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Preface: Nutrient management by the Australian grains industry

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The contributions to this special edition of the Australian Journal of Soil Research report recent research undertaken as part of a Nutrient Management Initiative established by the Grains Research and Development Corporation (GRDC). The Corporation is a statutory authority established to plan and invest in R&D for the Australian grains industry. Its primary objective is to support effective competition by Australian grain growers in global grain markets, through enhanced profitability and sustainability. The Nutrient Management Initiative operated as a national R&D program over the period 2004 to 2008, with projects in each of the three major grains regions (west, south, and north).

Many of Australia's cropping soils are old and leached, and do not naturally contain the level of nutrients needed to now sustain high-intensity cropping systems with high rates of nutrient removal in grain and fodder. Even in soils with higher natural nutrient levels, many years of grain removal is depleting the store of elements needed for good crop growth and optimal yields. Mass balance calculations (nutrients removed in agricultural products compared with amounts added in fertilisers) suggest that while more nitrogen (N) is often being added than removed in modern cropping systems, many growers are running down the amounts of crucial elements in their soils such as phosphorus (P), potassium (K), or sulfur (S), and occasionally magnesium (Mg) and trace elements such as zinc, copper, or manganese. In some cases the soil store of these elements remains adequate to cover the imbalance, but increasing symptoms of deficiency suggest that many growers are losing potential crop yield due to low nutrient availability.

Grain growers are well aware of the importance of nutrients in soil fertility, but fertilisers now also represent a significant proportion of all variable costs and their costs have been growing faster than the prices obtained for grain. Increasing prices reflect both the limited world supply of fertiliser ingredients, including N, P, and K and the gradual move to lower quality sources, as well as structural constraints which mean the fertiliser industry cannot respond immediately to the increased demand being driven primarily by developing countries. Biofuel production is adding to fertiliser demand, while there is increasing competition for some of the raw ingredients of fertiliser manufacture, for example natural gas that can be used directly as an energy source or as a feedstock for N fertiliser manufacture. Hence, there is increasing pressure to better match these expensive inputs to crop needs and to maximise the returns achieved by grain growers from their nutrient management.

At the same time, the fertiliser recommendations developed in the past may no longer be the best for modern farming methods such as full stubble retention and no-till, and a move to wider row spacings and inter-row sowing using guidance systems. Past recommendations tended to focus on one element and one crop, whereas growers now look to manage all nutrients so that no one nutrient is limiting, across a whole crop rotation sequence. The need for good environmental management, to ensure nutrients are not lost from cropping paddocks to cause unwanted impacts off-site, is a further issue for the industry.

These considerations led the GRDC, in 2004–05, to establish a national Nutrient Management Initiative (NMI), whose goal was the adoption by grain growers of methods to achieve improved nutrient availability and uptake under a range of cropping systems. Within the NMI, 9 R&D projects were funded. Eight worked with growers, advisers, and fertiliser companies to investigate and improve different aspects of nutrient management; the ninth focused on how growers use nutrient information and on delivery to the industry of the new information from the NMI in ways that enable and promote its adoption. The mix of outputs from these projects included:

- mass balances for key nutrients at paddock, property, and catchment scales to identify potential imbalances and off-site losses.
- quantification of the sizes of soil nutrient stores, and their changes over defined cropping sequences and in a range of seasonal conditions.
- collation of data on crop nutrient requirements throughout the growth cycle, including early tests for deficiency.
- development of innovative methods to utilise stored soil nutrients, and of fertiliser products and application methods that ensure nutrients are available where and when crops need them.
- development of methods for cost-effective soil testing to determine nutrient status and fertiliser requirements in relation to paddock management zones.
- plant types with increased nutrient uptake efficiency for major nutrients.
- integration of new and existing knowledge to produce updated regional fertiliser recommendations and decision support systems, linked to paddock management zones and nutrient responses testing.
- assessment of nutrient management by the grains industry in relation to catchment and waterway nutrient targets in contrasting regions.
- delivery of Initiative findings and products to growers through public and commercial networks, including development of training materials for growers and advisers and incorporation into EMS.

