Phosphorus Management and Availability in Highly Calcareous Soil

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Abstract

More than 1 million hectares of South Australia's cereal production area consists of highly calcareous alkaline soils. Despite decades of applied fertiliser phosphorus (P), productivity in some of these areas has not increased. Six years of trial work on Eyre Peninsula using fluid fertilisers as an alternative to high-analysis granular fertilisers such as MAP and DAP, have shown wheat yields can be increased through improved P availability by 15%-23% over a range of seasons.

Media summary

Fluid fertilisers are more efficient at supplying P to wheat than granular fertilisers on highly calcareous alkaline soils in low rainfall areas of South Australia.

Key Words

Fluid fertilisers, phosphorus, calcareous soils, wheat

Introduction

Alkaline soils comprise a large area of agricultural land throughout the world. In Australia, calcareous soils are widely represented in cropping regions, particularly those with Mediterranean and semi-arid climates. More than 1 million ha in the cropping areas of South Australia (SA) are highly calcareous and contain from 5 to 90% calcium carbonate. The carbonate consists of shell fragments of marine origin that were blown inland from the seafloor in a previous ice age. These soils have a naturally low P status. Despite many years of fertilisation with superphosphate, triple superphosphate (TSP), and later mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP), average wheat yields in the lower rainfall zone (200-300 mm/year) of the calcareous soil region on Eyre Peninsula in SA have not increased in 40 years. This paper summarises the results of research conducted over the last 6 years comparing the efficacy of granular and fluid P fertiliser formulations on wheat yields on the calcareous soils of Eyre Peninsula.

Results

A study by Bertrand et al. (2003) showed that bicarbonate-extractable P, the common predictor of soil P status in SA, overestimates plant available P to a considerable extent. Further, despite showing typical P deficiency symptoms and low tissue concentrations of P, plants respond poorly to applications of granular fertiliser. Even applications of up to 100 kg P/ha as TSP often only produce a flat response curve. The calcareous soils have a very high 'P-fixing' capacity despite high levels of total P, eg 300-700 mg P/g soil. Much of the applied P is apparently precipitated as insoluble calcium phosphates that are largely unavailable to crop plants.

In 1998, work began with fluid fertilisers such as ammonium polyphosphate (APP), dissolved technical grade (TG) MAP/DAP, or mixes of phosphoric acid and urea to compare their efficacy with granular P fertilisers. Micronutrients were also applied where possible in solution with the N and P. The fluid fertilisers were diluted with water and applied 25 mm below the seed at sowing using a ground driven, positive-displacement pump. Figure 1 shows the response of wheat in 1999 on a highly calcareous soil to fluid and granular fertiliser, with fluid fertiliser increasing P uptake in shoots and grain, and grain yield. In a recent isotopic study, Lombi et al. (2004) compared the behaviour of a fluid (dissolved TG-MAP) and a granular (MAP) form of P fertiliser in a highly calcareous soil in terms of P mobility and lability. The results indicated that P from fluid TG-MAP had a greater rate of diffusion and was potentially more available than P supplied as granular MAP. These results provided an initial explanation for the differential crop response between granular and fluid MAP fertilisers observed in field trials.

