Why are we interested in Fluid Fertilisers in SA? Are they worth trying in Qld?

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We started investigating fluid fertilisers in SA in 1998 because of a major problem with wheat production on a group of grey highly calcareous soils (10-90% calcium carbonate) covering a large part of western Eye Peninsula. Mean yields had not increased in this area for forty years. Research showed that granular phosphorus (P) fertilisers could be added to these soils at ever increasing rates – up to 100 kg P/ha – with only very slight responses. Most of the P added was being rapidly fixed and while the total P concentrations in the soil were high (e.g. 700 mg P/kg soil), the available P concentrations were very low, so plants continually suffered from poor tillering and uneven ripening, classic symptoms of P deficiency.

Lack of phosphorus was not suspected to be the major problem for many years until plant tissue testing became more widespread. The Colwell P test is universally used in SA for soil testing and indicated that P levels in these calcareous soils was adequate. It has since been found that the Colwell test actually removes some fixed P from the soil which plants cannot obtain, hence overestimating the real P status of the soil.

In the early 1990s, the role of zinc as a subsoil nutrient was being investigated at Minnipa Research Centre. Zinc was injected into the subsoil with phosphorus and nitrogen using a paraplow and to do this, liquid nutrients had to be used. The results showed that Zn uptake by plants and in the grain could be most improved by mixing zinc with N and P (as technical grade MAP and ammonium nitrate dissolved in water) in a single solution and injecting it into the soil to a depth of 40 cm.

It was also found that the fluid also greatly improved phosphorus uptake in shoots. This work was done at Minnipa on a red-brown slightly calcareous soil. When the experiments were duplicated on grey highly calcareous soils, there was a large improvement in growth and yield. Because of the stony soil, deep placement using a ripper was impractical, so injecting fluids just below the seed was tried. This too was very successful in improving the availability of P to plants. GRDC has now supported two programs to further investigate the ability of fluid fertilisers to improve P availability on difficult soils. Testing has also begun on other soil types and this paper summarises the results to date.

We now have more than 100 comparisons of a range of fluid and granular fertilisers conducted by our group on Central and Upper Eyre Peninsula (EP) over the past six years. With all this data, can we now say whether fluids have a place in our South Australian Farming systems, or even in other States? The first step is to look at what we have from Eyre Peninsula, and then see what is now happening in other areas.

Results from EP are restricted to grain yields from replicated wheat trials and all comparisons are from trials where the rates of nutrients have been balanced to ensure valid results. Increases or decreases in yields are based on statistical significance. If there is no significant difference, the yields are considered to be the same. In some cases, more than one comparison was made in the same trial, e.g. between two different products.

To begin with "all fluids ain't fluids". The different kinds of fluids available often perform differently in different soils, even in different areas of the same paddock. We compared

- ammonium polyphosphates (APPs) (often mixed with urea ammonium nitrate UAN),
- phosphoric acid-based products (usually with urea and micronutrients),
- technical grade MAP or DAP dissolved in water (often with micronutrients and extra nitrogen), and
- suspension fertilisers - mixtures of fine granular fertiliser with water, clay, and micronutrients.

These were compared with granular fertilisers like TSP, TSPMn5, MAP, DAP, 13:15Mn6, 17:19Zn2.5, Urea, UreaZn5. We preferred to use the fertilisers containing micronutrients if possible. Generally, comparisons were made at rates of between 5 and 15 kg P/ha and 5 and 25 kg N/ha, according to the rainfall.

Trials were conducted on three soil types: Grey highly calcareous sandy loams with 15-70% calcium carbonate content; Red-brown calcareous sandy loams with 5-15% calcium carbonate and; Red-brown loamy sands with 1-5% carbonate and low nitrogen fertility. The results are shown with the number of comparisons on each soil type and are summarised below. *All comparisons are at the same rates of P and other nutrients.*

Grey highly calcareous sandy loams

- *APP* – 21 comparisons with granular. 19 of these had a mean yield increase of 15% over an appropriate granular fertiliser. In 2 comparisons there were no yield differences – no micronutrients were added in one of these and in the other, manganese caused a precipitation in the preparation.
- *Phosphoric acid products* – 11 comparisons in all with a mean yield increase due to fluid of 23% in 8 of these. There were no yield differences in 3.
- *Technical grade MAP/DAP* - 11 comparisons, with a mean yield increase of 20% with fluids in all 11 comparisons. Micronutrients were mainly applied in the NP solution at sowing.
- *Suspensions* – 7 comparisons with a mean yield increase of 20% with fluid in all 7 comparisons. Micronutrients were applied in the suspension at sowing.

