Field evidence for efficiency of fluid fertilisers

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Introduction

Prior to 1998, there was no reason to believe that soil-applied fluid and granular fertilisers would perform differently in terms of fertiliser efficiency, on any soil used for cereal production in South Australia.

Hence the initial investigations of fluid fertilisers on the Eyre Peninsula produced results that were unexpected. Between 1993 and 1996, an investigation into the role of zinc in subsoil infertility was conducted on the Upper Eyre Peninsula using fluid mixtures of phosphorus (P), zinc (Zn) and nitrogen (N) (Holloway 1996). The fluids proved to be exceptionally efficient in terms of improving zinc uptake in cereals, but only when all three nutrients were supplied in a single solution. It was also apparent that NP solutions had a large effect on increasing P uptake in plants compared with granular applications on a red-brown calcareous soil at Minnipa, (Isbell 2002) (annual rainfall 320mm). After 1996, similar experiments designed to apply P, N and Zn to the subsoil were conducted at Cungena on a grey, highly calcareous soil, (annual rainfall 275mm) with spectacular results in terms of early growth and grain yield of wheat.

At the same time, Wilhelm and Growden (1998) identified the serious nature of P deficiency on calcareous sandy soils on the Upper Eyre Peninsula. They applied P as granular triple super phosphate at up to ten times the normal commercial rate with little response. Their conclusion was that "*current rates of P fertiliser application are insufficient to overcome P deficiency in this area and increasing the rates of application of current fertiliser types will not improve the situation*".

The earliest field experiments with fluid fertilisers were based on simple comparisons between clear liquid and granular formulations. At the time, more emphasis was placed on assessing differences in performance rather than economic or practical considerations. Eight years later, more than 90 statistically-based field comparisons between fluid and granular alternatives, coupled with detailed laboratory experiments, have provided good evidence for the greater efficiency of fluid fertilisers than equivalent granular formulations on highly calcareous soils on the Eyre Peninsula. There is also evidence that fluid fertilisers will improve nutrient efficiency for cereals and alternative crops on other alkaline soils and acid soils, particularly those that rapidly immobilise P.

Results and discussion

Grey highly Calcareous sandy loams

- *Ammonium polyphosphates (APP)*

A total of 21 comparisons were conducted between ammonium polyphosphates and granular fertilisers on the grey Calcarosols. Of these, APP produced a mean yield increase of 15% over granular in 19 of the 21 trials. The addition of phosphoric acid to APP to improve the solubility of zinc sulphate led to an improved zinc uptake in an experiment on this soil.

- *Phosphoric acid products*

A total of 11 comparisons were conducted with the fluid producing a mean yield increase of 23% in eight of the experiments. In three of the comparisons there were no yield differences.

- *Technical grade MAP/DAP*

In all, there were 11 comparisons with soluble technical grade MAP or DAP with granular products. There was a mean yield increase from the fluid of 20% over all comparisons. Micronutrients were mainly applied in the NP solution at sowing.

Overall, there were 43 comparisons on the grey Calcarosols, 38 showing a positive yield increase with fluid and five with no yield difference.

Red brown sandy loams

Ammonium polyphosphates

There were 13 comparisons between ammonium polyphosphates and equivalent granular fertilisers, with a mean grain yield increase of 14.3% due to APP in ten of these.

Phosphoric acid products

In 16 comparisons there were nine instances of yield increases with fluids and a mean yield increase of 11%. In each of the nine experiments, basal micronutrients were applied in solution with the phosphoric acid and urea. It appears then that application of micronutrients with phosphoric acid –urea solutions at sowing is a key factor in fluid fertiliser formulation.

Technical grade MAP/DAP (TGMAP/TGDAP)

Of nine experiments conducted on red brown Calcarosols there were no yield differences between fluid and granular in six of the experiments. However, as with the phosphoric acid solutions in which there were no yield differences, micronutrients were applied pre-sowing to the soil surface or foliar. In the three cases in which micronutrients were applied in the solution with TGMAP at sowing, there were yield increases, with a mean increase of 15%. Overall, there were 38 comparisons on the red brown Calcarosols, 22 with positive increases with fluids and 16 with no yield differences.

Red-brown loamy sand

This soil is represented by a single site with low N fertility. Overall, there were 11 comparisons on this soil, with four yield decreases with fluids (APP), one increase with fluids (TGMAP) and six with no yield differences recorded.

