Towards a 4R-consistent fertiliser industry

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The concept of 4R Nutrient Stewardship has been embraced by a wide segment of the fertilizer industry, and many of its associated partners in agriculture, government, and the environmental movement. The 4Rs communicate the essentials of responsible management of plant nutrition to a wide range of stakeholders, technical and non-technical. The specific nutrient application practices being encouraged vary from one region to another, because the implementation of 4R Nutrient Stewardship is site-specific. The core concept is that the right source of plant nutrient be applied at the right rate, right time, and right place to obtain improved sustainability outcomes. Industry needs to support an adaptive management approach at all levels. Segments of the industry including agri-service providers, retail, wholesale, manufacturing, and investors, working together, can ensure that producers are empowered and enabled to make the right choices to improve the performance of their cropping systems.

About 25 years ago, the United Nation's World Commission on Environment and Development produced a report titled "Our Common Future". This report provided the basis for the concept of sustainable development, and in particular, sustainable agriculture. Over the past few years, sustainability has become an important topic for corporations, including those in the agriculture and food sectors. Major food retailers are developing programs to assess and improve their own performance, along with that of their supply chain, extending all the way to the farm level and to the inputs used by farmers. These food retailers are engaging agri-business by participating in organizations like the Sustainability Consortium and the Keystone Alliance.

The 4Rs connect to sustainability

4R Nutrient Stewardship encourages more sustainable choices for the source, rate, time and place of application of crop nutrients. The Keystone Alliance, for example, has developed a "Fieldprint Calculator" which includes elements of 4R Nutrient Stewardship in its greenhouse gas component, and a Water Quality Index currently under development is likely to be linked to 4R Nutrient Stewardship as well.

Definitions of sustainable agriculture abound, but most emphasize a need to accommodate growing demands for production without compromising natural resources. This entails a balance among economic, social and environmental impacts of management choices.

The fertilizer rights – source, rate, time, and place – are connected to the goals of sustainable agriculture through the cropping system, as shown in **Figure 1**. Fertilizer management, to be considered "right," must support stakeholders' goals for how that cropping system performs, how it produces, how it affects the air they breathe, the water they drink, etc.

Scientific principles apply to the 4Rs

The sciences of physics, chemistry, and biology provide fundamental principles for the mineral nutrition of plants growing in soils. The application of these sciences to practical management of plant nutrition has led to the development of the scientific disciplines of soil fertility and plant nutrition. The management components source, rate, time and place each have unique science which describes the processes related to plant nutrition, and can be condensed into principles (**Table 1**). Understanding the sciences underpinning these key principles is critical for those advising crop producers on plant nutrition.

SOURCE, RATE, TIME, AND PLACE are completely interconnected in the management of plant nutrition. None of the four can be right when any one of them is wrong. It is possible that for a given situation there is more than one right combination, but when one of the four changes the others may as well. The 4Rs must work in synchrony with each other and with the cropping system and management environment. 4R Nutrient Stewardship emphasizes the impact of these combinations of management choices on outcomes, or performance, toward improved sustainability. For example, when potassium limits yield, application of potash fertilizer improves recovery and use efficiency of nitrogen and phosphorus.

Adaptive Management

Adaptive management for plant nutrition includes cycles of decision, implementation and evaluation (**Figure 2**). These cycles operate at several levels, including the farm, the regional and the policy levels. There is a role for industry at each level.

Agri-service providers—including retail dealers—

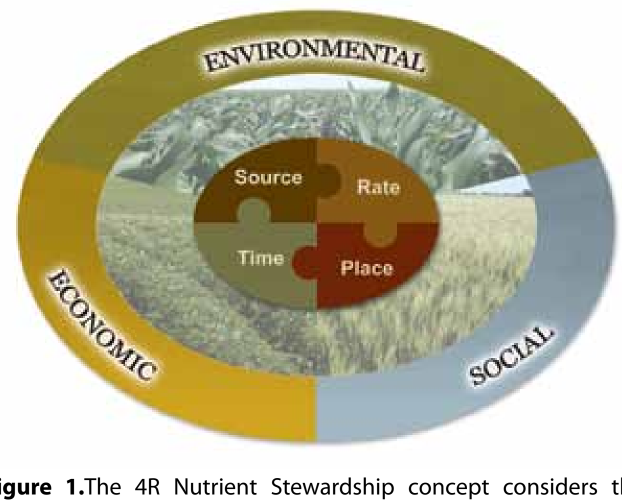

Figure 1. The 4R Nutrient Stewardship concept considers the right source, rate, time, and place for fertiliser application capable of producing the stakeholders' desired economic, social, and environmental outcomes for the ecosystem.

Table 1. Key scientifc principles associated with the 4Rs (IPNI, 2012).

