FINALREPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

UA00081

Determining the benefits of fluid fertilisers on neutral and acidic soils in eastern and western Australia

PROJECT DETAILS

PROJECT CODE:	UA00081
PROJECT TITLE:	DETERMINING THE BENEFITS OF FLUID FERTILISERS ON NEUTRAL AND ACIDIC SOILS IN EASTERN AND WESTERN AUSTRALIA
START DATE:	01.01.2005
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Summary

This project aimed to identify the soil characteristics where fluid fertilisers were likely to be more effective than granular products, and to demonstrate and compare these fertilisers in field experiments in Western Australia (WA) and New South Wales (NSW). Glasshouse experimentation identified high soil calcium carbonate ($CaCO_3$) content usually predicted fluid effectiveness, although some neutral and acidic soils also responded to fluid phosphorus (P). Fluid P fertiliser effectiveness in some acidic soils remains unexplained. Field experiments were seriously compromised by drought conditions in 2006. Fluid products improved early dry matter production at two of the nine sites, but these were not translated into grain yield, possibly due to moisture limitations.

Conclusions

Conclusions from results of the glasshouse experimental program are that the responses of wheat to application of fluid P sources on acidic and neutral soils are likely (80% chance) to be similar to P supplied in granular form. There may be some acidic and neutral soils where fluid fertilisers offer yield advantages over granular products, but the key soil characteristic that predicts on which soils this is the case was not identified. At the same time, results confirmed that on calcareous soils there is a very high probability that fluid fertilisers will provide agronomic advantages over granular P products. The efficiency of P supplied in granular form to calcareous soils is very low.

The field experimental program was compromised by the drought conditions prevalent across Australia in 2006, and firm conclusions regarding field responses of fluid products on acidic and neutral soils could not be made.

Recommendations

Growers on calcareous soils should consider the economics of switching from granular to fluid products, as investment in granular P on these soil types is a poor one. Fluid P (and trace elements) will outperform granular fertilisers agronomically on most calcareous soils.

At this stage, it is recommended that if growers are interested in switching to fluid fertilisers on neutral and acidic soils, they should first undertake strip trials 'on farm' to determine if yield advantages over granular products are possible. If the unit nutrient cost of fluid products is less than that of equivalent granular fertilisers then there will be economic advantages from using fluid fertilisers as fluids always perform equal to, or better, than granular products per unit P added. On calcareous soils, fluids can provide agronomic and economic advantages over granular products even where the cost per unit nutrient is greater than granular fertilisers.

Where growers wish to examine the possible agronomic and logistical advantages of fluid fertilisers, strip trials should first be conducted. Information for growers on how to set up on-farm strip trials is provided at www.fluidfertilisers.com.au

The economics of switching to fluid fertiliser systems need to be considered, and the relative cost of nutrients in fluid form, along with set up costs, need to be assessed before growers switch to the new technology. Information on these aspects is available on the Fluid Fertiliser website - www.fluidfertilisers.com.au

Outcomes

Economic outcomes

The project confirmed that calcareous soils are likely to be unresponsive to granular P fertilisers in comparison to fluid P, so that continued use of these products on calcareous soils represents an economic drain on growers for little benefit. The high likelihood of agronomic responses to fluid fertilisers could be translated into economic returns to growers, dependent on returns for grain and unit nutrient cost, both of which may vary from year to year.

The project has demonstrated that in acidic and neutral soils, fluid fertilisers have a lower probability of delivering significant agronomic advantages over granular products compared to calcareous soils. If nutrients delivered in fluid form are more expensive per unit nutrient than granular products, then there will be a low likelihood of economic advantage for growers to switch to this technology in these soil types.

Provision of comprehensive information to growers on the use of fluid fertilisers, strip trials, equipment issues, and economics through the fluid fertiliser website - www.fluidfertilisers.com.au - will allow growers to make informed decisions on the use of fluid products.