Project teams have identified opportunities for growers to better target nutrients over time (using seasonal forecasts and measured

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rainfall) and space (based on farm or paddock production zones). The following papers provide a summary of just some of the results of the Initiative; others have already been published or will be over coming months. Results from the NMI will also be provided in forms that promote their adoption by growers and farm advisers, including regional nutrient management handbooks, updated recommendations, improved nutrient testing and assessment, workshops, field days, and training programs.

This special editions starts with the paper **Chen *et al.* (2009)**, which discusses and ranks the key issues in managing crop nutrition in Western Australia as perceived by growers, advisers, the fertiliser industry, and researchers. These issues include changing nutrient management to reflect changing farming systems, the development of new fertilisers and application technologies, improving on-farm decision making about nutrient management, and the interaction of crop nutrient management with other aspects of agronomy and soil variability.

Different systems for conservation cropping have been adopted widely across the Australian grains industry over recent years, with >70% of crops grown in this way in some regions. Most systems include the retention of stubble with minimal soil disturbance at sowing. This has given improved moisture infiltration and retention, but also the potential for some nutrients to become stratified in the upper layer and thus possibly not available to crops when they are needed. **Ma *et al.* (2009)** discuss this issue in their paper in relation to several crucial nutrients and test the value of deep placement under conditions in Western Australia. The topic is further explored in the papers by **Vu *et al.* (2009)**, who examine the effects of tillage and crop rotation on stratification and transformation of P form within the profile, and **Mathers and Nash (2009)**, who consider the effects of stratification on potential losses of P and N. **Bell *et al.* (2009)** also examine stratification in soil of the northern cropping region, but this time for K availability, and suggest practical ways in which growers could address the problems described.

The location of nutrients within the soil profile, and their availability at times of high crop demand, also influence the returns likely to be achieved by growers from fertiliser application and other agronomic techniques. These issues are explored in a series of papers by **Dunbabin**, **Armstrong**, **Officer**, **Norton and co-workers** (**Dunbabin *et al.* 2009**; **Officer *et al.* 2009*a*, 2009*b***). The ROOTMAP model was used to establish a series of hypotheses about likely uptake of P and N and the effects of location (placement), timing, and seasonal conditions. The effects of N and P, either together or separately and early on and later in the growing season, were also studied, as was the availability of P from fluid rather than granular forms of fertiliser. This work has enabled the team to begin to develop strategies that growers can use to improve the likely benefits from nutrient additions, based particularly on starting soil moisture and seasonal conditions.

Oliver and Robertson (2009) examine the relative benefits to growers of managing seasonal variation and/or the spatial variability in nutrient (NPK) availability using crop simulation models and nutrient response curves. Seasonal variation was more important than knowledge of the spatial arrangement of soil types for the better soils with higher water-holding capacity (PAWC), providing two-thirds of the benefit of perfect knowledge. On soils with low water-holding capacity, knowledge of soil variation and seasonal influences on yield potential were similar contributors to potential profit gains.

Wong and Wittwer (2009) challenge the idea that N can be readily leached within many of the cropped soils of WA, and show that some wheatbelt soils have significant positive charge and anion exchange capacity. Their data show that several pore volume equivalents of drainage may be necessary before N is leached into deeper layers, and this may need to be taken into account in decision tools that assist calculation of crop N and hence fertiliser requirements.

The work of the Nutrient Management Initiative, part of which is reported in this special edition, contributes to the GRDC goal to develop optimal farm management practices that, when used to grow superior high-yielding varieties, will lead to increased productivity from sustainable grain production systems. Better farming practices contribute to increased productivity by enabling grain growers to obtain the maximum return from their inputs, while at the same time minimising losses and off-site effects. Improved nutrient management resulting from this research is being combined with new knowledge from other GRDC R&D initiatives, which enable growers to also identify soil constraints and to use precision agriculture technology to vary fertiliser application across the farm or paddock according to estimated crop demand. Agronomic packages that incorporate these R&D results are tailored to suit each region, and tested and further developed under local conditions by grower groups. Other GRDC investments support education, training and other capacity-building activities that facilitate on-farm practice change and allow the grains industry to make the best use of new technologies developed from the research initiatives.

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