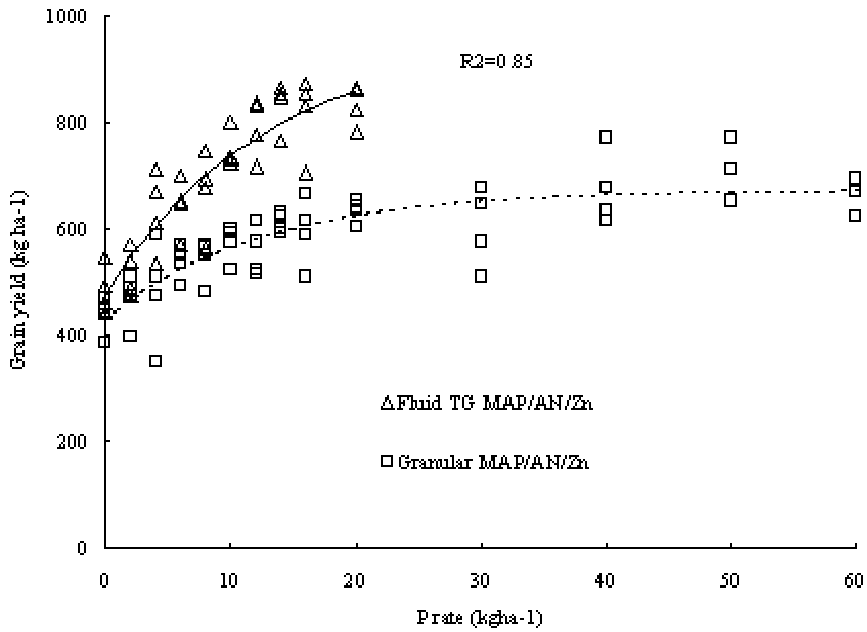


Figure 1. Response of grain yield of Frame wheat to rates of P applied as fluid technical grade MAP in solution with ammonium nitrate and zinc sulphate, or granular MAP with ammonium nitrate and zinc sulphate. From Holloway et al. (2001).

Since our initial studies in 1998, we have conducted more than 100 comparisons of fluid and granular fertilisers on calcareous and some non-calcareous soils. The results are summarised in Table 1. Fluid fertilisers had the greatest advantage on grey highly calcareous soils where yield increases compared to granular formulations were between 15 and 23%. The majority of the no-significant-difference trials were on P unresponsive sites.

Table 1. Summary of fluid vs granular fertiliser trials on Eyre Peninsula, South Australia, between 1998 and 2003.

Soil type	Total number of trials	Increase in wheat grain yield	Decrease in wheat grain yield	No significant difference
Grey highly calcareous sandy loams (30-90% carbonate)	50	45		5
Red-brown calcareous sandy loams (5-15% carbonate)	40	23		17

Red brown loamy sands (<1% carbonate)	11		4	7

In the past two years, fluid and granular P fertiliser comparisons have been carried out on soils from other parts of Australia. In 2003, a pot experiment was conducted at Horsham in Victoria using a wide range of soils to assess the early growth response of wheat to fluid (APP and phosphoric acid) and granular (TSP) formulations. There were growth increases with both APP and phosphoric acid compared with TSP on 5 acid soils, 4 alkaline red sandy loam soils, 3 red calcareous soils and 7 heavy clay soils from SA and Victoria (Figure 2). Recent work on some acid and heavy clay soils in Western Australia has also shown significant increases in grain yield with fluid fertilisers compared with the same nutrients applied in granular form.

In a long-term residual P trial on a grey highly calcareous soil, wheat yields the year after the application of fluid (APP) or granular (TSP) forms of P (plus N and micronutrients) were higher after APP than TSP. This was the first indication of a higher residual value of P from a fluid than a granular fertiliser (Figure 3).