Source	Rate	Time	Place
Provide essential elements	Assess plant demand	Assess timing of uptake	Consider where roots grow
Supply plant-available forms	Assess soil supply	Identify sensitive growth stages	Consider soil chemical reactions
Suit soil properties	Use all available sources	Assess dynamics of soil supply	Suit the tillage system
Recognise synergisms	Predict uptake efficiency	Recognise dynamics of losses from soil	Manage variability among felds
Respect blend compatibility	Maintain soil fertility	Evaluate logistics of feld operations	Manage variability within felds
Recognize associated elements	Consider economics		

often advise producers at the farm level. Producers review options for each crop, choosing recommendations for source, rate, time, and place of application which suit their local site factors. These site-specific factors start with soil and landscape and extend to a wide range of considerations including local regulations and land tenure.

At the regional level, agri-service providers make decisions on the nutrient sources (products) they will offer and on the logistics of how they can be delivered at the right time to the farm or to the field. Industry agronomists interact with producers and crop advisers to implement and interpret on-farm trials that aid in the evaluation of selected practices.

At the policy level (often a national or global level), manufacturers, investors and governments make decisions on product development, and investments in production facilities and transportation infrastructure. These decisions influence the range of source and time options available to producers.

All three levels need to be consistent in the goals against which they evaluate outcome. Source, rate, time and place are central to all, but it's the full framework that we mean when we talk about 4R Nutrient Stewardship, or the 4Rs.

Accountability

Systems for sustainability improvement and certification generally require accountability. Accountability at the farm level often requires a nutrient management plan. The general principles that make a 4R Nutrient Stewardship plan distinct from a regulatory nutrient management plan are: 1) asking the producer to state sustainability goals and performance indicators for the farm, 2) allowing producers