Overall, there were 50 comparisons, 45 showing a positive yield increase with fluid and 5 with no yield difference.

Red-brown calcareous sandy loams

APP – 10 comparisons. 7 of these had a mean yield increase of 14.3%. In 3 comparisons there were no yield differences. One of these was due to a low water rate – when the water rate was doubled, yield increased.

Phosphoric acid products **–** 16 comparisons. 9 had a mean yield increase of 11%. All of the 9 had micronutrients applied in solution with the phosphoric acid and urea. There were 7 comparisons with no yield differences. In these, either no micronutrients were applied, or they were applied pre-sowing to the soil surface or foliar, *i.e.* at a different time to the P solution.

Technical grade MAP/DAP - 9 comparisons. 3 had a mean yield increase of 15%, and in these micronutrients were applied in the solution at sowing. In 6 cases there were no yield differences. In these, micronutrients were applied pre-sowing to the soil surface or foliar.

Suspensions – 5 comparisons. 4 had a mean yield increase with fluids of 12.5%. In the 5th comparison there was no yield difference.

Overall, there were 40 comparisons, 23 with positive increases with fluids, 17 with no yield differences.

Red-brown loamy sand (low carbonate, low fertility)

APP- 6 comparisons. Two of these had a mean yield **decrease** with fluids of 10%. In 4 there were no yield differences.

Phosphoric acid products – 1 comparison had a yield **decrease** of 7% with fluid.

Technical grade MAP/DAP- 2 comparisons, no yield differences.

Suspensions – 2 comparisons. 1 yield **decrease** with fluids of 12%, 1 no yield difference.

Overall, there were 11 comparisons, with 4 yield decreases due to fluids and 7 with no yield differences.

There were 101 comparisons in all with 68 yield increases due to fluids, 3 yield decreases (all on one soil) and 30 with no differences. In some of the “no difference” comparisons, there were early dry matter increases due to fluids but these had disappeared by harvest. For instance, on the red-brown sandy loam soil in 2003, a fluid mixture of APP with UAN and ammonium thiosulfate produced 31% more dry matter at mid tillering than MAP with UAN, but there were no grain yield differences.

Other soils

We conducted pot experiments on a wide range of soils from Victoria, South Australia and Western Australia, to determine on which soils fluids offer benefits over granular P products. The P fertilisers tested were triple superphosphate (TSP), phosphoric acid (H_3PO_4), ammonium polyphosphate (APP) and a control of no P fertiliser. The amount of P applied to each pot was the equivalent of 12 kg P ha^{-1}.

Wheat responded to P application on 70% of the 29 soils used (Table 1). This response was not well correlated with methods commonly used to assess P availability such as Colwell-P.

Table 1: Dry matter response (g/pot) to fertiliser type. APP is ammonium polyphosphate, H_3PO_4 is phosphoric acid, Triple P is triple superphosphate and control is no P fertiliser. Values in the same row denoted by the same letter are not significantly different (P d” 0.05).

Soil type	No.	Control	APP	H_3PO_4	TSP
Acid	3	0.40 c	1.22 a	1.14 a	0.89 b
Neutral pH	7	1.06 b	1.55 a	1.59 a	1.48 a
Alkaline	12	0.87 c	1.54 a	1.57 a	1.25 b
Calcareous	7	0.54 b	1.03 a	1.06 a	0.60 b

Among the soil properties, soil pH (and calcium carbonate content) were the key soil characteristics controlling the differential response of fluid versus granular fertilisers (Figure 1). Surprisingly, fluid formulations also performed well in some acidic soils.

The greater cost of fluids, and equipment issues, need to be assessed against any possible yield advantages, although there are general logistical advantages with the use of fluid fertilisers.