Suspensions

Suspension fertilisers are produced by mixing a solid fertiliser with water and then adding Attapulgite or Bentonite clay to maintain a colloidal suspension that allows even distribution of nutrients at application. Other additives such as strong acid may be used to increase the rate of breakdown of granular products. Over time, suspensions will settle or ingredients may crystallise and long-term storage requires some form of regular agitation, either "sparging" with air or by recirculation with a pump. Suspensions can be easily applied with peristaltic or "squeeze" pumps, through tubes of about 6mm id. Nozzles are not required at the base of the application tube. The only need for filtration is to ensure that no large solid particles enter the application tank. Given the high cost of importation of clear liquids into South Australia, and the lack of basic ingredients such as super-phosphoric acid and liquid ammonia, it is possible that suspensions may have a place in the local market. They can be synthesised from basic solids such as fine (pre-granulated) MAP or from granular products such as DAP. Suspensions can be formulated to almost any ratio of a wide range of nutrients. Initial research on the three soil types has indicated that suspensions are likely to perform in a similar way to other fluids in general but as with clear liquids, fertiliser performance varies widely according to formulation and the combination of nutrients used.

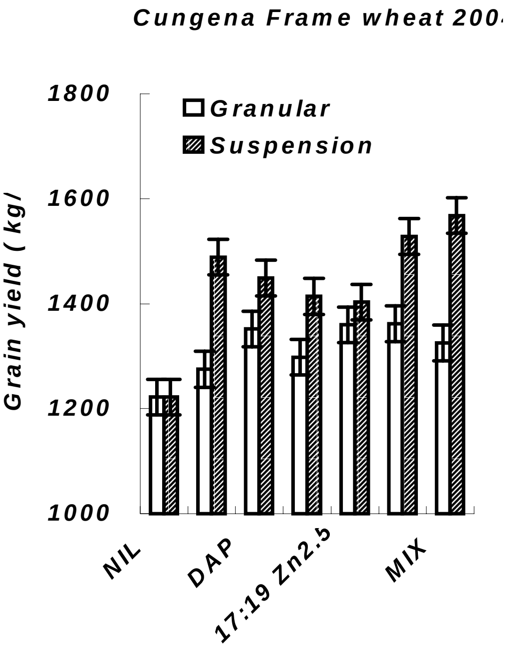

Figure 1. Grain yields of Wyalkatchem wheat with fertiliser applied in granular form or as a suspension at Cungena 2004.

In the case of most of the suspensions, the only additive, besides clay, was acid used to increase the breakdown rate of the granules.

Micronutrients

Where possible, micronutrients were applied in solution with fluid fertilisers and integral with granular fertilisers. Both zinc and manganese (Mn) sulphate can be readily mixed with phosphoric acid-urea solution. (Phosphoric acid and UAN should never be mixed under any circumstances because of the possibility of explosion).

Zinc sulphate can only be added in small quantities to APP but APP acidified with phosphoric acid is more amenable to the addition of zinc sulphate. Both fluids produced significantly higher dry weight of shoots and grain yield than the granular at both sites but the two fluids produced similar grain yields. Acidification of APP did not help with Mn. APP and manganese sulphate can only be applied at the same time if the Mn is applied separately.

Similarly, the acidification of TGMAP with phosphoric acid allows higher rates of P to be applied with micronutrients without the need to dilute the solution with large amounts of water. A commercial problem with TGMAP is that sufficient TGMAP dissolves in 100L of solution to allow the application of only 6kg P/ha. This amount can be doubled to 12kg P/ha by also dissolving TGDAP. However, while zinc sulphate can be dissolved in TGMAP, it cannot be dissolved with TGDAP due to the formation of insoluble zinc compounds. Hence, the acidification of TGMAP with phosphoric acid is an easier way to allow the addition of zinc and manganese sulphates to the solution.

There were significant responses ($P<0.05$) to all three nutrients with the fluid but not with the granular. It is apparent that applying micronutrients to the soil in solution with NP fluids is the most efficient way to apply micronutrients on these soils.

Summary of fertiliser experiments

There were 92 comparisons in all with 61 yield increases due to fluid applications; four yield decreases (all on one soil) and 27 with no difference. In some of these "no difference" comparisons, there were early dry matter increases due to fluids but these had disappeared by harvest. It is possible that this is due to higher water use early in the season, leading to a deficit with approaching maturity in the absence of late seasonal rains.

