Nutrient management to nutrient stewardship

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Abstract

As agriculture has met increasing production demands, the use of fertilizers has been a fundamental aspect of sustainable and productive systems. The use of fertilizers has moved from purely production to economic returns and now includes the third bottom line of environmental effects. The consequences of injudicious fertilizer use are significant for the environment and have resulted in several jurisdictions of legislative tools to manage grower practice.

A global framework designed to aid the development and adoption of fertilizer best management practices (FBMPs) is described within the context of sustainable development. The framework is based on the premise that four principles of nutrient management-right source, right rate, right time, and right place provide the basis and flexibility needed for nutrient management in global agriculture and be adaptable from small to large farmers. As such it summarises a process – rather than defining an endpoint - in developing sustainable nutrient management practices based on good science that consider the demands of multiple stakeholders.

Key Words

4Rs, fertilizer best management practices,

Introduction

Agriculturalists have been implementing and refining nutrient management since farmers first recognized crop growth could be enriched by the use of animal manures, composts, ashes, fish meal, bones, and other soil additives. The first nutrient management research at Rothamstead in 1843 sought to compare “new” chemical fertilizers against farmyard manure, and those experiments continue to provide insights about long-term trends in productivity and soil health (Rassmussen et al. 1998). Long term agronomic experiments including fertilizer rate trials were established in Australia in the early part of the 20th century but the only one still being managed is Longerenong Rotation 1 established in 1916 (Crawford et al. 2003). There also are long term superphosphate experiments at Rutherglen (pastures, 1914), Hamilton (pastures, 1977) and Walpeup (crop/pasture, 1947), and the outputs from these experiments were – and still are – used to assist understanding fertilizer rate responses in particular farming systems.

From those early experiments, "optimum" application rates were developed that got growers to the top of the yield response curve, with maximum production being the focus as the value of the output was relatively high and the cost of the input relatively low. As a result, generally high rates built up the current P bank we see in soil tests. For example, the 2001 National Land and Water Audit identified that the long history of superphosphate application had raised soil P levels significantly, and from that audit, 39% of soils had Colwell P values more than 30 mg/kg (ANRA 2001).

The development of agricultural or resource economics led to a review of fertilizer use, with the concept of marginal analysis applied to selecting economically optimum fertilizer use rates. The marginal increase in the value of added yield due applied fertilizer was compared to the marginal increase in the cost of the input, and when these were matched, maybe with a margin for risk, then an economically "rational" rate was determined (Malcolm et al.1996). In some situations, an added "value" or disbenefit could be included to consider off-site impacts, such as the impact of soluble or adsorbed P on a decline in water quality in adjacent catchments. The need to consider these issues has become more and more pressing as the use of fertilizers drives the increase in food production demanded by a larger and more affluent global population.

The impact of nutrients leaking into the environment has been felt in regions such as the Great Barrier Reef (Queensland), the Peel-Harvey catchment (Western Australia) and the Gippsland Lakes (Victoria). The response of governments has then been to educate and then legislate fertilizer management strategies.

The idea of nutrient best management practices (BMPs) is a relatively recent concept. Defined by fertilizer industry scientists as research proven practices that have been tested through farmer implementation to optimize production potential, input efficiency, and environmental protection (Griffith and Murphy 1991), BMPs related to nutrients encompass a host of terms. Fertilizer best management practices, integrated plant nutrient management, code of best agricultural practices, site-specific nutrient management, and other similar expressions are all descriptive components of plant nutrient management. All have an underlying goal to help ensure plant nutrients are used efficiently and effectively in ways that are beneficial to society without adversely impacting our environment. The concepts involved can best be described through global guidelines for nutrient stewardship.

In 2007, the International Fertilizer Industry Association (IFA) launched an initiative to define the general principles of fertilizer BMPs (FBMPs) and to develop a strategy for their wider adoption. During that workshop, Fixen (2007) introduced the idea of a global framework within which FBMPs could be adapted to local conditions. Since then, the concept of a global framework for FBMPs has been further developed by IPNI scientists (Bruulsema et al. 2008) and an IFA Task Force on FBMPs culminating with the publication of *The Global "4R" Nutrient Stewardship Framework* (IFA Task Force 2009). The framework is intended to aid the development and adoption of nutrient BMPs that meet sustainable development goals (i.e. economic, social, and environment) through simultaneously increasing crop productivity and profitability, while protecting the environment.

The global framework developed recognizes there are many stakeholders interested in nutrient management — farmers, crop advisers, scientists, policymakers, consumers, and the general public. Each stakeholder has different expectations of nutrient management which revolve around the pillars of sustainability. Profitability, land stewardship, clean food, land for nature, a clean environment and responsibility are all components of sustainability supported by economic, social, and environmental goals. Ideally, these three pillars of sustainability would be equally balanced, but in reality that does not occur. The balance between economic, social, and environmental goals for nutrient management depends on the issue, its context, and the stakeholders (IFA Task Force 2009). In some sensitive ecosystems, more emphasis might be placed on environmental goals, where in other situations social goals may be of greatest concern or economics (i.e. farmer profitability) may dominate. Regardless of the balance, it is constantly changing with improvements in knowledge and technology and changes in stakeholder expectations.