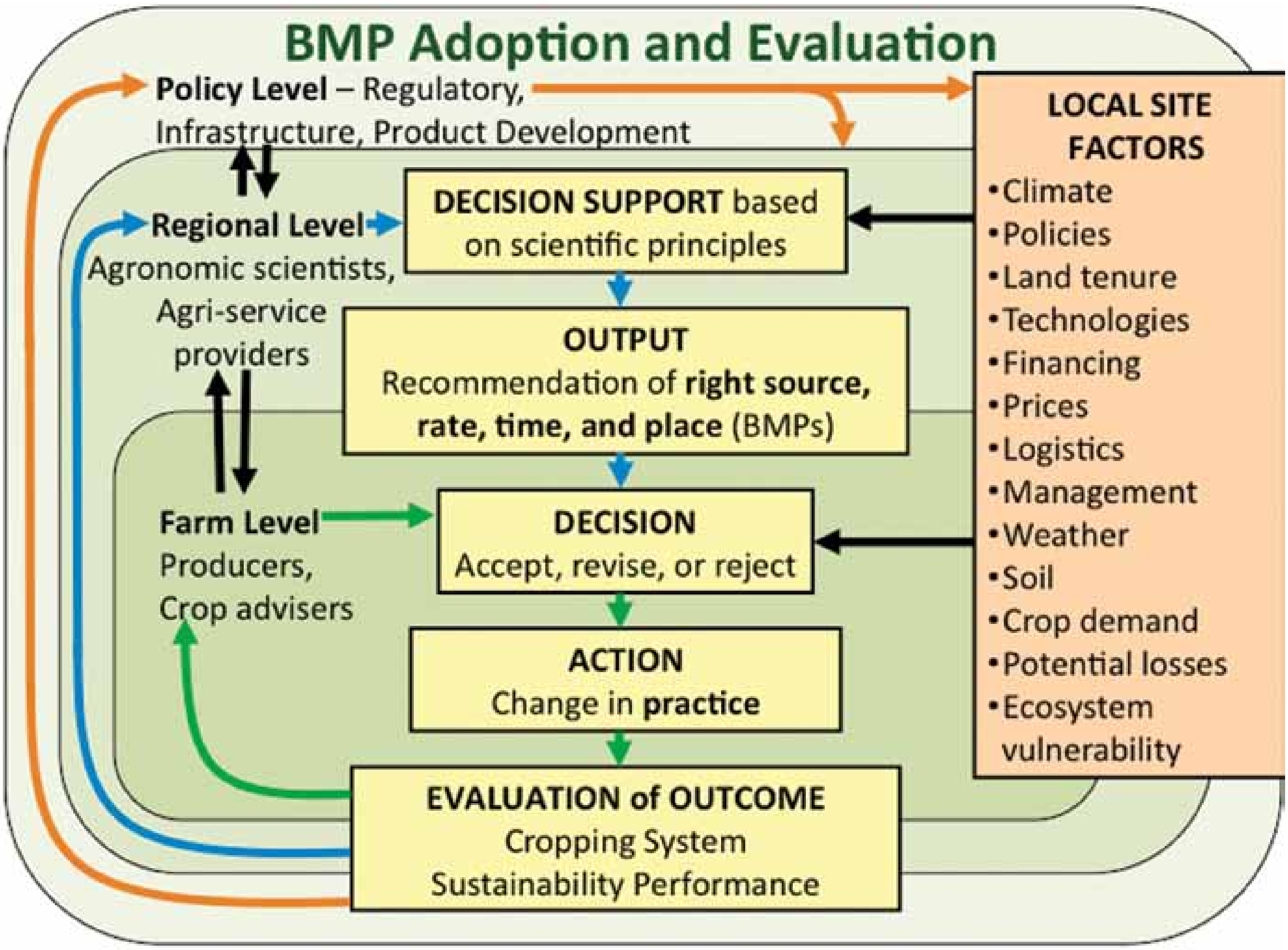

Figure 2. The 4Rs are included in adaptive management to take into account local site-specific factors in cycles of continuous improvement at farm, regional and policy levels.

flexibility to implement adaptive management by ensuring that the details of practices implemented for each crop and in each field are documented but kept private, and 3) publicly reporting progress in using indicators or measures of performance reflecting the economic, social and environmental pillars of sustainability. These principles are at the core of a management system consistent with international principles of accountability for sustainability performance.

Example – Managing Phosphorus Fertilizer in the Lake Erie Watershed

Phosphorus (P) is an essential nutrient for growing crops. But in the wrong place – in excess concentration in streams, rivers, and lakes – it can lead to algal blooms. In the Lake Erie watershed region in and around the state of Ohio, USA, levels of dissolved P in rivers and algal blooms in lakes have been trending upward from 1995 to 2011. Fertilizers applied to the predominant corn-soybean cropping system are not the only cause, but are one possible cause among many.

Research data show that when fertilizer P is broadcast and left on the surface, runoff resulting from rainstorms within a few days of application is enriched in dissolved P to levels far above those known to stimulate algal blooms, even though the losses amount to less than 5 to 10 percent of the fertilizer P applied. To mitigate these losses, 4R Nutrient Stewardship implemented in this region focuses on applying fertilizer at the "right time" and in the "right place." Wherever possible, fertilizer P is recommended to be placed below the soil surface, by injecting, banding, or by incorporating after broadcasting. Where incorporation is difficult, for example in no-till systems, producers are advised to pay close attention to the weather forecast, and avoid broadcasting P fertilizer when there is more than 50% chance of intense rain within the next few days.

A group of agri-business partners, government agencies and environmental organizations is working together to provide educational programs and raise awareness of how nutrient stewardship can contribute to reducing losses of dissolved P. This group includes The Nature Conservancy, the Ohio Agri-Business Association, the Ohio government departments of agriculture and natural resources, Ohio State University Extension, and several agri-retailers and crop producers. Further work is ongoing to develop better validated criteria for selecting practices, based on research monitoring actual edge-of-field losses. Further information on the program is available from The Nature Conservancy. By supporting management that is adaptive and addressed at economic and environmental goals at the same time, 4R Nutrient Stewardship assures continued progress in advancing crop yield s in this highly productive watershed.

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Reference

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Learning from Long-term Experiments – What Do They Teach Us?

By Rob Norton, Roger Perris, and Roger Armstrong

Established in 1916, the Longerenong long-term rotation provides a platform for evaluating long-term trends in farming systems and soil health over a period of many years. Longerenong rotation 1 (LR1) gives us essentially the same message as other long-term agronomic experiments. The message is that rotations can be sustained and productive provided the challenges of diseases, weeds, soil structure, and nutrient replacement are met.

Long-term agronomic experiments (LTAE) reflect new ideas and practices in farming systems. The longest running experiments were established at Rothamsted in the United Kingdom (UK) in 1843, and seven are still running today (Rassmussen et al., 1998). There are only 10 others of these classical (more than 50 years) experiments across the globe, including

LR1 in Australia.LR1 is Australia's longest running annual cropping system experiment, established in 1916 on a self-mulching, alkaline Grey Vertosol near Horsham in southeastern Australia. Average annual rainfall is about 420 mm. LR1 sought to identify what crop sequences would provide improved yields and over time it has became a platform for other research such as on the use of superphosphate. The experiment compares seven cropping rotations and although not spatially replicated, each cropping phase is present every year. The rotations are continuous wheat (WWW), wheat/fallow (WF), wheat/oats grazed/fallow (WOgF), wheat/barley/peas (WBP), wheat/oats/peas (WOP), wheat/oats grazed/fallow (WOgF) and wheat/oats/oats grazed/fallow (WOOgF). The crops receive no fertilizer N, 10 kg P/ha on cereals, and 5 kg P/ha on other harvested crops. Crop establishment, weed control, and crop protection activities follow district practice. In the soil, N and P are present in a range of forms that have different availabilities to plants. Most of the soil N is present in organic forms which are mineralised to nitrate which is the form that plants can take up. Applied P is partitioned into a range of soil pools with different plant availability, due to differences in desorbtion, dissolution, and mineralisation rates that contribute to plant P nutrition.