There is no doubt that fluid fertilisers, including suspensions, have the potential to make a significant improvement in fertiliser efficiency on many of the Calcarosols especially those with high concentrations of calcium carbonate and possibly a wide range of other alkaline and acid soils as well. It is also suggested that the "ideal" fluid fertiliser for testing on a wide range of soils is TGMAP with urea and micronutrients dissolved in a single solution.

Economics of fluid fertiliser application in SA

Fluid fertilisers available in South Australia are relatively expensive compared with the granular fertilisers available. In early 2004, DAP and MAP were available on the Upper Eyre Peninsula at a cost of about $422/tonne delivered. The unit cost of P was $1.92/kg with MAP and $2.11/kg with DAP. In this case, any N combined with the P was supplied at no extra cost, with P the major limiting nutrient.

Table 1. Approximate prices ($/tonne) on Eyre Peninsula of a range of fluid fertilisers compared with granular 17:19 Zn 2.5 in early 2004. Cost/ha is based on 10kg P, 8.8kg N and 1.3kg Zn/ha, with costs of extra urea and zinc sulphate included. Break-even column (1) shows the percentage increase in wheat yield required to cover the extra cost of fluid fertiliser in a 1.5t/ha crop at a net wheat price of $165/t. Column (2) is based on a 1.5t/ha wheat crop and a net grain price of $200/t.

Fertiliser	$/ton	Cost $/ha	Break even yield % increase (1)	Break even yield % increase (2)
17:19 Zn 2.5% Granular	572	30.1		
Phos acid	800	45.8	6.9	5.2
Phos acid	900	49.6	7.9	6.5
Phos acid	1500	72.0	16.9	13.9
11:12:0 1%Zn	480	43.1	4.3	4.3
11:12:0 1% Zn	580	51.5	8.6	7.1
11:12:0 1% Zn	680	59.8	12.0	9.9
APP 14:21:0	935	67.6	15.1	12.5
APP 14:21:0	842	61.9	12.8	10.6
APP 14:21:0	1029	73.3	17.4	14.4
Liqui NP 9:12:0	530	54.0	9.6	7.9
TGMAP	800	41.9	4.8	3.9
TGMAP	1000	49.4	7.8	6.4
TGMAP	1200	56.8	10.8	8.9

Table 2 indicates that for all but the lowest priced products a 10% yield increase is required for the marginal return to be reliably positive, and with some products a 20% yield increase would be required to give some level of confidence. In this regard, the price of the suspension from WA is very competitive.

Table 2. Changes in marginal return of wheat income net of fertiliser costs over a range of fluid fertilisers compared with granular 17:19 Zn 2.5 in early 2004. Marginal returns are calculated on increases in yield of a 1.5t/ha crop minus fertiliser cost at a net wheat price of $200/t.

Fertiliser	$/t	Change in marginal return $/ha 5% yld increase	Change in marginal return $/ha 10% yield increase	Change in marginal return $/ha 20% yield increase
17:19 Zn 2.5% Granular	572			
Phos acid	800	-2.23	11.27	38.27
Phos acid	900	-5.96	7.54	34.54
Phos acid	1500	-28.34	-14.84	12.16
11:12:0 1%Zn	480	0.48	13.98	40.98
11:12:0 1% Zn	580	-7.86	5.64	32.64
11:12:0 1% Zn	680	-16.19	-2.69	24.31
APP 14:21:0	935	-18.26	-4.76	22.24
APP 14:21:0	842	-23.97	-10.47	16.53
APP 14:21:0	1029	-29.68	-16.18	10.82
Liqui NP 9:12:0	530	-10.35	3.15	30.15
TGMAP	800	1.66	15.16	42.16
TGMAP	1000	-5.74	7.76	34.76
TGMAP	1200	-13.15	0.35	27.35

Conclusions

There is now a sound scientific basis for the use of fluid fertilisers on many of the Calcarosols. In many cases, yield increases were the result of multi-nutrient interactions (principally P, N and Zn), which only occurred with fluids.

The interactions between nutrients applied in fluid form are a promising new arena for research, as are interactions between fluid formulations and soil types. Of the fluids tested, TGMAP applied with additional N and micronutrients appears to be the most adaptable of the fluids to a range of Calcarosols. If TGMAP can be imported into SA at a reasonable cost and marketed in dissolved “ready to use” form, it may prove to be of considerable benefit to the state’s farmers, particularly on soils which immobilise P. Similarly, suspension fertilisers may also be a cost effective form of fluid fertiliser for SA. Given the finite nature of world P supplies, it is important that fertiliser efficiency becomes a major imperative in determining the formulation of fertilisers for broadacre use.

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