4R Nutrient Stewardship

The global 4R nutrient stewardship framework attempts to integrate the economic, social, and environmental expectations of the different stakeholders within cropping system management objectives of productivity, profitability, cropping system durability, and a healthy environment (Figure 1).

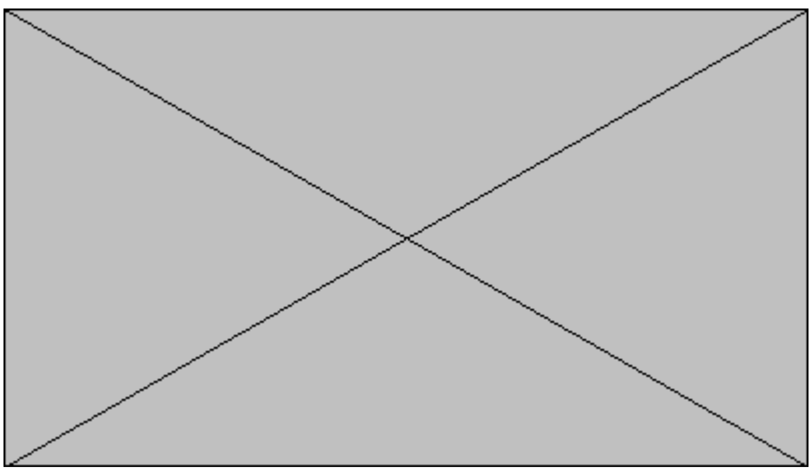

Figure 1. The 4R nutrient stewardship concept defines the right source, rate, time, and place for plant nutrient application as those producing the economic, social, and environmental outcomes desired by all stakeholders to the soil-plant ecosystem.

The 4Rs are the foundation and guiding principles of nutrient BMPs (Roberts 2007). The approach is simple and universally applicable … apply the correct nutrient in the amount needed, timed and placed to meet crop demand. Examples of the 4 rights of nutrient stewardship include:

Right Source – match the nutrient source or fertilizer product with soil properties and crop needs. Apply nutrients in plant-available forms. Balance applications of nitrogen, phosphorus, potassium, and other nutrients according to crop needs and available soil nutrients. Beware of nutrient interactions, blend compatibility, and non-nutritive elements.

Right Rate – Match application rates with crop requirements. Set realistic yield goals and use adequate methods to assess soil nutrient supply (e.g. soil testing, omission plots) and crop need (e.g. tissue analysis, crop nutrient budgets, crop scouting). Predict fertilizer use efficiency, consider economics and soil resource impact.

Right Time – Assess timing of crop uptake and synchronize nutrient availability with crop demand. Assess soil nutrient supply. Utilize pre-plant, split applications, controlled release fertilizers, and urease and nitrification inhibitors to manipulate the timing of nutrient availability and consider logistics of field operations.

Right Place – Recognize root-soil dynamics. Place and keep nutrients where the crop needs them and where nutrient use efficiency will be maximized. Crop, cropping systems, and soil properties will dictate the most appropriate method of placement, but incorporation is usually preferred to keep nutrients in place and increase their use efficiency. Beware of and manage spatial variability.

Right source, rate, time, and place are science-based principles of fertilizer management. Each of the 4Rs is guided by scientific principles and supported by years of research. They are not static, but are changing and improving with new gains in knowledge and technology development. They are interdependent and interlinked with agronomic management practices applied in cropping systems (Bruulsema et al. 2009). The 4Rs provide flexibility to nutrient management recognizing that FBMPs are site and crop specific depending on soils, climatic conditions, crop and cropping history, and management expertise, and can be applied in large-scale, extensive agriculture or small family farms. These issues have been discussed in-depth by American Society of Agronomy (Mikkelsen et al. 2009; Phillips et al. 2009; Stewart et al. 2009; Murrell et al. 2009).

The framework shows the interaction between BMPs and allows assessment of FBMPs on the cropping system performance within the goals of sustainability. Performance is the outcome of implementing a FBMP. Figure 1 shows various cropping performance indicators, i.e. yield, quality, soil productivity, nutrient loss, etc. and how they are interconnected. A “best” management practice should positively address at least two and preferably three goals of sustainability within the cropping systems. For example, nutrient use efficiency is often considered the foremost performance indicator relative to fertilizer use. Nutrient use efficiency can be increased simply by reducing application rates (Roberts 2007). If the objective of nutrient management was to maximize nutrient use efficiency, then the farmer would merely target lower parts of the yield response curve where the first increments of applied fertilizer gives the greatest yield response. Singling out rate reductions could reduce nutrient loss (beneficial for the environment), but it may also negatively impact yields and profitability, reducing the economic sustainability of the farmer. Performance measures or indicators must be considered within a cropping system and in relation to the goals of sustainability. They are set by the farmer, his or her advisers, and other stakeholders in society concerned with how nutrients are managed. The need for and usefulness of performance indicators in improving

FBMPs is outlined at greater length by Bruulsema et al. (2009) and by the IFA Task Force (2009).

