FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

UQ00079

Organic matter and nutrient availability

PROJECT DETAILS

PROJECT CODE:	UQ00079
PROJECT TITLE:	ORGANIC MATTER AND NUTRIENT AVAILABILITY
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SUPERVISOR:	MICHAEL BELL
ORGANISATION:	UNIVERSITY OF QUEENSLAND
CONTACT NAME:	MICHAEL BELL

Summary

This project:

1. Reviewed literature outlining the technical understanding of soil nitrogen (N) and sulphur (S) supply processes and environmental losses.

2. Surveyed more than 300 advisers and agribusinesses nationally to determine how N fertiliser recommendations are made and the assumptions underlying them.

3. Documented the key Decision Support Systems (DSS) and their assumptions used to help practitioners arrive at an N or S fertiliser recommendation.

In each component, the strengths, weaknesses and knowledge gaps underpinning N and S fertiliser decisions were documented. Technical and industry perspectives of priorities and gaps were compared and a set of priorities to guide future research, development and extension (RD&E) investment was developed.

Report Disclaimer

Conclusions

See section 8.0 of review (Attachment).

Recommendations

See section 8.0 of review and Table 8 for investment priorities by grains region (Attachment).

Outcomes

Economic
The scoping study has provided a benchmark against which the $1.2-$1.8 billion annual fertiliser N investment can be assessed, as well as highlighting the growing importance of (and lack of understanding about) declining soil S reserves. Considerable uncertainty about the validity of current commercial approaches to fertiliser management in changing farming systems is highlighted, as is the growing importance of managing fertiliser losses.

Environmental
The scoping study has provided guidelines for future R&D investment that will contribute to maximising the efficiency of fertiliser use in cropping systems while minimising offsite impacts.

Social
The project has provided a benchmark against which industry can confidently assess current fertiliser N management practices and which GRDC can use to target future research investment.

Achievements/Benefits

The aims of this project have been:
o To undertake a technical review of the factors determining relationships between soil organic matter and nutrient availability (particularly N), including the rates of N mineralisation and potential losses of mineral N via different pathways, and to identify opportunities for improved fertiliser N management.
o To understand the strengths and weaknesses of processes used in commercial industries (especially advisers and the fertiliser industry) to derive N fertiliser recommendations, and to identify both perceived knowledge gaps and any inconsistencies between existing DSS and rules of thumb used by advisers and the technical understanding from the literature.
o To compile a list of regionally based recommendations for future GRDC investment to improve the understanding of N and S dynamics in the Australian grains industry and to deliver a framework for better fertiliser decisions for growers.

The technical review has been undertaken from two different perspectives, both of which aimed to identify knowledge gaps and R,D&E priorities for future investment. The first component of the review was undertaken from a technical perspective and focused on the level of understanding of the processes influencing N and S availability to crops (from both soil and fertiliser sources) in the published and unpublished literature, primarily with an Australian focus. This component identified knowledge gaps and priorities for future research investment.

The second was a national assessment of the industry approach to N fertiliser management decisions through a detailed survey of advisers who are responsible for delivering fertiliser advice, with some limited benchmarking of this process against grower clients. This involved survey questionnaires and follow up in depth interviews with a subset of participants with a focus on the level of understanding (and uncertainty) about different components of that fertiliser decision. Information from this process was used to derive a set of perceived gaps in knowledge and extension and training needs to better equip the industry for getting fertiliser decisions 'right'. Due to the limited use of S in most fertiliser programs, this survey focused exclusively on N.

A final integrative section of this review then examined the consistency (or otherwise) of perceived knowledge gaps between the research and agricultural adviser communities, as well as looking at the effectiveness of the current decision support tools, processes and rules of thumb used to make N and S recommendations. This analysis focused on deriving an industry roadmap that can be used to prioritise investment (on a regional basis) that will lead to improved N and S recommendations and greater returns from fertiliser investment.

Executive summary

The Australian grains industry has traditionally relied on the mineralisation of soil organic matter and plant residues to provide a source of N and S that can be utilised during the cropping phase of a rotation, with the balance to meet crop needs supplied by fertiliser applications. However, as soil organic matter continues to decline, despite adoption of stubble retention and reduced or zero tillage, and grain cropping regions continue to intensify production by shifting to continuous cropping rather than mixed cropping and grazing systems, the reliance on synthetic fertiliser inputs to maintain productivity and balance nutrient removal in harvested grain is increasing. The cost of nutrients such as N already dominate most fertiliser budgets, with evidence of shortfalls in S availability increasingly evident in some regions, along with supply of mineral nutrients like phosphorus (P) and potassium (K). The increasing demand for nutrient inputs is accompanied by growing uncertainty about the capacity of microbially-mediated soil supply processes to make a reliable contribution to meeting N and S demand, especially as cropping and tillage systems change. This uncertainty about likely soil N (and to a lesser extent S) availability, the greater need for costly fertiliser inputs and the imperatives for efficient nutrient use have collectively initiated this study.

The study consists of three distinct components: (i) A review of published and unpublished literature (where available) outlining the technical understanding relating to soil N and S supply processes and the environmental losses that can reduce plant available N and S from both soil and fertiliser sources; (ii) A survey of more than 300 (primarily) advisers and agribusinesses nationally, to determine how N fertiliser recommendations are made and the assumptions underlying the decisions themselves; and (iii) A documentation of the key DSS and their underlying assumptions that are used to help practitioners arrive at an N or S fertiliser recommendation.

