn + Cu	1.17	12.4	8.9
Sulphate of Ammonia, SOA	1.24	11.8	11.4
SOA + Mn	1.20	12.1	17.7
SOA + Zn	1.21	12.2	12.8
SOA + Cu	1.20	11.8	11.4
SOA + Mn + Zn	1.19	11.6	14.6
SOA + Mn + Zn + Cu	1.15	11.7	11.5
Significant Difference	**NS**	**NS**	**S**
L.S.D 0.05	**0.41**	**1.11**	**5.8**
CV%	**12.2**	**4.7**	**15.5**

Interpretation

Under the drought conditions experienced this year, there were no benefits to applying micronutrients or N at the Hopetoun site at GS30. Crop performance was not improved with the use of N or Sulphur. No deficiency symptoms were observed throughout the year. It should be noted, the site has had a good history of Zn and N applications. In 2006 70kg of Urea and 30kg MAP + 2.5% Zn was applied at sowing. There was no improvement in crop performance or grain yield to any treatment, which would suggest that the initial applications at sowing were adequate for crop growth. Previous BCG studies have found responses to N and Zn applications on a soil with a good history would be unlikely, especially in a dry year. The results from the grain analysis have not yet been received and will be available in later publications.

Commercial Practice

Commercially, where there has been good history of application, micronutrient deficiencies are rare.

Application of micronutrients, particularly zinc, at sowing with the granular fertiliser, is still the cheapest means of ensuring adequate levels of micronutrients in the long term. There is also a residual value for micronutrient applied to the soil in the granular form, whereas foliar applications are for that season only. It costs about $3/ha to add 1% Zinc to the starter fertiliser. Foliar micronutrients cost ranges between $4-14/ha plus the extra operation during the year to further increase the expense.

BCG trials have found adequate levels of Zn can be maintained by ensuring at least 2kg Zn/ha (at sowing – with fertiliser) is applied every 5 years. Manganese is not normally a problem in the Wimmera Mallee region, however, where Mn is a problem, application would need to occur every cropping year. In contrast, copper has longer residual value and therefore 1kg of Cu every 35-40 years should be adequate in the Wimmera Mallee region.