Liquid phosphorus and micronutrients in the Mallee

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This trial is part of an on-going study to determine whether the fluid product technical grade mono-ammonium phosphate (TGMAP) is more efficient than the granular formulation MAP. The trial also investigates the addition of micronutrients Zinc and Copper.

Take Home Messages

- Over two years of trial work, there has been no economic advantage for the use of fluids.
- The site was yield responsive to high rates of liquid P.
- At rates typical of farmer practice there was no difference between granular and fluid.
- The crops did not respond to trace elements.
- High soil EC will limit the response to P irrespective of the form of P.

Background

It is important to improve nutrient delivery to crops and to increase fertiliser use efficiency. Phosphorus efficiency is generally quite low and most of the P applied in a given year is not taken up by the crop (15-20% of P applied is used in the first year of application). In some alkaline soils, much of the P is made unavailable (fixed) by chemical reactions in the soil and the residual benefit of P fertiliser is reduced. Large pools of unavailable P may build up in the soil. Liquid P fertilisers have potential to increase the availability of P to crops and to improve P efficiency.

There are several reasons why there is potential for liquid (otherwise known as fluid) P fertilisers to be advantageous in the Mallee and Wimmera:

- P fixation in alkaline and calcareous soils, where the level of $CaCO_3$ may be as little as 5% up to 90%.
- P diffusion from the fertiliser band is further and more evenly distributed when fluids are applied, compared to granular products, on alkaline calcareous (Lombi et al; 2004).
- Delivery of micronutrients such as Zinc (Zn) and Copper (Cu) is improved
- Soluble TGMAP (containing 22% P) is mixed with water prior to application; the amount of TGMAP required will depend on the rate required. The resultant solution is then applied as a continuous flow in a band below the seed. This eliminates distribution problems found when using low P rates of granular fertilisers, particularly with narrow row spacings.
- Fluid fertilisers can deliver P more efficiently than granular products (e.g. require less P to achieve same dry matter and yield).

There are however, significant drawbacks from the use of fluids;

- The machinery change-over costs from using granular to fluid fertiliser can be between $10,000-70,000 depending on the setup.
- Previous BCG work found the per unit cost of fluid P is 1.3 times that of the granular products (BCG Manual 2004). Transport contributes further to this extra expense. If there was a large market for fluids this figure would be expected to decrease.

- Responses appear to be linked to soil type and climate, and are not always consistent with these factors. For example, Victorian studies have not seen consistent responses every year, even on the same soil type.

A comparison of fluid and granular fertiliser at Sea Lake in 2005 showed fluid fertiliser improved early growth of wheat, but there was no significant effect on yield.

Method

Location:	Hopetoun	
Replicates:	4	
Plot Size:	2m × 25m	
Crop:	Annuello, Wheat	
Previous Crop:	Canola, stubble retained and slashed prior to sowing	
Sowing Date:	18th May 2006	
Target Seeding Density:	175 plants/m^2	
Seeder:	Incitec Pivot Seeder – No Till, narrow points, presswheels, 20.2cm row spacings (8-inch)	
Herbicide:	10/5/06	Roundup PowerMax (1.5L/ha)
	26/7/06	Atlantis (330mL/ha)
Soil Type:	Mallee Sandy Clay Loam with moderate subsoil constraints	
Soil pH:	Topsoil 8.6 (H_2O)	
Colwell P:	18ppm	

ZincSol and CopperSol were used to apply the desired rates of Zinc (Zn) and Copper (Cu). The treatments (Table 1) were applied in two ways, TGMAP in a dribble band (a continuous stream of liquid behind the tyne) and the MAP was banded with the seed. All the micronutrients were dribble banded and agitated with water prior to application. The micronutrients were applied with TGMAP down the tube in the fluid treatments.

Table 1: List of treatments used in this trial

Treatments	P rate (kg P/ha)	Micronutrients Rate (per hectare)	Application Method
Control	0	0	
MAP	3	0	Banded
TGMAP	3	0	Dribble Band
MAP	6	0	Banded
TGMAP	6	0	Dribble Band
MAP	12	0	Banded
TGMAP	12	0	Dribble Band
MAP	18	0	Banded
TGMAP	18	0	Dribble Band
MAP	12	0.5kg Zn	Banded, Dribble Band
TGMAP	12	0.5kg Zn	Dribble Band
MAP	12	0.5kg Zn, 0.5kg Cu	Banded, Dribble Band
TGMAP	12	0.5kg Zn, 0.5kg Cu	Dribble Band

Fertilisers

- Mono-ammonium Phosphate, MAP (N10-P22-K0-S1): a commonly used fertiliser in the Mallee (granule).
- Technical Grade Mono-ammonium Phosphate, TGMAP: same formulation as MAP but mixed with water before application (fluid).
- ZincSol, Zn (16.7% $ZnSO_4$): soil or foliar applied fertiliser
- CopperSol, Cu (6.7% $CuSO_4$): soil or foliar applied fertiliser

Measurements

Plant counts were recorded at the 2-3 leaf stage of the crop. At Growth Stage 30 (end of tillering), tiller counts and dry matter production was recorded. Total P uptake was also measured using ICP-AES analysis of the whole shoots (at GS30). Head counts were taken at anthesis and the crop was harvested on the 23rd November. Hand cuts were taken pre-harvest to determine the harvest index for all treatments. Harvest index is a measure of the percentage of grain produced in proportion to the dry matter at the time of harvest.