Achievements/Benefits

Background

Benefits of fluid P, nitrogen (N) and trace element formulations have been clearly demonstrated on highly calcareous soils in South Australia (SA), both in the field and in glasshouse experiments, the latter indicating some possible mechanism for the efficiency of fluid products. Growers from Queensland (QLD), NSW and WA are showing great interest in fluid and suspension fertilisers, and are requesting information on the efficiency of fluid products on their soil types. At present, there is no independent assessment of the various fluid and suspension formulations that can be provided to growers. Fertiliser companies run their own product evaluation trials, but these are seldom open to independent verification and scrutiny, with data being used to promote and market company materials. Gaps in our knowledge were identified and this project aimed to address these.
1) Growers have a keen interest in fluid and suspension formulations due to the real and perceived benefits of these products, based on SA and VIC research. However, verification of efficacy claims has only been substantiated on alkaline soils. Growers need independent, rigorous experimentation coupled with a critical interpretation of data obtained. Much of the current information for growers derives from fertiliser industry sources (marketing material derived from company trials), or anecdotal evidence.
2) CSIRO, University of SA, South Australian Research & Development Institute (SARDI) and VIC Department of Primary Industries (DPI) research has suggested that the benefits of fluid formulations may not be confined to alkaline soils, and that acidic soils may also show significant responses to fluid or suspension products.
3) Possible yield responses using fluid or granular formulations need to be put in perspective to the costs of converting to use of these products, and the net benefit to growers clearly enumerated.

Achievements
Glasshouse experimentation
Phase 1 of the project involved glasshouse experimentation to examine the potential for acidic and neutral soils to also show benefits (over and above granular fertilisation) from fertilisation with fluid P products. Twenty eight different acidic and neutral soils were collected from the grain growing regions of Australia. Samples from the top 10cm of soil were collected from 28 sites representing a wide range of soil types used for dryland grain production in Australia including:
1) Six soils from WA (Alexander Bridge, Pemberton, Mt Barker, Gibson, Collie and Newdegate);
2) Four soils from QLD (Bauer-Kingaroy, A10-Kingaroy, Blackdown-Condamine, and Nebri-Drillham);
3) Five soils from NSW (Balranald, Culcairn, Temora, Tudgey and Kelley);
4) Three soils from VIC (Birchip, Hamilton and Kalkee);
5) One soil from Tasmania (TAS) (Ulverstone);
6) One soil from the Australian Capital Territory (ACT) (Otterbourne); and
7) Eight soils from SA (Lenswood, Keith, Monarto, Bordertown, Jacka, I'Anson and Warramboo).

The Warramboo soil collected from Eyre Peninsula contains high levels of free $CaCO_3$, on which wheat yield responses to applied P have been consistently greater for liquid than granular P. Soils were fully characterised chemically.
Basal fertilisers (except P) were applied to all pots, and P fertilisers applied at one rate. It was decided that only one rate of P would be used due to the practical constraints of adding a range of P rates and testing such a wide range of soils and four

fertiliser types. The fertilisers used were granular monoammonium phosphate (MAP), fluid MAP and ammonium polyphosphate (APP). Wheat plants were grown for four weeks and shoot growth and nutrient uptake determined. Plant responses to fertilisers were compared between treatments, related to soil chemical properties, and related to measures of available P in soil as determined by Colwell, Bray, resin and Diffusive Gradients in Thin-Films (DGT) techniques. Phosphorus buffer index (PBI) and isotopically exchangeable P were also determined.