In each component of the study, the strengths, weaknesses and knowledge gaps underpinning the fundamentals supporting N and S fertiliser decisions were documented. It then attempted to contrast the technical and industry perspectives on priorities and gaps, and collectively develop a set of priorities to guide future RD&E investment for the grains industry.

From the technical perspective, the review notes that while there has been considerable research conducted on soil N supply processes, much of that research is now quite dated and conducted in mixed cropping and grazing systems that are no longer representative of the reduced or zero tillage, more intensive cropping systems that are currently employed. In addition, changing rainfall patterns are influencing the relative importance of fallow and in-crop organic matter mineralisation, with implications for both the timing and availability of nutrients for crop uptake. While similar comments can be made for S, the overall level of research and process understanding of S cycling and release for plant availability is poorly developed.

There are substantial knowledge gaps relating to environmental losses of N and S and the loss in response to different environmental conditions. Leaching losses on lighter textured soils have only been explored to any extent in western regions. The gaseous losses of N via denitrification and volatilisation are less well quantified across all regions. The former is especially relevant on clay soils and duplex soils or those with elevated soil C status (i.e. after a pasture phase), while the latter are

increasingly important given the trends to move to in-crop top dressing of fertiliser N in southern and western areas. The recent national focus on N_2O emissions via the National Agricultural Nitrous Oxide Research Program (NANORP) project, especially when combined with 15N isotope studies, has shown that while N_2O is important from a greenhouse gas emissions perspective, the major denitrification product is N_2.

The review has also noted a lack of integrated, long term studies to look at the interaction between fertiliser application strategies, nutrient losses, crop recoveries and system nutrient budgets. Where these have occurred, the results of partial nutrient balances are often at odds with more quantitative isotope studies showing significant fertiliser losses. This suggests that 'apparent' nutrient balance for a locally relevant N fertiliser rate may have been achieved by mining the soil organic matter pool of nutrients, rather than balancing nutrient inputs to removal rates.

Advisers are using a combination of methods to derive N fertiliser recommendations, with the majority using 'rules of thumb' and local knowledge rather than elaborate DSS. Few DSS even consider S availability or derive application rates. Advisers are increasingly concerned about the accuracy of the simple N decision methods, and even the more elaborate DSS, given the major changes in soil fertility and cropping systems that have occurred since those tools were developed. The resulting uncertainty in fertiliser recommendations exists for advisers who are well trained and familiar with the research on which tools were developed, as well as those newer to the industry who have not experienced N workshops and training packages, and are using a DSS 'black box' without understanding the embedded assumptions and caveats.

The smaller relative contributions of both N and S derived from soil organic pools compared to that from synthetic fertiliser inputs on a crop by crop basis are increasing the pressure on advisers to achieve a 'correct' fertiliser decision. Given the uncertainty in seasonal forecasting, and hence likely nutrient demand, advisers are less interested in fine tuning recommendations than they are in ensuring there is an adequate nutrient buffer to meet any unexpected crop demand. Similarly, better understanding of the characteristics of events that generate N or S losses, the soil properties which amplify or minimise the risks and the appropriate management response are areas of concern.

Much of the information on soil N supply has been integrated into the main DSS and some 'rules of thumb' used by industry to derive a fertiliser recommendation. However, few DSS or advisers factor in environmental losses or even consider S. There is considerable resistance to developing ever more detailed, process-driven DSS for use by time poor advisers, but building on existing DSS used by commercial providers and improving the ways of delivering that information in real time offer opportunities.

The integrated review, adviser survey and DSS overview have been developed into a set of regionally focused recommendations for future R,D&E investment (Table 8), with recommendations across the R,D&E spectrum. The balance between investments in N and S should be heavily skewed in favour of N, given the impact that it has on productivity and the importance it plays in both the costs of production and the profitability of grains cropping. However, it is very obvious that a level of basic investment is required to improve S management in these systems.

The R&D investment should be focused on both definitive research about the nature and extent of N and S losses from both soil and fertiliser sources, and more applied research to test the validity and robustness of current N and S mineralisation assumptions in more intensive, cereal and oilseed dominated farming systems under reduced or zero tillage. The interaction between fertiliser application strategies, nutrient losses and crop recovery should also be addressed. In terms of extension investment, there is a clear need to train the adviser and reseller community in the basics of N and S management and fertiliser decision making processes, given the significant generational turnover in both the reseller and adviser community, combined with the general absence of succession planning and on the job mentors for younger staff. There are many new advisers who have not undergone basic training and who are working on the basis of a poorly understood set of assumptions that may or may not be still relevant.

Other research

There have been a number of R&D opportunities outlined in the review conclusions (See Attachment).

Intellectual property summary

The report authors have been granted a six month period in which the technical reviews can be published as manuscripts before the final project release by GRDC.

There are no constraints on the distribution of the regional research priorities developed in the project.

Additional information

Attachment

Review - Organic matter and nutrient availability in Australian grains soil - a focus on supply and loss of nitrogen and sulphur and implications for industry fertilizer strategies.