Results

Table 2: Responses in wheat production from the addition of P, Zn and Cu.

Treatment	Plants Counts (m^2)	Tiller Counts at GS30 (m^2)	Dry Matter At GS30 (kg/ha)	Total P-uptake (kgP/ha)	Head Counts (m^2)	Yield (t/ha)	Cost ($/ha)
Control	146	104	234	0.76	178	1.23	0
MAP (3kg P)	137	99	297*	0.96	163	1.25	$7.20
TGMAP (3kg P)	134	137	284	0.94	164	1.27	$15.50
MAP (6kg P)	157	116	281	1.04*	169	1.10	$14.50
TGMAP (6kg P)	136	119	270	0.92	179	1.26	$30.95
MAP (12kg P)	138	136	269	1.00*	172	1.29	$28.95
TGMAP (12kg P)	135	137	302*	1.05*	182	1.37	$61.90
MAP (18kg P)	133	155	269	1.03*	187	1.32	$43.40
TGMAP (18kg P)	146	134	280	1.03*	187	1.42*	$92.90
TGMAP (12kg P) + **ZINC** (500g)	132	122	289	1.08*	192	1.36	$74.40
MAP (12kg P/ha) + **ZINC** (500g/ha)	133	130	263	1.00*	159	1.26	$41.50
TGMAP (12kg P/ha) + **ZINC** (500g/ha) + **COPPER** (500g/ha)	145	120	250	0.88	177	1.39*	$83.80
MAP (12kg P/ha) + **ZINC** (500g/ha) + **COPPER** (500g/ha)	134	132	277	0.98	166	1.38*	$50.80
Significant Difference			**P<0.05**	**P<0.05**	**P<0.05**	**P<0.05**	
L.S.D 0.05	**NS**	**NS**	**56.2**	**0.24**	**23.5**	**0.15**	
CV %			**13.6%**	**15.4%**	**4.1%**	**10.6%**	

* indicate the treatment is statistically significant from the control

Prices effective January 2007, pick up Geelong: MAP $555/t, LiquidFert (TGMAP) $1,342/t, ZincSol $1,452/t and CopperSol $1,046/t.

Costings were made assuming the prices above, it would be fair to say the granular products with the micronutrients would be cheaper if using Zn enriched P fertilisers. Typically, applying fertilisers containing zinc, costs about $3/ha extra to apply.

In terms of yield, there were no significant differences observed between the fluid and granular when comparing the products at the same rate of P. However, when averaged over all rates there was a significant difference between products, fluid (1.35t/ha) and granular (1.27t/ha) (LSD 0.07, CV 11.2%). The results show that a significant yield response occurred at the highest rate of the fluid fertiliser and there was no response at all to any of the P rate for granular fertiliser. While these rates are clearly uneconomical it is nevertheless significant that the only times that you get a significant yield response is when you used a fluid.

There were no differences found between the products at any of the P rates. Although, when 12kg P or more was applied as TGMAP, there was at least a 10% increase from the control (Figure 2). TGMAP 18P was the only P rate to yield significantly greater than the control. Although these yield increases are only slight, responses may have been greater if seasonal conditions were not as devastating as in 2006.