Wheat responded to P application in 93% of the soils tested. In 21%, wheat yield responses were significantly ($P<0.05$) larger for P applied as one or both liquid P sources compared to the granular P source, with the liquid source producing 15-50% greater biomass than with granular P fertiliser. The potential use of soil properties to predict shoot responses to applied P was assessed using stepwise linear regression. Ten soil properties were multiple tested for inclusion in a predictive model: $CaCO_3$ content, PBI + ColP, pH (H_2O), total aluminum (Al), total iron (Fe), total N, total P, water content at field capacity, clay content and total organic carbon (TOC). Soil content of $CaCO_3$ and Fe was the major predictor of fluid effectiveness. The data from this trial were combined with a previous experiment using 29 soils in GRDC Project CSO231, and soil properties predicting fertiliser effectiveness were again examined. $CaCO_3$ content was the only significant predictor in this model, accounting for 73% of the observed variance in yield response to fluid fertiliser (over and above yield obtained with granular P).

All five soil P tests evaluated adequately predicted responses of dried wheat shoots to P applied as all three sources, but resin P was generally the best predictor of yield responses to applied P.

Field experimentation

All field trials were adversely affected by the drought conditions prevalent throughout southern Australia in 2006.

In NSW, four sites (Temora, Balranald, Yarrawonga, Culcairn) were chosen to represent contrasting soil types in southern NSW. The sites ranged from acidic (pH approx. 4.5) to alkaline (calcareous). A factorial design was used consisting of four products by three rates of application, plus a control, with four replicates. The products were MAP, TGMAP (a soluble form of MAP), phosphoric acid and EZY NP (a commercial product from Incitec Pivot). The rates of application were 10, 20 and 30kg P/ha. The N contents of each fertiliser were balanced with urea to provide a total N application rate of 60kg/ha. Grain at the Temora site responded negatively to applied P while the other sites retained a response to P, at least to 20kg P/ha. Fluid P sources were not significantly different to the granular MAP product, except for early dry matter and P uptake at the calcareous Balranald site. This did not carry forward into grain yield during the dry spring.

In WA, six sites (Merredin - two sites, Newdegate, Badgingarra, Boyup Brook and Geraldton) were chosen with soil pH values varying from 4.3 to 5.7. Treatments were nil P, granular P at 5kg P/ha as superphosphate (9%P), granular P at 10kg P/ha, granular P at 20kg P/ha, fluid P at 5kg P/ha, fluid P at 10kg P/ha, and fluid P at 20kg P/ha. Where grain yield increases (responses) to applied P were obtained both liquid and granular P sources were equally effective for grain production of wheat at Newdegate and canola at Boyup Brook. Liquid fertiliser was more effective than granular P for producing dried canola shoots at Boyup Brook but both sources were equally effective for producing canola grain in this experiment. No grain yield response to applied P was obtained in the experiment at Badgingarra because there was already enough P in soil for grain yield of wheat and canola. No grain yield responses were measured at Merredin because of severe infection with wheat streak mosaic virus (WSMV).

The data from both the glasshouse and field experimental program, while compromised by the drought, suggest that in acidic and neutral soils, fluid fertilisers have a low probability of delivering significant agronomic advantages over granular products. It was still unable to be predicted which acidic and neutral soils are likely to be agronomically responsive to fluid fertilisation.

Economic analysis

Generally, fluids are three to seven times more effective in providing P on highly calcareous soils than granular fertilisers, if the needs for other nutrients are also met. But what does this mean economically? Performance wise, two different fertilisers providing the same nutrients can only really be compared using a rate response trial. In this way, the differences in yields over a range of rates (e.g. of P) can be compared and it is possible to look at the ‘relative effectiveness’ of one fertiliser with respect to the other. Another way of looking at it is to see how much P, as say fluid, it would require to produce the same yield as a granular fertiliser. This is the most realistic way to compare fertilisers and you can work out substitution values for one fertiliser compared with another. The glasshouse trials cannot be evaluated in this manner as only one rate of P was applied, and the plants were only grown for a short period and not to grain harvest. In the field trials, severe drought affected most of the sites, and the restricted range of P rates used also meant that a detailed economic analysis could not be undertaken.