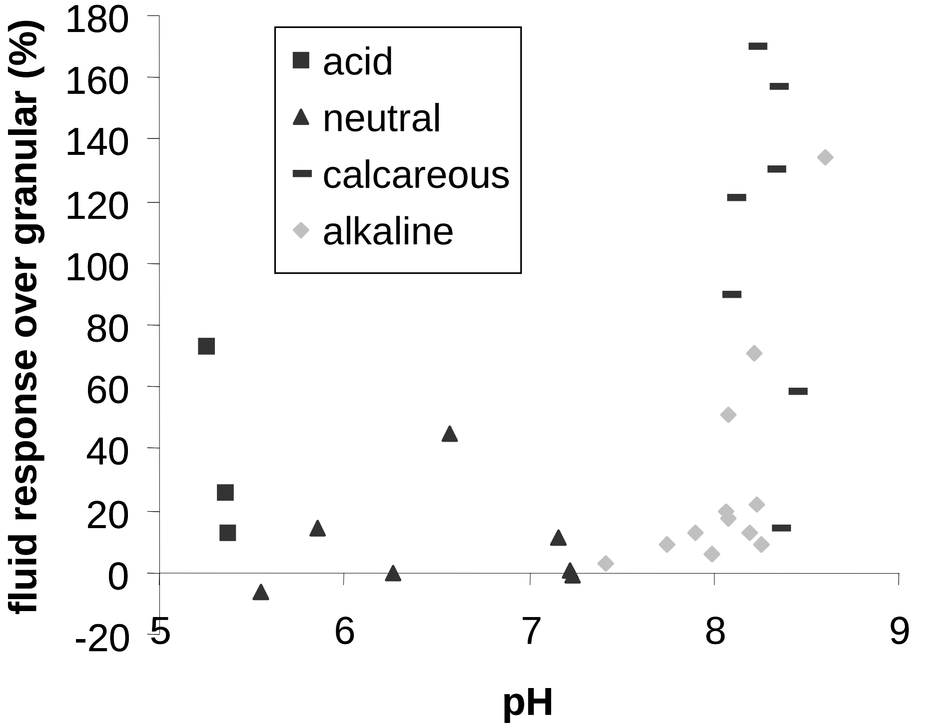

Figure 1. Dry matter response of wheat to fluid fertilisers (APP and phosphoric acid), expressed as a percentage benefit over granular P fertiliser (TSP).

Other soils

In 2003, a pot experiment was conducted at DPI Horsham to assess the early growth response of wheat to APP, phosphoric acid and granular triple superphosphate (TSP). There were growth increases with both APP and phosphoric acid compared with TSP on

5 acid soils from SA and Vic, 4 soils from the Northern Mallee (Vic), 3 soils from the Birchip area and 7 heavy clay soils from the Wimmera (Fig.1). In 2003, field trials were conducted at Kalkee near Horsham, at Walpeup in the northern Mallee and at Birchip (Fig. 2). DAP (18:20) was also included in these trials.
There were improvements in early shoot production with a phosphoric acid solution at Kalkee and with both phosphoric acid and APP at Birchip, but not at Walpeup. Grain yields were higher at Birchip with the fluid fertilizers at rates up to 12 kg P/ha.

Trials conducted by Dr Nigel Wilhelm in 2002 showed positive responses to fluid fertiliser (Tech grade MAP cf MAP) at Warooka (YP) and at Orroroo (Upper North), with no response at Minlaton (YP).

We also compared the lability, solubility and mobility of P applied as either a fluid (3 products) or granular (3 products) form to two calcareous and one alkaline non-calcareous soils in the laboratory. Over a five-week period, between 9.5 and 18 % of the P initially present in the fertiliser granules did not diffuse into the surrounding soil. The degree of granule dissolution was independent of the soil type.

In contrast, P solubility, lability and diffusion were significantly greater when fluid products were applied to the calcareous soils, but not in the alkaline non-calcareous soil. Solubility, lability and diffusion of P from fluid fertilisers was enhanced in highly P-fixing calcareous soils in comparison to granular products.