Concluding Comments

Right source, right rate, right time, and right place is a simple slogan that integrates a century of science and experience into nutrient stewardship. Who decides what is right? Who decides the best application, best method of placement, or best nutrient source? There is no right answer … right must be site-specific, dictated not only by soil and environmental conditions, but by social and environmental concerns and objectives. Research backstops the principles of 4Rs with science, but the stakeholders decide what is right. The farmer, the fertilizer industry, natural resource managers, extension workers, crop advisers, environmental NGOs, and others with a vested interest help in deciding what is the right or best nutrient management practice. The people impacted by nutrient management decisions, i.e. the consumer, are also involved and policymakers help make those decisions for them.

Nutrient use regulatory and policy developments are becoming common place in North America and the European Union and becoming more common in Australia. New Zealand has regulated nutrient management, and here we have seen regulations on fertilizer use in the wet tropics and the restriction of soluble P sources in particular catchments. The 4R's approach to nutrient stewardship provides a voluntary framework that is soon to become part of a national dairy industry nutrient stewardship program. The shift from a production to stewardship approach to nutrient management – while it may not avoid legislation, it will demand that the evidence on best practice is considered in developing use guidelines.

Farmers can achieve better management through implementation of 4R nutrient stewardship. Validated by research, the 4R nutrient stewardship framework allows farmers to improve their performance and sustainability. Economic, social, and environmental performance is reflected through performance indicators chosen by the stakeholders of the cropping system. 4R nutrient stewardship is gaining global acceptance, but continued education and multi-stakeholder dialog between farmers, the fertilizer industry, policymakers, and other relevant groups are still needed to keep moving forward.

References

Bruulsema TW, Lemunyon J, and Hertz B. 2009. Know your fertilizer rights. Crops & Soils/March-April 2009. American Society of Agronomy. Madison, WI. pp. 13-18.

Bruulsema TW, Witt C, Garcia F, Li S, Rao TN, Chen F, and Ivanova S. 2008. A global framework for fertilizer BMPs. Better Crops with Plant Food 92(2), 13-15.

Crawford MC, Sonogan R, Unkovich M and Yunusa IAM. 2003. 'Review of Long-term Agronomic Experiments in Victoria'. Department of Natural Resources and Environment, Victoria. http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/lwm_ltae Accessed May 08, 2012.

Fixen PE. 2007. Can we define a global framework within which fertilizer best management practices can be adapted to local conditions? In Fertilizer Best Management Practices. IFA International Workshop on Fertilizer Best Management Practices (FBMPs). 7-9 March 2007, Brussels, Belgium. pp. 77-86.

Griffith WK and Murphy LS. 1991.The development of crop production systems using best management practices. Potash & Phosphate Institute, Norcross, USA

IFA Task Force. 2009. The global "4R" nutrient stewardship framework. Developing fertilizer best management practices for delivering economic, social, and environmental benefits. IFA Task Force on Fertilizer Best Management Practices. International Fertilizer Industry Association (IFA). Paris, France. AgCom/09/44. A/09/116

Malcolm W, Sale P and Egan A. 1996. Economic Principles of Profitable Production, Ch 5 in "Agriculture in Australia, an introduction" Oxford University Press, Oxford UK. p172-209.

Mikkelsen R, Schwab G, and Randall G. 2009. The four rights: selecting the right source. Crops & Soils/ May-June 2009. American Society of Agronomy. Madison, WI. pp. 28-32.

Murrell TS, Lafond GP, and Vyn TJ. 2009. Know your fertilizer rights: right place. Crops & Soils. March-April 2009. American Society of Agronomy. Madison, WI. pp. 29-33.

National Land and Water Resources Audit. 2001 Nutrient management in Australian agriculture, Australian Agricultural Assessment 2001, Natural Heritage Trust. http://audit.deh.gov.au/ANRA/agriculture/docs/national/Agriculture_Nutrient.html Accessed May 08, 2012.

Philips SB, Camberato JJ, and Leikam D. 2009. Selecting the right fertilizer rate: a component of 4R nutrient stewardship. Crops & Soils/July-August 2009. American Society of Agronomy. Madison, WI. pp. 13-18.

Rassmussen PE, KWT Goulding, et al. 1998. Long term agroecosystem experiments: Assessing agricultural sustainability and global change. Science 282, 893-896.

Roberts TL. 2007. Right product, right rate, right time and right place … the foundation of best management practices for fertilizer. In Fertilizer Best Management Practices. IFA International Workshop on Fertilizer Best Management Practices (FBMPs). 7-9 March 2007, Brussels, Belgium. pp. 29-32.

Stewart WM, Sawyer JE, and Alley MM. 2009. The four rights: timing. Crops & Soils/September-October 2009. American Society of Agronomy. Madison, WI. pp. 24-28.