Because fluid fertilisers are currently more expensive per unit (kg) of P than granular fertilisers, it may be considered that they cannot be economical, even on the grey highly calcareous soils of Eyre Peninsula where they have performed best. Using data from trials on the Eyre Peninsula, an analysis of the economics of fluid use was undertaken where good agronomic responses to fluid fertilisers were obtained (Holloway et al. 2006). The current situation with the relative prices of fluid and granular fertilisers is a 'Catch-22'. Fluid prices are not likely to fall until there is an established market in eastern Australia and there is not likely to be an established market until prices fall. So fluid prices are higher, but are they uneconomically higher? Using typical grain yield responses on the calcareous soils, 17:19 Zn 2.5 was compared with a solution of phosphoric acid, urea and Zn sulphate hepta-hydrate. It was assumed that the price of the 17:19 Zn 2.5 was $515/tonne delivered to Upper Eyre Peninsula. The 2006 delivered price for 81% phosphoric acid was $850/tonne compared with $1,160/tonne ex store in 2005. This decrease in price does indicate that fluids should not be 'written off' as too expensive without actively searching the options that may be available. The cost of P in the 17:19 Zn 2.5% is $2.71/kg, and in the phosphoric acid, $3.20/kg. However, the 17:19 Zn 2.5 also contains 'free' N and Zn, if the cost of the P is considered only. To make a solution of phosphoric acid, urea and zinc sulphate, the cost of the urea and zinc also has to be added to the total fluid cost. The difference in yield at each P rate between the two fertilisers and its value at a wheat price of $135/tonne net of transport, levies and compulsory charges were calculated. This gave the marginal gross return to fluid fertilisers above granular at each rate of P applied. If the extra cost of the fluid fertiliser is subtracted from this, it leaves the net marginal return to fluid fertiliser. The marginal net return is a simple way of looking at the economics of the fertilisers alone. Marginal net returns of using fluid fertiliser were always positive (at all rates of P applied) and peaked at a P rate of 10kg P/ha. Obviously the relative cost per unit P of fluid versus granular P affects this analysis, and in a scenario where fluid P was $5.50 per kg and granular P $3.16 per kg, it was unprofitable to use fluid P at a rate above 10kg P/ha. Discussion with the fertiliser industry indicated that it would be financially possible to produce a fluid fertiliser for SA such as 9:17 Zn 0.5% (w/v%) at a delivered cost of $540/tonne. The cost of P in this product would be $4.12/kg P, and because the product contains N and Zn, the amounts of urea and Zn sulphate required to add the same nutrient ratios as in granular 17:19 Zn 2.5% are less than with the phosphoric acid alone.

Obviously, where no agronomic advantage of fluid fertiliser is measured, unless fluid P matches or is less costly than granular P, it will be uneconomic to switch to use of fluid fertilisers on agronomic grounds. In addition, costs of changing equipment and storage from granular to fluids need to be considered. These costs vary widely and no minimum or maximum figure can be quoted. Often, existing farm equipment can be modified or adapted to fluid fertiliser delivery or storage.

The above economic analysis only considers responses to P. It has been demonstrated that fluid sources of Zn and Mn are more effective than granular sources of these trace elements on calcareous soils. This needs to be factored into the economic analysis.
In switching from granular products to fluids, the grower also needs to consider the logistical and precision agriculture benefits of fluid fertilisers.

Other research

The mechanistic basis explaining the better agronomic performance of fluid P on acidic soils has yet to be elucidated fully. It may well be through mechanisms similar to those active in calcareous soils, where instead of Ca diffusing into granules and precipitating P, high concentrations of Al and Fe in acidic soil solutions are drawn into fertiliser granules to precipitate P as Al and Fe phosphates.

Additional information

McBeath, T.M., McLaughlin, M.J., Armstrong, R.D., Bell, M.J., Bolland, M.D.A., Conyers, M.K., Holloway, R.E. and Mason, S.D. 2007. Predicting the response of wheat (Triticum aestivum L.) to liquid and granular phosphorus fertilisers in Australian soils. Aust. J. Soil Res. (in review).

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