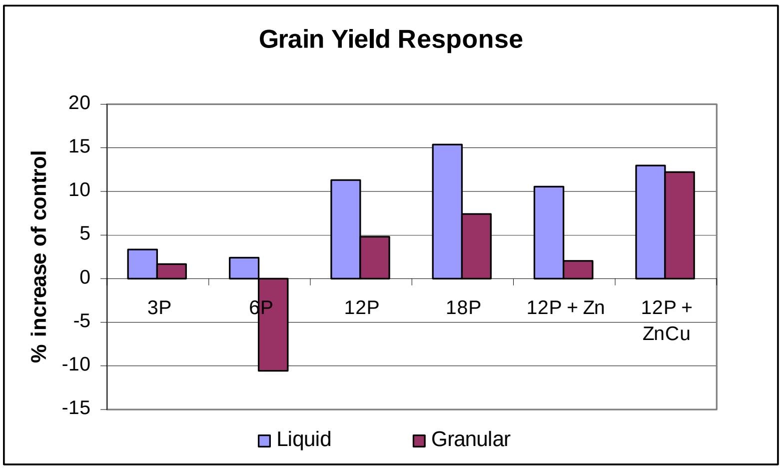

Figure 2: Wheat grain yield expressed as a % of control

The trend towards negative yield responses such as the MAP 6P treatment led to further investigation. In-crop observations identified areas of good and poor growth. Using an EM38 survey taken earlier in the year a relationship was determined between the level of yield response and the Electrical Conductivity, EC (salt) level in the soil. Significant decreases in the level of yield response was found when high P rates (18kg P/ha) were applied to high EC soil. This data suggests P responses are limited by high soil EC. At the low EC, the yield response to fluid P (at 18kg P) is about 0.5t/ha whereas at high EC there is no response, irrespective of the form of P. Figure 3 illustrates the reduction in grain yield at the highest level of applied P as the EC level increases.

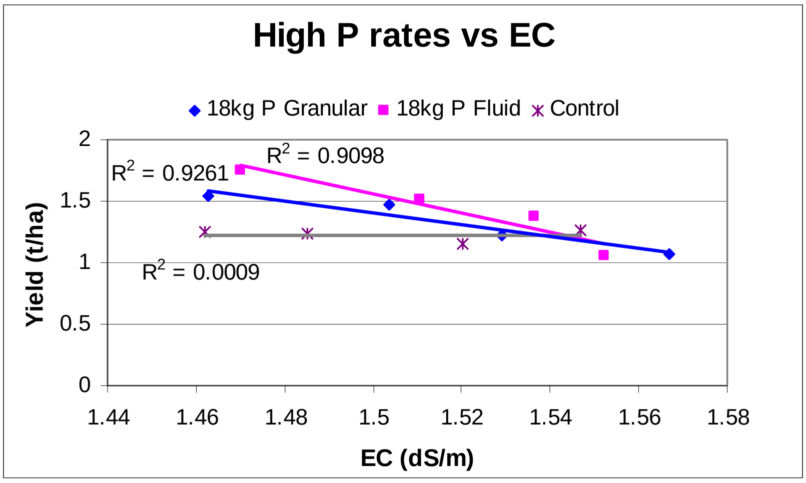

Figure 3: The of effect high P rates on wheat grain yield (t/ha) when EC levels increase

Interpretation

Responses to P are limited by many factors. Seasonal differences, sowing time and soil type all influence nutrient responses. In paddocks with a good P history, and a Colwell P above 15, response to P applications (greater than 6kg P/ha) would be minor, especially in dry years. Variations in responses have been seen from several P trials (even on the same soil type) in the Mallee.

In terms of this year's responses, it is important to consider the season. The Hopetoun site did not receive any rain for seven weeks after sowing and the crop was subject to several frosts. Crop growth during this period was slow and there was arguably an adequate level of P (Colwell P 18) in the soil for growth.

From this study there was no effect of fertiliser treatment on crop establishment. Previous BCG trials have shown no benefit, in terms of yield, to P application over 6kg P/ha on a Sandy Clay Loam with a Colwell P > 15. Phosphorus responses are more likely when less background P is present in the soil. There will always be an interaction between P response and seasonal conditions at a given site.

Early growth was not affected by the P rate or the form of P. In 2005, with regular rainfall events, significant responses in dry matter were found at the five-leaf stage of a wheat crop. In 2005, the site had a relatively high soil P status (Colwell P 26) yet a response to P additions, in terms of early growth and vigour, was observed. Seasonal differences during the early stages of crop growth will influence the P response. If the soil is warm and moist, early responses could be expected.

The uptake of P, when measured at GS30, was not influenced by the form of P. From the results in Table 2, most of the treatments, regardless of product, significantly increased the amount of P taken up by the crop. Arguably, differences may have been seen between treatments if this analysis was taken at flowering. It has been found that under drought conditions, maximum P uptake occurs at flowering (Zubaidi *et al* 1999). The measurement taken in this trial was to assess if more P was taken up in the early stages of crop growth.

Significant increases in grain yield only occurred at 18 kg P/ha and only when fluid fertiliser was used. Crop responses to 18kg P/ha was influenced by the level of EC (salt), as no response was found when the EC level increased. This also occurred with the granular treatment of the same rate (Figure 3). The effect of EC was probably exacerbated by the exceptionally dry period, and such correlations may not be found in better years. The addition of micronutrients, Zn and Cu, had no benefit on crop performance.

Commercial Practice

Based on these data alone, it is not cost effective to use fluid P fertilisers. If the unit cost of fluid products were to reduce significantly the benefits would make conversion more attractive and profitable.

This study will continue to investigate the responses and behaviours of P fertilisers in the Mallee in 2007. Of particular focus will be the influence of seasonal conditions and soil moisture to better understand their influences on P responses.

References

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