In contrast, in an alkaline non-calcareous soil, P behaviour was not related to the form of fertiliser P used. Incomplete dissolution of granular fertiliser is probably not the major cause for these differences because similar results were obtained in all soil types investigated. This suggests that the differences in the effectiveness between granular and fluid P fertilisers, observed in field trials on calcareous soils, may be due to different P fixation processes around fertiliser granules and fluid fertiliser bands. This is confirmed by the fact that in a Vertosol with a lower P retention capacity, P supplied as granular or fluid showed a similar behaviour.

Other points

- In a long-term residual P trial at Warramboo (grey highly calcareous soil), wheat yields in 2003, the year after application of APP (and N plus micronutrients) or 13:15 Mn 6/ Urea Zn5% were higher after the APP. This is the first indication of higher residual value of P from a fluid fertiliser.
- On a red-brown sandy soil low in N, fluid UAN was less available to plants than granular urea, particularly with wet soil at sowing. The use of ammonium thiosulphate (ATS) with UAN may reduce ammonia volatilisation and reduce nitrate leaching. There is some evidence of improved UAN performance with ATS in our trials this year.

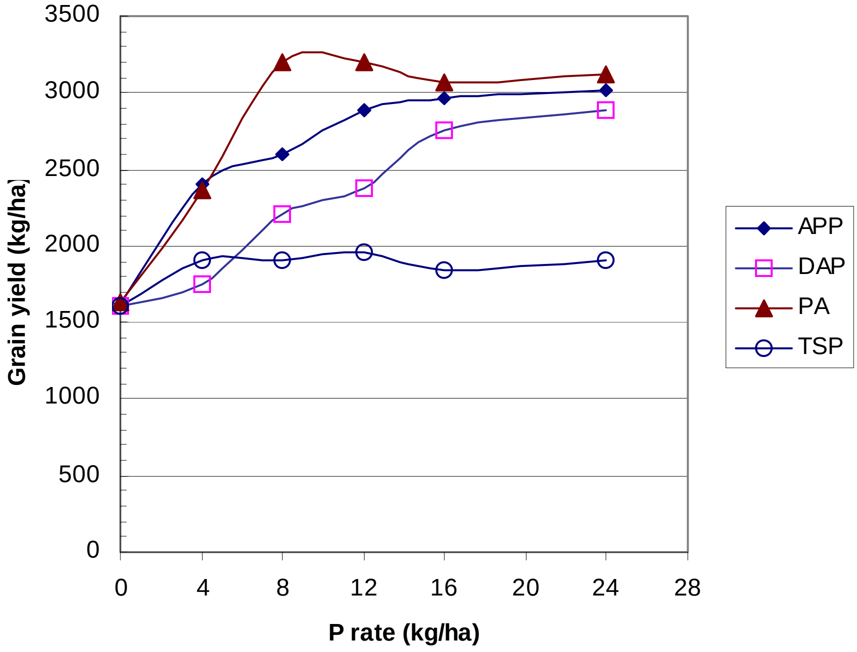

Fig. 2 Effect of P fertiliser form and rate on the grain yield of wheat at Birchip 2003. l.s.d. (5%) Fertiliser form x rate = 210.

- Suspension or "liquid granular"(copyright J Lamb) fertilisers can be made at competitive prices given a sufficient market. They are more difficult to handle and store than clear liquids. In 14 comparisons with MAP/DAP-based products, they increased grain yields in 12. There was one instance of no difference in yield and one of a yield reduction. This occurred on the red-brown loamy sand soil and it is likely due to poor utilisation of N in fluid form.

- According to "a reliable source" prices of fluid P in WA from one company this year may be similar to granular.

Conclusions

- Fluid fertilisers are likely to give positive yield increases compared with granular on highly calcareous grey soils in low rainfall areas.
- Non- or low-calcareous sandy soils may have problems with loss of N from fluid UAN. More research is needed in the use of ATS to help prevent this.
- Best results with phosphoric acid solutions came from applying N (as urea) and micronutrients in the same solution at sowing.
- When there is a likelihood of deficiency of more than one nutrient they are best applied together in a single solution if possible. If not, they should be applied at the same time to the same soil via a separate system, e.g. zinc and manganese solution and APP will precipitate but they work well if applied in separate systems.
- Suspension fertilisers are likely to be a cost effective way of using fluid technology.