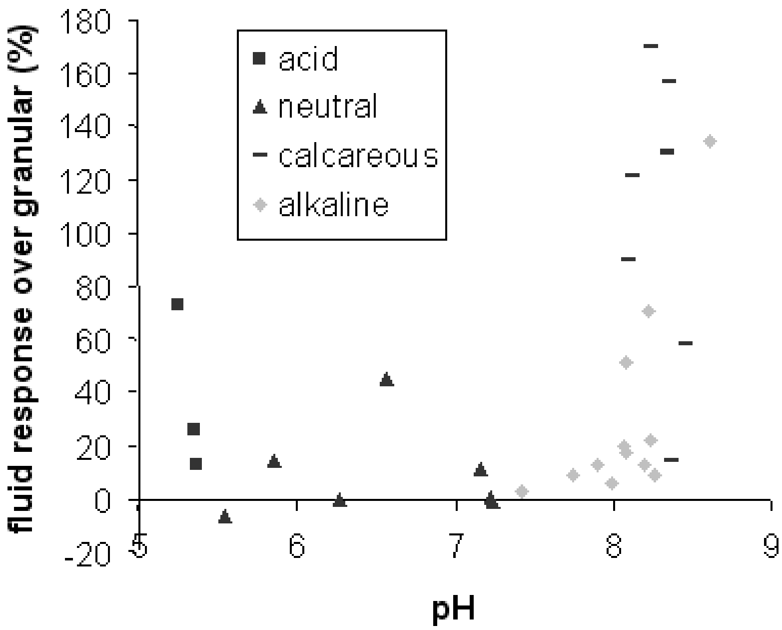
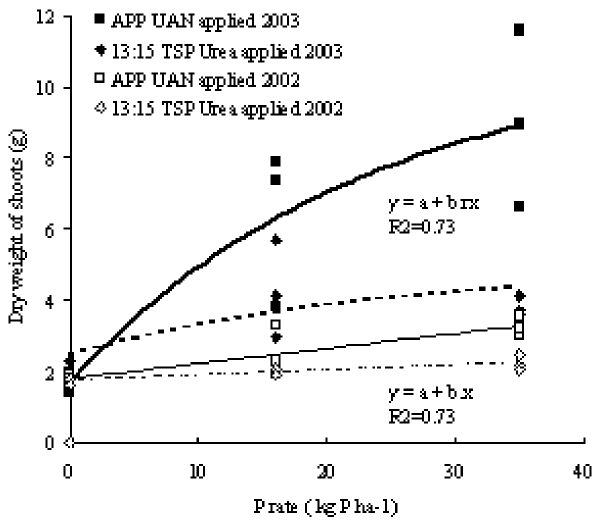
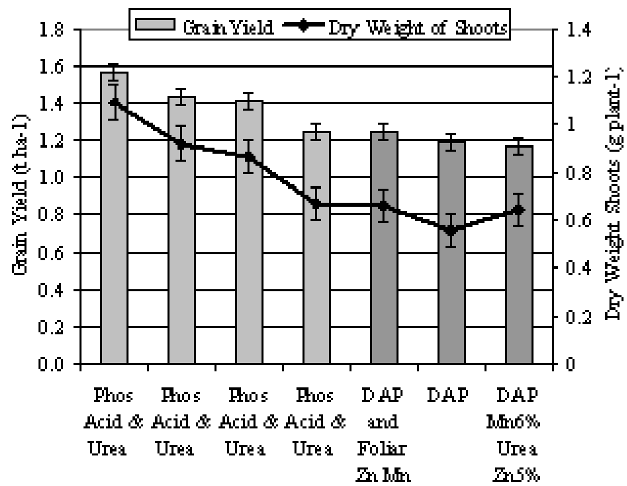


Figure 2. Dry-matter response of wheat to fluid fertilisers (APP and phosphoric acid), expressed as a percentage benefit over granular P fertiliser (TSP).

A trial at Miltaburra on upper Eyre Peninsula in 2003 showed that applying micronutrients in fluid P fertilisers banded near the seed on grey highly calcareous soils at low rates was a very effective method of improving early growth and overcoming micronutrient deficiencies such as manganese and zinc (Figure 4).





P	15	6	6	6	10	10	6
N	20	12	12	12	9	9	12
Zn	2	1	0.5		0.44		1
Mn	3	2.4	1.2		1.3		2.4

Figure 3. Relationships between dry weights of shoots of Frame wheat in 2003 and rate and form of fertiliser applied to a calcareous sandy loam soil in 2002 (residual effect) and in 2003 (current effect). UAN is a mixture of urea and ammonium nitrate applied with the APP.

Figure 4. Krichauff wheat grain yield response to multinutrient fertiliser combinations at Miltaburra SA, 2003.

Conclusions

In southern Australia, fluid P fertilisers are likely to give significant yield increases compared with granular formulations on highly calcareous soils in low rainfall areas. The best results with phosphoric acid, APP and technical grade MAP/DAP solutions have been achieved when solutions containing P, N and micronutrients were applied together at sowing.

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